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December '91/January '92 — Issue 24

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EDITOR'S INK

Ken Davidson

Our Upcoming Year

Now that I've scared off all our potential authors ("English: The Forgotten Language?" in issue #23), I want to share with you our editorial calendar for the upcoming year.

Issue #25 (February/March 1992)

Theme: Building Automation

Special Section: Embedded Signal Conditioning

Article Deadline: October 18, 1991

Issue #26 (April/May 1992)

Theme: Distributed Control

Special Section: Embedded Programming

Article Deadline: December 27, 1991

Issue #27 (June/July 1992)

Theme: Real-Time Programming

Special Section: Embedded Sensors and Storage

Article Deadline: February 28, 1992

Issue #28 (August/September 1992)

Theme: Signal Processing

Special Section: Embedded Interfacing

Article Deadline: April 24, 1992

Issue #29 (October/November 1992)

Theme: Measurement and Control

Special Section: Embedded Graphics and Video

Article Deadline: June 26, 1992

Issue #30 (December '92/January '93)

Theme: Debugging, Simulators, and Emulators

Special Section: Embedded Control and Conversion

Article Deadline: August 28, 1992

If you have an article idea related to one of the themes listed above, let us know about it. We'll work with you to develop your idea into a bang-up article. Even if you have an idea that doesn't fit one of the themes, we still want to talk to you. We run articles unrelated to the theme in each issue of the magazine and are constantly working on new volumes of The Circuit Cellar Project *File* books. As long as you know your stuff, we'll work with

you to produce a literary wonder. Obviously, the deadline for issue #25 is past, and we are hard at work putting that issue together as you read this.

THE ISSUE AT HAND

One of the most popular articles we've ever run was on generating holograms using a computer, some basic photography, and a laser ("Computer-Generated Holograms," *CIRCUIT CELLAR INK*, issue #14). The beauty of the concept was the simplicity of the code used to generate the images. Dale Nassar is at it again, producing more three-dimensional images using a computer, but this time with the same red/blue glasses with which you used to watch 3-D movies. As before, the code is very short, and the results are spectacular.

We also have another article from a popular author, Chris Ciarcia (Steve's brother, if you hadn't figured it out by now). This time, he's talking about designing optical systems (specifically, a lens) by computer. Most of our readers know all about circuit design by computer, but optical design is probably new to many.

Don't miss this issue's special section, where we present a nifty little controller that has everything you need for most control applications right on the board. The IBM PC keyboard interface and video output especially caught our eye.

THE NEXT ISSUE

The theme of the next issue of *CIRCUIT CELLAR INK* is always a popular one: Building Automation. The Circuit Cellar engineering staff is hard at work designing the Home Control System II (HCS II) and will start presenting the system's building blocks. We're also planning some changes and improvements to the look of the magazine I think you'll like.



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CIRCUIT CELLAR **INK**®

THE COMPUTER APPLICATIONS JOURNAL

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Three-Dimensional Graphics by Computer

Computer-Generated Anaglyphs

by Dale *Nassar*

Dale Nassar enjoys combining three-dimensional imaging with computers. Find out how to create images on your computer screen with realistic-looking depth.

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PC-Based Optical System Design

Using Your PC to Design a Lens

by Chris *Ciarcia*

Most of us are familiar with circuit simulation by computer, but how often do we consider doing the same for optical systems? Chris Ciarcia gives us a sampling by showing how to design a lens by computer.

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A Video Editing Control System-Part 2

by William J. *Kressbach*

In the last issue, Bill Kressbach described the hardware aspects of a video editing controller. In this final part, he gives the software particulars.

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High-Resolution Timing on a PC

by Bruce *Ackerman*

Timing events with microsecond resolution using your IBM PC is easier than you think. See how it's done with no additional hardware.

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Third Design Contest Results

Winners of Circuit Cellar INK's Third Annual Design Contest

The results are in. Yet again, the judges had a difficult time selecting from a superb field of entries. We salute this year's design contest winners.

SPECIAL SECTION: Single-Board Solutions

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The FS- 100 MC68HC11 -Based Single-Board Computer

On-board Keyboard and Video Interfaces Complete this Single-Board Powerhouse

by Frank *Swiger & Joe G/over*

Take the popular MC68HC11, add an IBM PC keyboard interface, a video output, and some additional I/O and you have a super single-board solution.

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FINAL WORD ON STANDARD DEVIATION

Since the exchange letters between Charles Boegli and me ("Reader's INK," issues #21 and #22 of *CIRCUIT CELLAR INK*) regarding his article, "Adjusting Standard Deviation to Sample Size" ("Practical Algorithms," issue #20), I've done a bit of research to resolve the question of the c_2 adjustment divisor. (Yes, Norman, there is a c_2 !)

Briefly, if the sample drawn from the population is unbiased, then the sample standard deviation,

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

is the best estimate of s , the standard deviation of the population. A sample whose elements are drawn at random from the population is unbiased. An example would be a designed experiment wherein the experimental runs were done in random order.

On the other hand, in running a control chart on an ongoing process, s is usually estimated from a series of successive runs, rather than randomly. This sample is biased, since no data on future runs are used. In this situation the best estimate is s/c_4 , where c_4 corrects the bias. This is a larger estimate than for the random situation, and reflects the added uncertainty of the outcome of future runs. If the sample standard deviation is estimated by dividing the sum of squares by n (a time-honored practice, but a bad one in my opinion), then the correction divisor is c_2 . The estimated value of s is the same by either method of calculation. The values of c_2 and c_4 are functions of the sample size, n . The exact expressions involve gamma functions (not commonly available on your handy pocket calculator), but can be approximated closely by a square root fit, as Mr. Boegli has neatly shown.

The bottom line is that the proper estimate to use depends on the sampling protocol. This point was not brought out in Mr. Boegli's article. I think it is important to do so.

Norman F. Stanley
Rockland, ME

WHAT ABOUT THE SCHEMATIC READER?

I felt compelled to write after reading Bruce Webb's article "OrCAD Schematic Design Tools" (*CIRCUIT CELLAR INK*, issue #23). As a technician who has to use OrCAD-generated drawings, I'd like to pass on a few recommendations and observations to those folks who do the circuit layouts.

1) Signal names. Names cut down on repair time. Names need to be consistent, no name changes should be made on a signal path unless that signal is modified through a component.

My personal experience with poor naming technique is with a drawing of a CPU board that has several lines that go through up to six name changes without going through another part, then to top it off, the lines are not connected to anything.

2) Power and grounds. Granted, any engineer or technician should know where the power and ground pins are at on most 7400 TTL and CMOS chips. How about ECL? Or a proprietary chip? Or surface-mount PLCC? Or a PAL, Xilinx, or other related programmable chip?

The drawings that I've seen rarely show power and ground connections on the chip. Sometimes there is a chart that lists those points; that helps. Otherwise you need a stack of data books to hunt down some of the more elusive connections.

3) Block diagrams. Sometimes it's faster to lay out the schematic as a block diagram, just to show how the major parts of a system are tied together. This is especially useful when the system you're working on is several pages deep. Showing that U78 on page 2 is connected to U4 on page 32 via a line called ACK01 as a one-page block does simplify matters and speeds up diagnostics.

In using OrCAD-generated schematics, I have had to resort to redrawing the schematics of several boards to block diagrams, just to make the various boards easier to visualize. After making the block diagrams, my time spent in searching through all the various schematics has been cut down by about 75%.

4) Programmable gate arrays. Yes I know, you don't want your competition to know your circuits work by using a PAL or similar device. What about your service personnel? If your field service rates are \$150 an hour and

your service people can't troubleshoot a board because they don't know how a signal is acted upon thorough a PAL, whose fault is that? And are you going to bill the customer for your failure to inform that service person?

I routinely deal with PALs and Field-Programmable Gate Arrays. It ain't easy troubleshooting one of those things if you don't have a program listing or even some sort of logic analyzer. Especially some like a Xilinx part where there can be over a hundred signal connections going in and out of the chip and you have no idea what the serial ROM is supposed to do.

5) Signal Flow. Just as proper names are needed for signal paths, showing which way signal paths come and go can be helpful too. This is especially true for programmable chips, where an I/O line needn't be unidirectional. Having the standard left-to-right diagram flow with all or most of the inputs on the left side and the outputs on the right helps make things consistent.

6) Circuit Board Parts Locations. Whenever possible, have the parts on the board labeled or least laid out on a page sequentially. Some of the boards that I have worked on have U1 at one end of the board, U2 through U4 aren't used, then U5 is way over on the other side of the board. This consumes a lot of time looking for a part when you have a high-parts-count board.

7) Parts Lists. Having a way to find the right part is vital, as well as the means of getting it quickly. Make sure that a parts list goes with each schematic drawn.

Now back to OrCAD. On a scale of 1 to 10, I give OrCAD a 2, mainly because a poorly made schematic is still better than no schematic at all. Now, I have never seen OrCAD in action at a workstation, I just use the end result. However, I've talked with engineers who do use OrCAD, and they readily admit that for schematic generation, OrCAD just doesn't cut it. OrCAD might be good for net lists and such, but for us technicians, it's the pits.

As you might have noticed for both OrCAD and Schema articles, the points that go off the illustrated schematic don't say anything about where they go. The diagrams I work with are up to 20 pages thick. I don't want to spend the time to hunt through 20 pages of drawings to find how parts are connected together. It's time consuming and frustrating trying to chase down a signal path when you have no idea where it's going to and coming from.

Schematic-generating programs, like word processors, do help in making information transfer easier. Engineers need to be aware of who will be using their drawings. Factory and field service people need all the information they can get their hands on to work with these circuits. Having the circuit information laid out in a logical and easy-to-follow way cuts down on service time, eases the technician's tension level, and helps to cut down, on overhead. My contention is that if written documents were generated the same way OrCAD drawings are, we would really be in a mess.

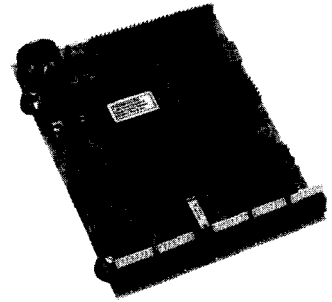
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5

TAKING ED TO TASK

Issue #23 arrived today! I went directly to my favorite: the "Firmware Furnace." What a shock to have Ed Nisley proclaim that he will no longer stoop to assembler ("C for microcontrollers has arrived") and then spends most of the rest of the column apologizing for lousy performance, unpredictable results, and incompatibilities across compilers. It will be interesting, you blinking lights with your Avocet and other megabuck compilers while your readers struggle ("...changing the startup code is not sinful-it can be essential") to figure out what has to be changed for our pedestrian compilers.

Face it, Ed. C sucks cycles, and is about as appropriate on an 8032 as COBOL was on a 4K 1401. For over 30 years I have programmed most of IBM's computers in all of the languages and C is the most illogical tripe ever foisted off onto "developers." I'll be damned if I'll fork over \$600 to prove you can blink lights with C.

T.B. Kester
Atlanta, GA

Ed Nisley responds:

Give me one more chance! "Firmware Furnace" in this issue explores an 8031 C language development system that costs \$100: Micro-C from Dave Dunfield. While not exactly free, it brings "real C" to the 8031 in a way

that kilobuck compilers just can't touch. I've used it for several nontrivial projects and it's a winner.

But I agree with you: not only does C suck cycles, it bulges at the seams of the 8031's code space. That's why I don't hesitate to drop in huge blocks of assembler code where it will do the most good. C provides control logic and formatted I/O, leaving fast bit-banging to assembly code where it belongs.

For example, the firmware for an X-10 modem (which you'll read about in issue #25) weighs in at 900 lines of C and 700 lines of assembler. C was neither fast enough nor small enough for everything, but it let me concentrate on the hard parts and get the whole job done faster.

Ah, yes: the modem has three LEDs. The C code gets to blink only one of them.. .

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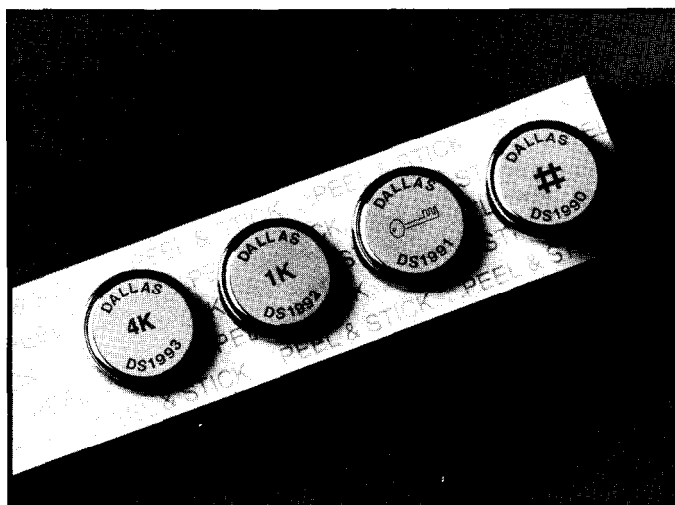
conducted by Harv Weiner

TOUCH-CONTROLLED MEMORY CHIP

Dallas Semiconductor introduces **DS199x Touch Memory**, a nonvolatile memory chip in a durable, steel **MicroCan**. Touch Memory is a data carrier read and programmed by momentary contact with a computer. Available with adhesive backing, the Touch Memory firmly attaches data to virtually any object for instant availability.

Touch Memory shares some of the applications of a bar code, but it can be changed on demand. The chip can hold up-to-date, relevant information because it can be reprogrammed while attached. Available in densities of up to 4K bits, it records over 100 times the data of a bar code and transfers error-free data at a rate of 16K bits per second.

Touch Memory communicates through a one-wire signaling scheme. Special circuitry on the chip multiplexes address, data, and



control wires onto a single bond pad. This bond pad is extended to the can's lid, and the rim and bottom become ground.

When contacted, the Touch Memory emits a wake-up signal, followed by its family code, a CRC code, and a unique 48-bit serial number. The serial numbers are written using a laser, and are registered and unalterable. The CRC code validates the serial number and qualifies the electrical connection.

The chip includes an internal scratchpad that prevents inadvertent writing over existing data or to the wrong location. Data is first written to the scratchpad and then verified before it is transferred to memory. Once the transfer is initiated, a copy of the scratchpad is faithfully reproduced in memory, even if the contact is broken.

Secure versions of Touch Memory require 64-bit passwords to be entered

before data is transferred. In this way, mere possession of the chip is not sufficient to learn its contents.

Touch Memory can monitor product processing during manufacture, access control, asset management, and product information storage. Quickly retrofit any PC to read Touch Memory using the DS9097 COM port adapter. A model DS9092 Touch Probe is also available.

Prices for Touch Memory range from \$1.58 to \$3.71 in 1000-piece prices, depending on storage capacity. The DS9092K Touch Starter Kit, which provides hardware and software for quick evaluation of the Touch Memory family using a personal computer serial port, is available for \$75.

Dallas Semiconductor
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Dallas, TX 75244-3219
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PC CONTROL INTERFACE KITS

Home Control Concepts has simplified using a PC for home control applications with the introduction of two new devices. The Powerline Interface Kit allows PC control of lights, appliances, and other devices in the home by using X-10 modules (or compatible modules by Stanley, Heath, Tandy, etc.). The interface kit requires a PC with a serial or parallel port. Hardware and software installation takes about five minutes, and a software utility program verifies proper installation.

The Powerline Interface Kit aids in the development of custom "smart home" systems. Develop a system that uses the two-way interface to monitor the status of the home's lights and appliances, and make intelligent decisions based on their on/off status. Develop a home control system that uses IF-THEN logic. A Two-Way Powerline Interface Module (model TW523 by X-10 [USA] Inc.) is included with the kit that transmits to and receives from the powerline. Programming consists of sending and receiving simple serial "packets" of information. In addition to the TW523, the interface kit includes cable, adapter, software (including a library of C utilities), documentation, and technical data. The kit sells for \$79.

The **PC-to-Infrared Interface Kit** allows PC control of infrared devices in the home. The interface kit requires a PC with a serial port and a remote control (One-For-All or 1-Control). A software utility program called SendIR allows one to "push buttons" on the remote control from the computer's DOS environment. For example, a simple command from DOS can mute a stereo system or change a television channel.

The interface kit aids in the development of custom systems. Write software either around the SendIR utility program or from scratch with the sample C code provided. The PC-to-Infrared Interface Kit includes cable, hardware interface, software, documentation, and technical data, and it sells for \$79.

Home Control Concepts
9353C Activity Rd.
San Diego, CA 92126
(619) 693-8887
Reader Service #501

DSP SOFTWARE FOR IBM PC

Durham Technical Images has released PC Data Master 3.0, a Digital Signal Processing (DSP) software package for the IBM PC and compatibles. It offers a range of DSP and data display functions, an interactive help facility, and a pull-down menu interface. The basic PC Data Master distribution forms a complete system for DSP, but data analysis functions written by the end user are easily integrated into the package using virtually any language compiler or assembler compatible with MS-DOS 3.0 or higher.

The PC Data Master shell provides both pull-down menus and traditional DOS command windows for user interaction by either mouse or keyboard. Create multiple graphics windows for data display, and control them by mouse, shell commands, or dynamically from application routines. The interactive help utility is driven by a chain of help files, which can be expanded to describe user-written modules using any text editor.

Efficient binary data pipes are used to link processing modules implemented as independent executable (EXE) files.

Process data files of any size using these pipes. If insufficient RAM is available, the shell automatically creates temporary spill files to buffer the excess data. Add processing modules using any language that supports the standard DOS file I/O system.

PC Data Master also has a set of DSP utility modules. These modules include fundamental operations such as forward and inverse FFT routines, convolution, correlation, window generation, FIR and IIR filter design

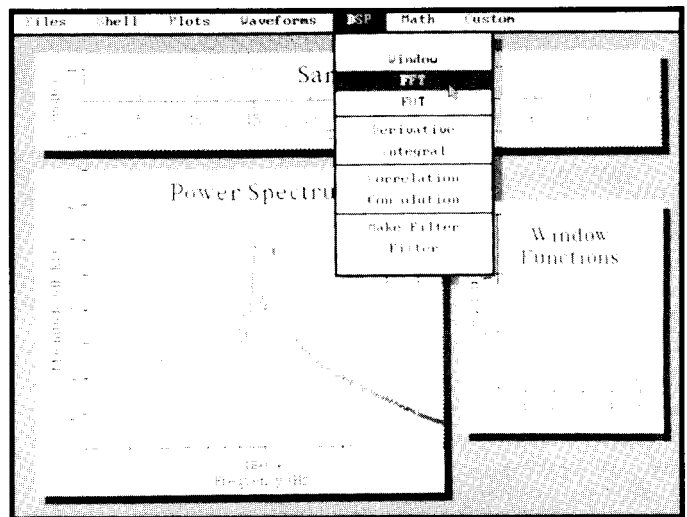
and implementation, derivative and integral test data generation, and fifteen real and complex data file math functions. Implement many multistage transformations, such as the Cepstrum and the Hilbert Transform, without creating new software by combining these basic operations with data file math routines in data pipes.

The PC Data Master distribution includes a module for displaying waveform data. Use the plot system's autoconfiguration capabilities for quick display of individual or multiple data files. For more exacting applications, the plot system's interactive mode provides full or partial control over the design of data displays.

An add-on package is available to support two-dimensional signal processing. Called the "2D-Up-grade," this package extends the test data generation, data file math, FFT, convolution, and other modules in the basic package to handle two-dimensional data files. Graphics capabilities are also extended to include "waterfall" plots, "wire-mesh," 3-D surface plots, and contour plots.

PC Data Master sells for \$185, including both the Basic Distribution and the Application Development Toolkit. An Academic Site License is available to universities for an additional \$95. A Demonstration disk is available for \$10, and the 2-D Upgrade costs an additional \$85.

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DOWNLOADABLE EPROM EMULATOR

DPR0M 2, a new version of a downloadable EPROM emulator, was introduced by Applied Data Systems. This unit handles larger EPROM sizes, has internal battery power for downloads, and has easier configuration.

DPR0M 2 uses a microprocessor and RAM to simulate the operation of an EPROM in a target system. The unit uses a cable terminated in a DIP connector to connect to the target. An RS-232 connection transfers ROM code from a standard serial port. Because this emulator stores the ROM code in RAM, it allows changes to the code and overwrites of previous versions by downloading the revised file rather than burning EPROMS to test code revisions.

A single DRPOM 2 can emulate any 2732-27010 EPROM in an 8-bit system. Additional units may be daisy chained to fill multiple EPROM spaces, to provide emulation in systems with 16 or 32-bit buses, or to emulate a 27020 EPROM.

DPR0M 2 has a NiCd battery to supply power during downloads, so connecting the unit to the target system during file transfer is unnecessary. The internal battery also backs up the memory contents. DPR0M 2 operating parameters, such as baud rate and EPROM type, are easily set by means of a rotary switch and a push button.

This emulator can receive file transfers at 9600, 19.2k, 38.4k, and 57.6k baud rates. It accepts files in Intel hex, Motorola S, and binary formats.

DPR0M 2 is offered in four separate models. DP-64 with 64K of internal memory, which emulates EPROMs up to 27512. DP 128 with 128K of memory emulates smaller EPROMs as well as the 27010 and, when used in pairs, the 27020. Both models provide access time of 150 ns at the EPROM socket. The DP-64FM and DP-128FM models have the same capabilities, but offer access times of 100 ns at the EPROM socket.

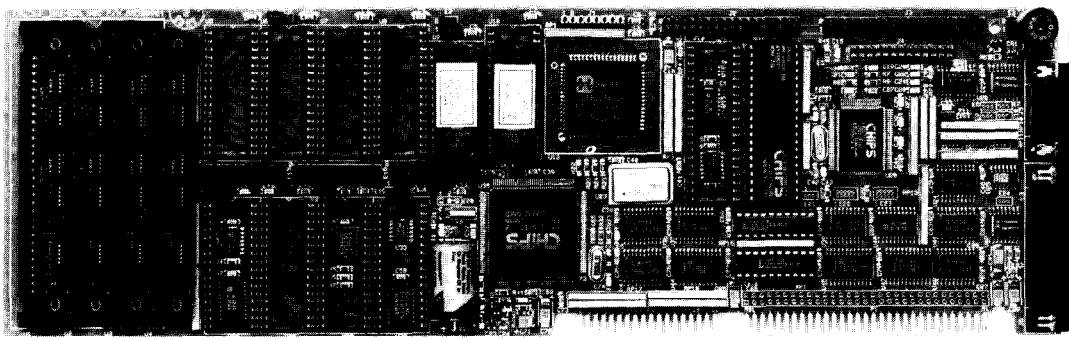
The cost of DPR0M 2 ranges between \$125 and \$250, with a thirtyday money-back guarantee.

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SINGLE-BOARD COMPUTER FOR EMBEDDED APPLICATIONS

IND-286 is a single-board computer for embedded systems applications with stand-alone diskless operation from Micro Computer Specialists Inc. It is a fully equipped 80C286 16-MHz, zero wait state, PC/AT-compatible computer on a standard size XT-type, plug-in board, specifically designed for backplane applications. IND-286 features ROM-DOS, a ROM-based, MS-DOS 3.3 compatible operating system that requires less memory and provides faster operation than MS-DOS.

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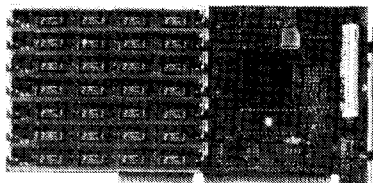
Additional features include up to 4 megabytes of DRAM, two RS-232 serial ports, a parallel printer port, a PC/AT-compatible keyboard port, a dual speed floppy-disk port, an IDE hard-disk port, a clock/calendar, and a socket for an optional 80C287 coprocessor. An embedded BIOS setup utility is included for system configuration and setting the

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The price of the IND-286 computer is \$795.

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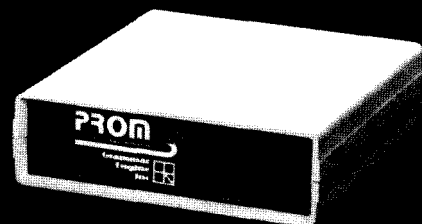
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NEWPRODUCTNEWS NEWPRODUCTNEWS

COMPUTER TO VIDEO CONNECTION

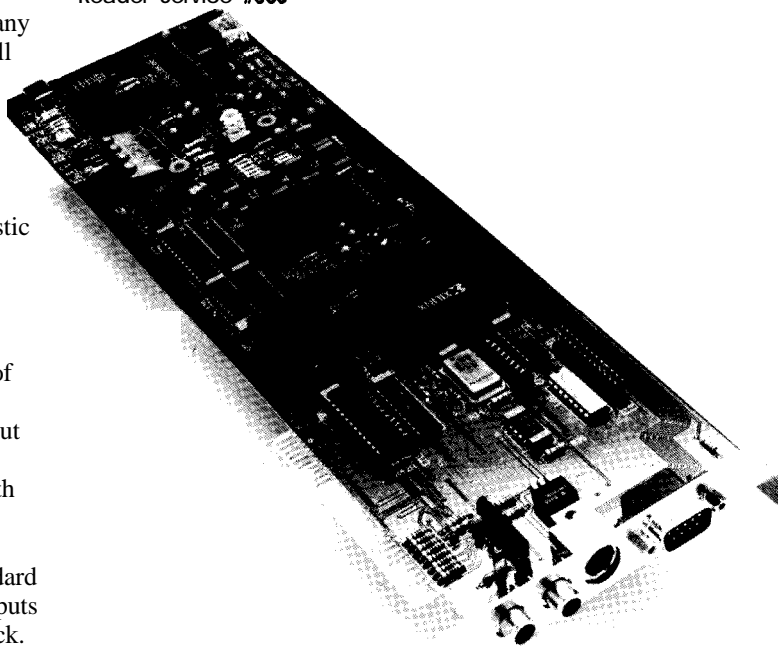
IEV International Inc. has released its **VGA Broadcaster Board**, which allows you to take what you create on a computer screen and record it on a VCR, display it on a TV, or project it with a video projector. The board connects to an existing VGA card feature connector and does not require any software reconfiguration or performance loss. It supports all standard VGA, EGA, CGA, and MCGA modes, and all extended VGA modes up to 768 x 480 x 256 colors. A

The optional EDSUN Continuous Edge Graphics chip provides antialias operation for smoother edges, decreased "jaggies," and increased effective resolution for smooth images. With EDSUN, over 700,000 colors bring photorealistic capabilities to your output. Add-on software programs are available for animation, titles, and chalkboard. The Broadcaster is compatible with most software programs.

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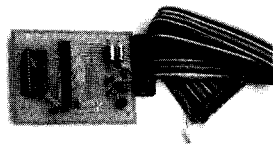
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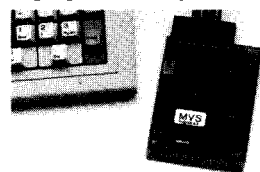
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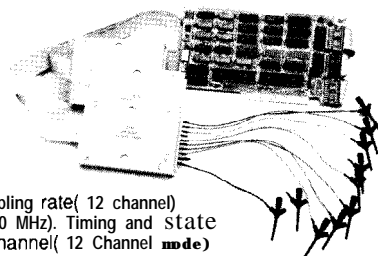
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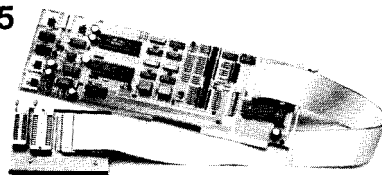


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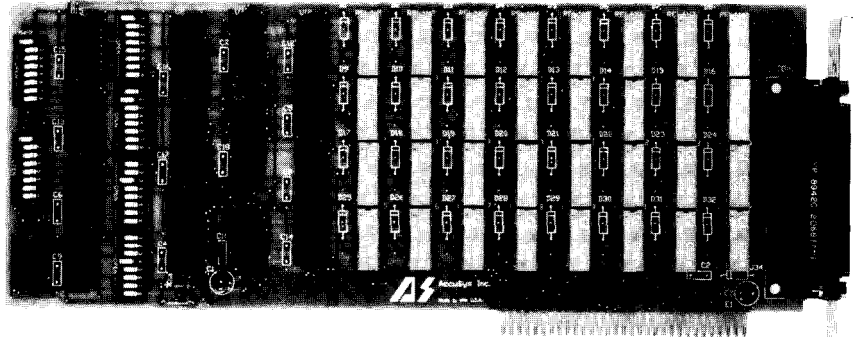
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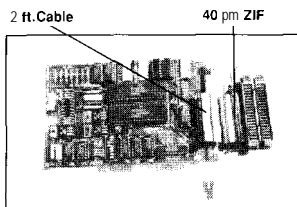
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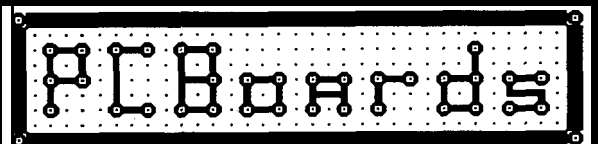
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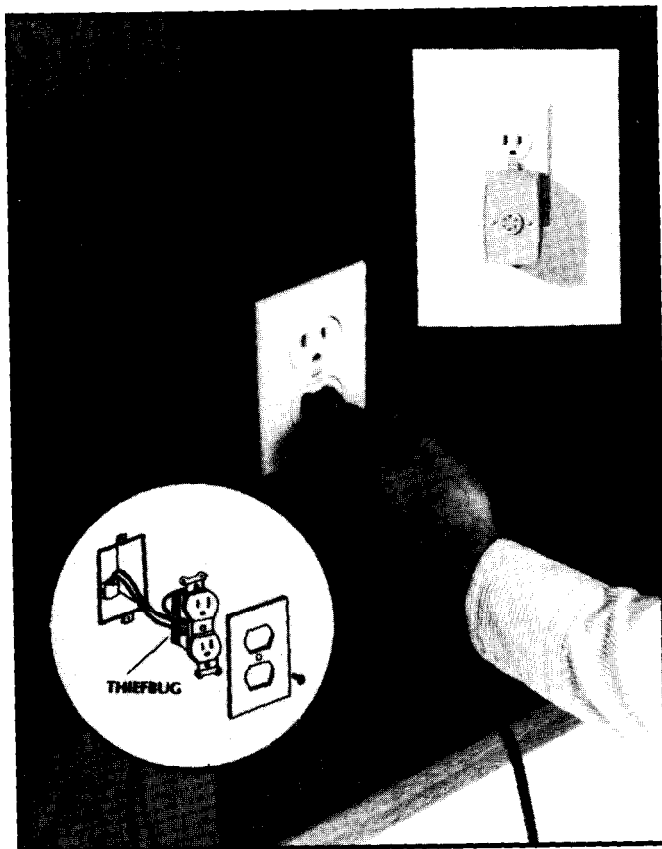
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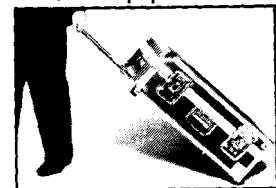
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High-Resolution Timing
on a PC

Three-Dimensional Graphics by Computer

Computer-Generated *Anaglyphs*

Light: the miraculous carrier that transports colorful boundless information into our minds as we probe the world around us through a most remarkable pair of biological optoisolators. With this built-in real world interface, the most glamorous element of the PC is its ever-improving video display.

In this article, I will describe a way to graphically simulate the depth of our real world on your PC's two-dimensional screen, using the color and resolution features of your video system. Because I am mocking part of the human visual process, I will look at it briefly. Most quantities that pertain to the human eye are approximations determined by formulas, definitions, and references. Although most calculations do not involve exact numbers, the results agree closely enough to be consistent with the principles applied in this article. Also, I'll describe what could become the basis of some very peculiar graphics applications, the number of which seems almost limitless.

You are able to see depth because each eye "sees" your world from a slightly different viewpoint and calculates the distances of objects using mental triangulation, a process more commonly known as depth perception. While these actions could be simulated with a computer in several ways, I will use a fun method: the old "red and blue 3-D glasses" or anaglyphic technique prevalent (albeit rarely) in specially filmed movies. Successfully incorporating this process to the PC requires the definition and plotting of two distinct, mathematically superimposed, color-

coded perspective views of a scene. The colored eyeglasses separate the superimposed images and direct a particular image to the correct eye. This method seems realistic because it influences the brain to encode (in plotting), and subsequently decode (in viewing), the image in a manner that causes the eyes to refocus when shifting from a nearer to a farther part of the image, or vice versa. Compare this focusing sensation when you view the anaglyphs with that of standard "flat 3-D" computer images.

I chose the anaglyphic method because it produces beautiful images of strikingly realistic depth, and all you need are a couple pieces of inexpensive, colored plastic and your VGA. You can even program the colors to your taste or to whatever filter constructs you have lying around. Don't be discouraged by the quality of the 3-D movies you've seen. The computer-generated anaglyphs look much better. In fact, when you view the anaglyph, the depth is realistic enough that the image looks unrelated to the screen.

Fortunately, we're in the era of the low-cost high-powered VGA-based color video standards. When I started work on this project a few months ago, a standard VGA with sixteen colors at 640 x 480 pixel (pel) resolution had the highest quality per cost ratio for applications needing high-quality color graphics. Now the modes supporting any 256 of 256K colors at 1024 x 768 pel resolution are the best-and for the same or lower cost than the previous VGA standard. These high-color, high-resolution video modes open up a whole new

world of image synthesis possibilities. At this rate of improvement, I can't help but wonder what the next video breakthrough will bring.

COLOR AND RESOLUTION: WHAT'S IDEAL?

Now 1024 x 768 at 256 colors sounds great, and if you're familiar with the photographic quality obtainable with this super VGA graphics, you may wonder if improving the image quality further would result in significant improvement.

Consider aspects like pel density, which takes into account display size as well as pel resolution, when determining how much computer resolution the eye can resolve. For example, if you take a 10" x 7.5", 1024 x 768 graphic image and blow it up to the size of a giant TV screen, the image acquires a very grainy appearance. Although the resolution remains unchanged, the pel density lowers and the (local) image goes from high quality to poor quality. This change in appearance is important because of the great size differential between the PC screen and the minuscule retinal area of the human eye perceiving the significant visual information.

Let me compare the high-resolution graphics screen and the human eye, in terms of those resolution and color characteristics generated by the PC and generated by the eye. Very (very) loosely speaking, you "see" or perceive an image that is focused onto the retina by the lens of the eye. This optical information is "picked up" at the retinal surface by millions of receptor cells, which are connected by

nerve fibers to the brain through the optic nerve. A portion of this image is focused onto the **fovea**, a tiny active central area of the retina. The information striking the fovea is responsible for sharp image perception, such as in reading and in concentrating on fine detail. The larger area outside the fovea is also light sensitive, but its role is mostly limited to peripheral vision.

packed cone cells. Around the edge of the fovea, the cones become less packed and the rods more plentiful. This distribution explains why peripheral vision is better at night. In fact, directly viewing an object in low light is difficult because you focus on it with your fovea, which is relatively insensitive in low light. Strange as this fact may seem, focusing slightly away from an object brings the image

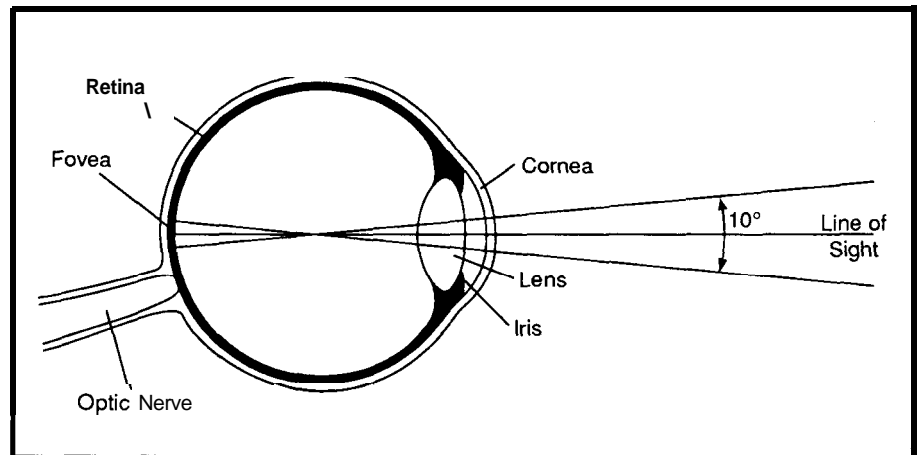


Figure 1 -The fovea area is approximately the retinal area illuminated by a 10° funnel of light directly entering, and crossing at the center of the eye.

The key to this dual vision system is the two types of receptor cells lining the retina: canes and (smaller) **rods**, named according to their respective shape. Cones are primarily sensitive to bright light and are responsible for distinguishing colors. Rods cannot distinguish colors, but are more sensitive to light intensities, and are primarily active for night or low-light vision. This distribution of abilities is why colors are difficult to see in low light levels.

The fovea consists of a somewhat circular arrangement of tightly

information onto the rod cells for a better look under low-light conditions.

Obviously, the area of interest concerning my applications the most is the fovea. Therefore, I will concentrate on this small retinal region. Let me start by calculating its surface area, which is often defined in terms of funnel-shaped fields of vision entering the eye. As Figure 1 shows in cross section, the central field of vision is defined as the funnel-shaped volume of space bounded by a 10° arc emanating from the center (focal

point) of the sphere (eye) through the lens. Given the radius of the eye as 12.5 mm, I calculate the illuminated fovea area to be approximately 3.7 mm². In terms of resolution quantity, think of the fovea as a tiny PC screen only 1.9 mm². The fovea surface area has been approximated as slightly larger than a pinhead.

Now that you know the approximate retinal "screen size," let me describe resolution. The biological analogue of the pel is a retinal cone cell. The cone size (diameter) is also calculated as an arc similar to the fovea area calculation, but with a much smaller angle: 1/2 minute (0.00833"). The cone has a diameter of approximately 0.0032 mm and an area of about 0.00001 mm². Therefore, the corresponding pel density is approximately 300 pels/mm. For a 10" x 7.5", 1024 x 768 resolution VGA monitor, the pel density is about 4 pels/mm, not even close to that of the eye. Makes the eye look good doesn't it? But now let me calculate the actual number of pels involved in each device: for the fovea I get 600 x 600 = 360,000 pels. For the VGA screen 1024 x 768 = 786,432 pels, more than twice as many as the eye. Now are you relatively impressed by the VGA? Don't let the illusion fool you; examine all the angles and you will find the eye wins hands down!

You can easily determine if a graphical image could be made of a higher quality (or not) given viewer conditions. For example, suppose you want to view a 1024-pel, 10-inch VGA line at full eye resolution (300 pels/mm). Give the problem a little thought: the individual pels become more evident if you are closer to the

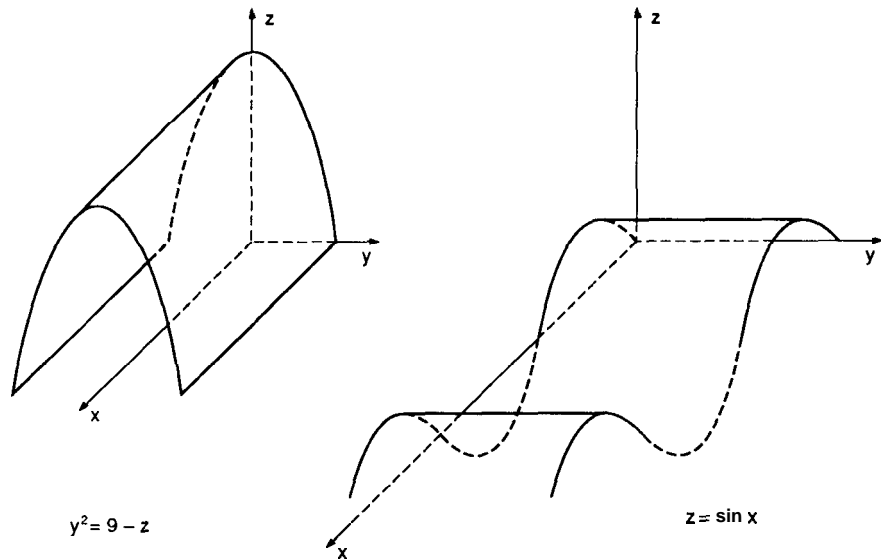


Figure 2—Typical projections for causal viewing of three-dimensional surfaces.

screen and are obvious if you view them through a magnifier. Therefore, you must do the opposite: decrease the image size (without removing any pels) or move the image farther away to eliminate redundancy in the viewed image with respect to the resolution elements of the eye. Refer to the simple geometry depicted in Figure 1 and you'll see the line should be placed at a viewing distance of about 367 feet! This distance is the minimum the 10-inch line can be positioned from the eye while remaining in the 10-inch fovea arc. You are in no danger of exceeding your eye resolution while viewing even the most impressive super VGA graphics images.

While describing the resolution element of the eye as the size of three cones instead of one may be advantageous due to the three color types (red, green, and blue), given its high resolution, even this 300% resolution

reduction is insignificant. Conversely, the pel density may actually be somewhat larger because the cones are compressed to about rod diameter in the fovea.

ENCODING DEPTH ON THE SCREEN

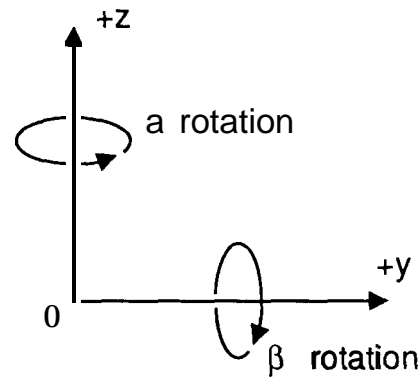
Although the common PC has come a long way in display technology, it still lacks the characteristic most responsible for making the actual visual world around us realistic—depth.

To realistically simulate three-dimensional images using a less-than-ideal two-dimensional PC monitor, you must employ graphical projection techniques that take into account the nature of the image, the circumstances under which the viewer will observe the simulation, and the sensing characteristics of the viewing apparatus itself. In this case, as in most cases, the viewing apparatus will be a set of human eyes. The projection technique is anaglyphic as described earlier.

I chose rotated three-dimensional mathematical surfaces as the subjects of my original computer-generated anaglyphs. Many people would claim these are the most difficult to manipulate, but I feel the results are worth all the work.

The first step is to choose a suitable coordinate system. I chose a stan-

Figure 3—Initially, the (unrotated) x-axis is perpendicular to the screen. The origin (0) projection always remains (pivots) at the center of the screen. The α rotation (rotation about the z-axis) moves from the initial +x position toward the initial +y position. The β rotation (rotation about the y-axis) moves from the initial +z position toward the initial +x position. Negative rotations are simply 'evened'.



standard right-handed rectangular Cartesian coordinate system, consisting of three mutually perpendicular axes labeled x, y, and z. Figure 2 shows a typical system as represented by calculus and solid analytic geometry texts. While they are good for illustrative purposes, if a precisely true perspective is needed, these text illustrations won't suffice because they do have an inherent flaw. Note if the yz-plane is projected perpendicularly onto the page (as is the case), then the true x-axis should be perpendicular to the page and should have no projection. Because I need a mathematically accurate image definition, my projection technique cannot tolerate distortion. Also, the image must be rotatable if it is to be realistic as well as practical. Consider the plot of the top half of a sphere—a parachute shape. My view would be only a two-dimensional half circle if I plotted this surface with no rotation or tilting.

I also must have a method to realistically model a computer-generated surface form for my anaglyphs. Plotting all the pels making up the figure simply results in a solid half-circle with no clue of depth. I choose to use the “wire-frame” surface that represents the surface as a series of two sets of disjointed two-dimensional “slices” of the surface. One set is parallel to the x-axis and the other set is parallel to the y-axis, giving the surface a nice “netted” appearance.

My next step is to devise a method that accurately draws a set of rotated three-dimensional xyz-axes on the screen. This drawing is not just a parallel projection of the axes onto the screen, but an actual perspective projection given an actual viewing (eye) position.

Figure 3 shows the initial unrotated position of the axes. Note the origin is in the center of the screen with the initial position of the axes as follows: +y is to the right, +z is up, and +x is perpendicularly out of screen. I will define two rotation angles: The first, alpha (a), is a clockwise rotation about the z-axis. Clockwise about the z-axis is defined as a rigid rotation about the z-axis such that the initial +x-axis rotates toward

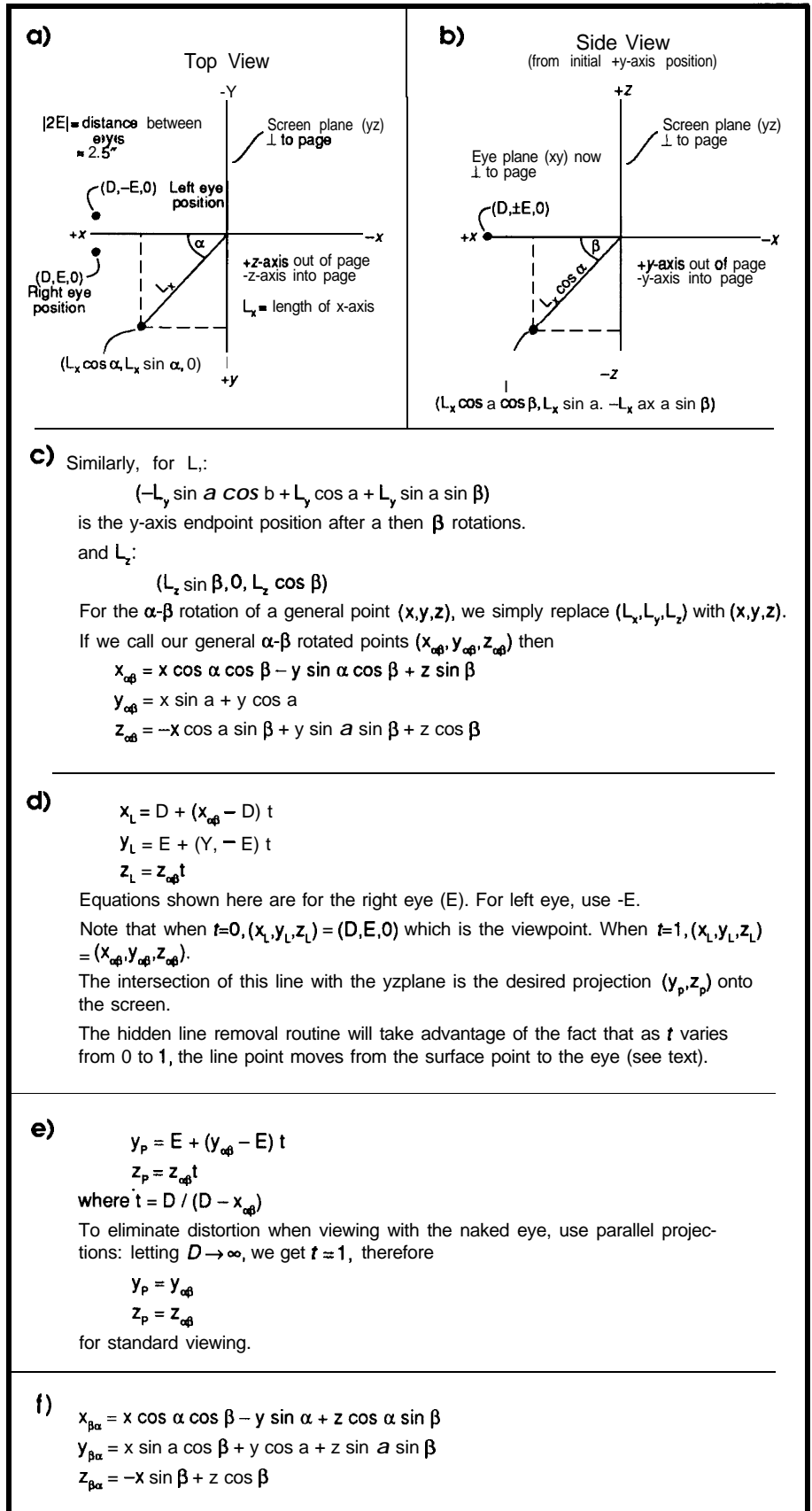


Figure 4—(a) The x-axis endpoint position after a rotation. (b) The x-axis endpoint position after α then rotation. (c) The formula for α - β rotated position (x_{0b}, y_{0b}, z_{0b}) of (x, y, z) . (d) The parametric equations (parameter t) of a space line through viewpoint $(D, E, 0)$ and rotated point (x_{0b}, y_{0b}, z_{0b}) . (e) The intersection of the viewline (x_L, y_L, z_L) with the screen (yz plane) is plotted as (y_p, z_p) . This gives the required perspective projection for the anaglyphic images. (f) The formula to rotate (x, y, z) in a β then α sequence. This formula undoes α - β rotation.

the initial +y-axis position. Negative rotations simply turn in the opposite direction. The α rotation allows you to look around the surface if you wish to picture one in this coordinate system. This rotation simulates walking around the object and is much like a "turn." The second rotation, beta (β), is a rotation about the initial y-axis position in which a positive rotation moves the initial +z-axis position toward the initial +x-axis position. As before, a negative rotation is a rotation in the opposite direction. This β rotation lets you "tilt" the surface. A + β rotation results in a downward tilting, letting you look at the top side of the surface. You can peek under it with $-\beta$ rotation. Thus, with α - β rota-

tions you can view a surface defined in this coordinate space from virtually any position.

FORMULA DERIVATION

In the formula derivation process, I first derive a simple set of equations that, given an α rotation, a β rotation, and a viewpoint, simply calculates the endpoints of the three coordinate axes. I calculate and plot the intersection of the line through the viewpoint (eye) and the axis endpoint with the yz-plane because I want the perspective projection onto the yz-plane. The origin is always fixed at the screen center and is independent of rotation. Therefore, I simply draw straight lines

REM AXES PROJECTION—640x480x16

```
*****
REM 3D-AXES PROJECTION RED/GREEN/BLUE=X/Y/Z AXES
REM NEGATIVE AXES ARE DOTTED
REM ORIGIN (0,0,0) IS CENTER OF SCREEN
REM +Y IS TO RIGHT +Z IS UP +X IS OUT OF SCREEN
*****
```

```
CLS : PI = 3.1416: SCALE = 480 / 640: AXESLEN = 75
INPUT "Alpha rotation "; A
INPUT "Beta rotation "; B
INPUT "Viewing distance "; D
INPUT "1/2 eye separation "; E
```

```
A = A * PI / 180: B = B * PI / 180: C = C * PI / 180 'DEG TO RAD
SCREEN 12
WINDOW (-100, -100)-(100, 100)
```

```
COLOR 4: LOCATE 26, 16: PRINT "X=RED"
X = AXESLEN: Y = 0: Z = 0
GOSUB 100
IF XAB < 0 THEN STYL = &HF0F0 ELSE STYL = &HFFFF
LINE (0, 0)-(YP, ZP), , , STYL
X = -50
```

```
COLOR 2: LOCATE 26, 36: PRINT "Y=GREEN"
X = 0: Y = AXESLEN: Z = 0
GOSUB 100
IF XAB < 0 THEN STYL = &HF0F0 ELSE STYL = &HFFFF
LINE (0, 0)-(YP, ZP), , , STYL
```

```
COLOR 1: LOCATE 26, 60: PRINT "Z=BLUE"
X = 0: Y = 0: Z = AXESLEN
GOSUB 100
IF XAB < 0 THEN STYL = &HF0F0 ELSE STYL = &HFFFF
LINE (0, 0)-(YP, ZP), , , STYL
```

```
COLOR 5: LOCATE 27, 25: PRINT "Broken lines are into screen"
DO: LOOP WHILE INKEY$ = ""
COLOR 7
END
```

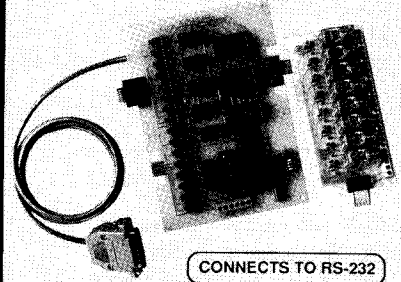
```
100 XAB = X * COS(A) * COS(B) - Y * SIN(A) * COS(B) + Z * SIN(B)
YAB = (X * SIN(A) + Y * COS(A))
ZAB = -X * COS(A) * SIN(B) + Y * SIN(A) * SIN(B) + Z * COS(B)
T = D / (D - XAB)
YP = SCALE * (E + (YAB - E) * T)
ZP = ZAB * T
```

```
RETURN
END
```

Listing 1—This program draws equal length x-, y-, and z-axes in red, green, and blue given an α rotation, a β rotation, half the distance between the eyes (E), and viewing distance (D).

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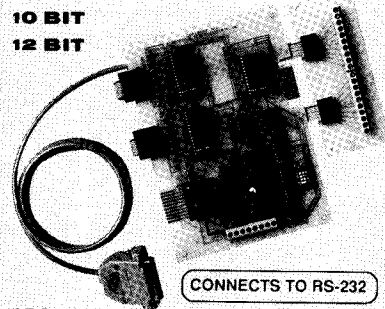


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E = half eye separation
 D = viewing distance
 A = α rotation
 B = β rotation
 XI = lower x boundary
 XF = upper x boundary
 DX = separation of x slices
 YI = lower y boundary
 YF = upper y boundary
 DY = separation of y slices

AMP = amplitude of splash
 DEC = decay of splash
 FREQ = frequency of splash

Figure 5—You should use the parameters described here as a starting point. Feel free to experiment to achieve different results.

(A and B units are degrees, all others are pixels)

For a quick cross-section view of an unrotated curve, try something like:

E,D,A,B,XI,XF,DX,YI,YF,DY = 0,9999,0,0,0,1,1,-300,300,3

A good starting reference for AMP, DEC, and FREQ is 200, 0.00002, 0.025

For a clean closed surface, XI and XF should be divisible by DX and YI and YF should be divisible by DY.

A math coprocessor is almost a must when experimenting with full surfaces.

```

REM SURFACE OF REVOLUTION (MATH SPLASH) ----- 1024x768
'$INCLUDE: 'gplib.bas'
'$INCLUDE: 'grrlib.bas'
retcode% = gxSetDisplay%(gxTS.38)
retcode% = gxSetMode%(gxTEXT)
PI = 3.1416
INPUT "E,D,A,B,XI,XF,DX,YI,YF,DY "; E, D, A, B, XI, XF, DX,
  YI, YF, DY
INPUT "Amp, Dec, Freq "; Amp, Dec, Freq
A = PI * A / 180: B = PI * B / 180
COsa = COS(A): COsb = COS(B): SINA = SIN(A): SINb = SIN(B)
COsaCOsb = COS(A) * COS(B): SINAcosb = SIN(A) * COS(B)
COsaSINb = COS(A) * SIN(B): SINaSINb = SIN(A) * SIN(B)

retcode% = gxSetMode%(gxGRAPHICS)
retcode% = grSetViewPort%(0, 0, 1023, 767)
retcode% = grSetViewWorld%(-511, -383, 511, 383)
retcode% = grSetWorld%(gxTRUE)
retcode% = grClearViewPort%

FOR mesh = 1 TO 2
FOR x = XI TO XF STEP DX
XSQ = x * x
FOR y = YI TO YF STEP DY
YSQ = y * y: XSQYSQ = XSQ + YSQ

Z1 = Amp * EXP(-(Dec * (XSQYSQ)))
Z2 = COS(Freq * SQR(XSQYSQ))
Z = Z1 * Z2

XAB = x * COsaCOsb - y * SINAcosb + Z * SINb
YAB = x * SINA + y * COsa
ZAB = -x * COsaSINb + y * SINaSINb + Z * COsb

TL = D / (D - XAB)
YP = CINT(E + ((YAB - E) * TL))
ZP = CINT(ZAB * TL)

retcode% = grPutPixel%(YP, ZP, grRED)
NEXT y
NEXT x
SWAP DX, DY
NEXT mesh
DO: LOOP WHILE INKEY$ = ""

```

Listing 2—Before creating a complete anaglyph, it is useful to experiment with different parameters. This program displays a solid surface given the parameters described in Figure 5.

from the center of the screen to each of the three projected axes endpoints (connecting two projected points gives the projected line), and I then have a perspective projection of the rotated coordinate system from only three plotted points. The beauty of this method is I have the complete rotation transformation equations for plotting any point with no more effort than drawing the axes if I let the endpoints of the coordinate axes be variable—sweet and simple.

Consider how a point is plotted in three-dimensional space: go along the x-axis to the desired value of x, then along the y-axis for the value of y, similarly for the z-axis, and then plot this final position. For example, to plot the projection of the point (3,1,2), calculate the two-dimensional (horizontal and vertical) projections onto the yz-plane of the, possibly rotated, points (3,0,0), (0,1,0), and (0,0,2). Then the final horizontal and vertical coordinates of the projection are the sum of the horizontal components of the three points and the sum of the vertical projections of the three points, respectively. To illustrate, suppose the two-dimensional yz-plane projection coordinates of (3,0,0), (0,1,0), and (0,0,2) are (y_1, z_1) , (y_2, z_2) , and (y_3, z_3) , respectively. Then the desired projection of (3,1,2) onto the screen is $(y_1+y_2+y_3, z_1+z_2+z_3)$. I find doing all my own derivations is much easier because the formulas used for my particular (and sometimes general) applications have no gray areas and they always work. In Figure 4, I detail the derivation with sketches and equations.

Listing 1 draws equal length x-, y-, and z-axes in red, green, and blue, respectively, given an α rotation, a β rotation, half the distance between the eyes (E), and a viewing distance (D). [Editor's Note: Software for this article is available from the Circuit Cellar BBS and on Software On Disk #24. See page 105 for downloading and ordering information.] Any axis that rotates behind the screen is dotted to ensure I see the correct perspective, eliminating the into or out of screen confusion that can occur with naked-eye viewing. Of course, if I pay attention to

my angle input I would know where everything should be and avoid any confusion. Run the program in Listing 1 with various A and B inputs (in degrees) until you fully understand the rotations. Be sure to do some negative rotations. For these trial runs, use $E = 0$ and a large value for the viewing distance, $D = 99999$ for example. A large viewing distance simulates a parallel projection, which is more desirable in the nonanaglyphic case. Setting E to zero simply places the viewpoint on the initial x -axis line giving a straight-ahead view. Note all units are in pels. An example of a pel density calculation may be helpful: for a 640×480 , $10'' \times 7.5''$ VGA screen you have 64 (640/10 or 480/7.5) pels/inch. A horizontal or a vertical scale factor may be used to equalize these two ratios if they are unequal on your screen. As I will explain later, using units of pixels in the drawings greatly simplifies some sticky points encountered in hidden-line removal procedures.

I am now in a good position to illustrate the difference between parallel and perspective projections using Listing 1. Parallel projection can be simulated by assigning a large viewing distance (D), which gives uniform image projections over the entire screen. For a smaller value of D you get a close-up view magnifying the nearer parts of the surface. This value can give a distorted appearance if the image is viewed with the naked eye. Try various viewing distances using a pel density of 64 per inch. Thus, for a viewing distance of 24 inches use a value of $E = 1536$. Notice what happens as D gets very near or even falls inside the axes space. You can even use negative D values that try to view the image from behind. Eye separation is typically 2.5 inches, so the standard value of E is 80 (1.25 inches). A **nonzero** value used for E moves the viewpoint off of the x -axis (it never moves out of the xy -plane). After this movement, the projected image corresponds to the viewpoint at E . Try various values of E , in conjunction with D if desired, until you fully understand its significance (don't forget the negative values).

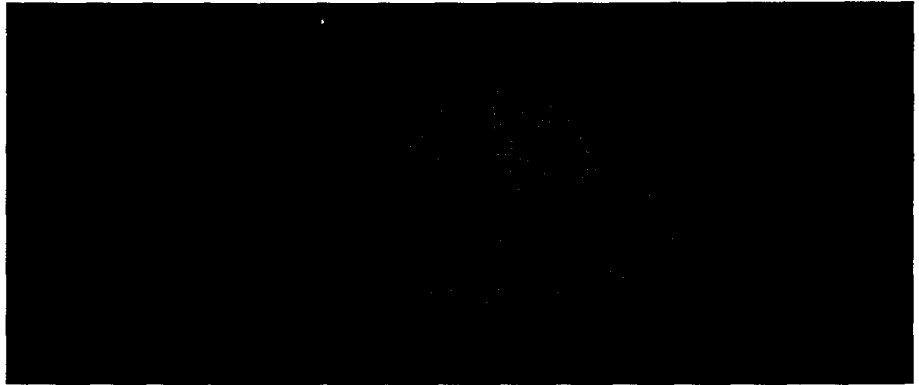


Photo 1 --The resulting display when the program in Listing 2 is run with the parameters in Figure 5.

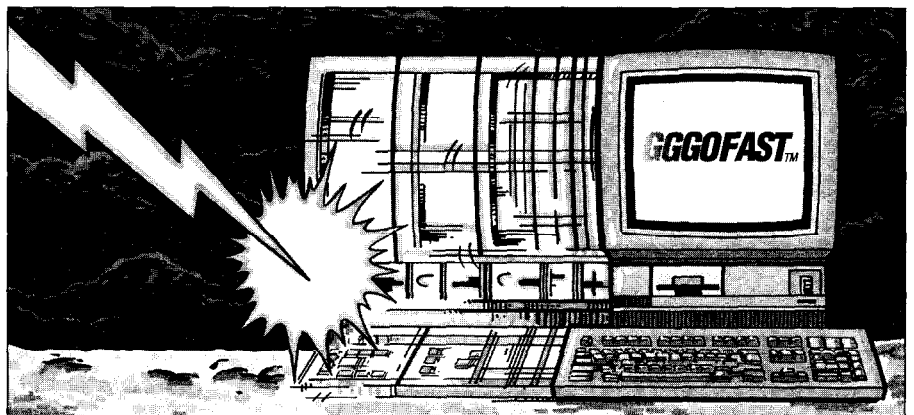
Note also when E is **nonzero** the projected z -axis now becomes tilted, which is impossible through simple α - β rotations. These features indicate the power of this little program. Using two values of E (± 80) provides the two viewpoints of each eye in anaglyphic images; therefore, two separate (color-coded) images of the anaglyph are drawn.

A more mathematical way of getting parallel projections is with limits. Simply take the limit of the perspective projections as D approaches

infinity and out pops the exact parallel projection formulas ideal for undistorted viewing of **nonanaglyphic** images.

PLOTTING THREE-DIMENSIONAL MATHEMATICAL SURFACES

To illustrate this process and a couple of tricks involved, I'll make an interesting figure: the famous water-splash surface. Because I can't just guess at the equations that become great surfaces, I'll begin by defining a



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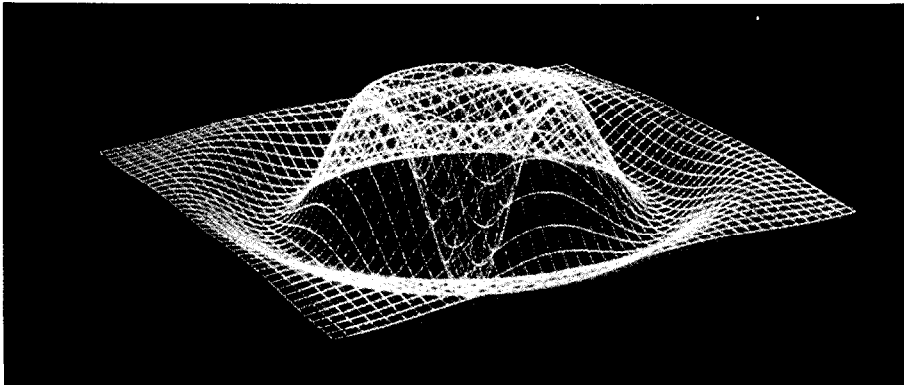


Photo 2—When the program in Listing 3 is run, this anaglyph is the result.

two-dimensional surface and revolve or spin it about the z-axis, then I'll plot the rotated wire-frame model of the resulting "solid of revolution."

These actions may sound a little difficult but they're not. I begin with a preview of the final surface. the two-dimensional curve that when re-

volved produces the desired surface using a cosine wave with an exponentially decaying amplitude. Figure 5 shows how this curve is created. If you use this method, getting nice expected images on the screen on the first try at a new surface becomes a snap. Otherwise, unless you know exactly what the equations will do and have a suitable scale, you will probably end up with a lonely pel or two plotted on the screen for your "finished image." Use Listing 2 to experiment with the parameters described in Figure 5 until you get a desirable preview.

I now have a nice flat curve, but how do I get a formula for the three-dimensional surface of revolution for a given two-dimensional curve? Simplicity itself. Starting with a standard two-dimensional function

$$y = f(x)$$

replace x with

$$\sqrt{x^2 + y^2}$$

and replace y with z . That's all there is to it! You end up with

$$z = f(\sqrt{x^2 + y^2})$$

Now plug in the desired rotation angles and surface parameters and plot the wire-frame model. The resulting screen image is shown in Photo 1.

TRANSPARENT ANAGLYPHS

Now I'll construct an anaglyphic image of the water splash of Photo 1. I input the desired rotation and surface parameters and watch the anaglyph as it is drawn on the screen, executing Listing 3. The red wire-frame image is drawn first, followed by the blue one. If you look at a real-life three-dimensional surface with your left eye open and your right eye closed, then vice versa, you will see this image shift. You will see the same effect if you view the anaglyph through the filters and open your left eye and your right eye closed, then vice versa. Of course, in addition to

```

REM TRANSPARENT ANAGLYPH-----1024x768
'$INCLUDE: 'gplib.bas'
'$INCLUDE: 'grlib.bas'
RETCODE% = gxSetDisplay%(gxTS.38)
RETCODE% = gxSetMode%(gxTEXT)
PI = 3.1416
INPUT "E,D,A,B,XI,XF,DX,YI,YF,DY "; E, D, A, B, XI, XF, DX, YI, YF, DY
INPUT "Amp, Dec, Freq "; TI, U, V
A = PI * A / 180: B = PI * B / 180
cosa = COS(A): cosb = COS(B): sina = SIN(A) : sinb = SIN(B)
RETCODE% = gxSetMode%(gxGRAPHICS)
RETCODE% = grSetViewPort%(0, 0, 1023, 767)
RETCODE% = grSetViewWorld%(-511, -383, 511, 383)
RETCODE% = grSetWorld%(gxTRUE)
RETCODE% = grClearViewPort%

FOR image = 1 TO 2
FOR mesh = 1 TO 2
FOR X = XI TO XF STEP DX: XSQ = X * X
FOR Y = YI TO YF STEP DY: YSQ = Y * Y

Z1 = TI * (EXP(-(U * ((XSQ) + (YSQ))))))
Z2 = COS(V * (SQR((XSQ) + (YSQ))))
Z = Z1 * Z2

XAB = X * cosa * cosb - Y * sina * cosb + Z * sinb
YAB = X * sina + Y * cosa
ZAB = -X * cosa * sinb + Y * sina * sinb + Z * cosb

TL = D / (D - XAB)
YP = CINT(E + ((YAB - E) * TL))
ZP = CINT(ZAB * TL)

pcolor% = grGetPixel(YP, ZP)
IF image = 1 THEN
RETCODE% = grPutPixel%(YP, ZP, grRED)
ELSEIF image = 2 AND (pcolor% = grRED OR pcolor% = grMAGENTA) THEN
RETCODE% = grPutPixel%(YP, ZP, grMAGENTA)
ELSE
RETCODE% = grPutPixel%(YP, ZP, grBLUE)
END IF

NEXT Y, X
SWAP DX, DY
NEXT mesh
E = -E
NEXT image
BEEP
DO: LOOP WHILE INKEY$ = ""
RETCODE% = gxSetMode%(gxTEXT)
END

```

listing J—Adding a bit of extra code to Listing 2 results in a pair of surfaces, one intended for each eye.

appearing repositioned for each eye, the images change colors.

Notice the drawings have many points where the blue intersects the red pels; these points should be transmitted to both eyes. Therefore, you must not overwrite the red pel with a blue one plotted later because critical right-eye information would be deleted. Simply plot a red and blue position with magenta (color red + blue). This way the pel information passes through both color filters and reaches both the left and right retinas.

While very few people have trouble seeing the three-dimensional effect, keep in mind a large part of the illusion depends upon your attitude. Although your brain knows there is no actual three-dimensional surface present, the anaglyphic coding usually overcomes this knowledge. You should see a magenta surface straddling the screen with no apparent relation to the glass surface when the two images are properly merged. Notice you focus and refocus your eyes when glancing at parts of the surface with different depths.

REMOVING HIDDEN SURFACE POINTS

Notice in the anaglyph that the hidden lines, the ones that in the real world would be blocked from your view by the surface area between your eyes and the point in question, are all plotted. Unfortunately, the equation of the surface knows of nothing but the set of all points making up the surface. Creating an algorithm to perform this task is left to you, something that perhaps has the reputation of being "a royal pain," especially when mathematical surfaces are involved. I investigated several known methods and none of them appealed to me, so I set out to try it myself (with a mental note to prepare "to bail out and settle for what's available"). Although the analysis and solution of this problem consumed by far the greatest effort in this entire project, I got lucky and found a hidden line removal method that works for a mathematical surface of any rotation, executes fast, requires no buff-

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ers, and is short and simple (the BASIC listing of the general procedure fits on a single screen).

A hidden-surface removal procedure can be either very simple or very complex, depending upon how you break down the problem and how each step of the procedure is solved. I've also found I have to try to form a mental block towards any known procedures when attempting to create a new one. This mindset helps promote design originality. Of course, you should use any known procedures that are satisfactory.

My procedure begins as follows: consider a surface point hidden if a line drawn from the point in question to the viewpoint intersects the surface elsewhere. Note in a wire-frame model a completely unplotted area can block the view of a point. In other words, treat the region bounded by a netted square as an opaque surface even though none of it is plotted. Thus, it appears as though you will be required to define every point, not just the netted regions, of the surface equation. But I found a slick way around this problem. As you plot the (rotated) surface, use only a subset of the entire surface in creating a wire-mesh model. Identify any hidden points by testing each point of the wire-frame model as it is drawn. The test is made by defining a space line with endpoints of the current surface point and the viewpoint. If you can move along the line from the viewpoint to the surface point without intersecting the surface elsewhere, then the point at the end of the line is visible; if you intersect the surface en route, then the point is hidden and should not be plotted.

Careful consideration of this procedure as applies to a computer program should make obvious a serious obstacle: the digital computer must find the precise intersection of a line with any part of a rotated surface. Therefore, every resolution element of the unbroken line must be tested. As a further complication, the surface has no particular relationship to the line points. Even if you test for values within a 0.001 unit error you would miss a surface-line intersection



Photo 3—The display generated by the program in Listing 4.

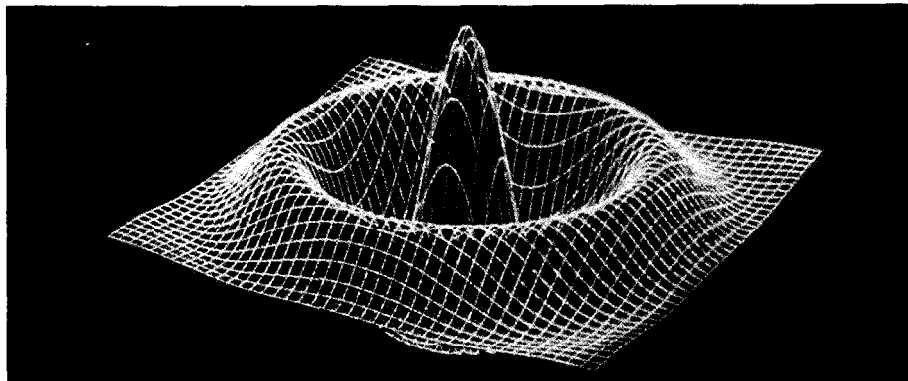


Photo 4—The final anaglyph with hidden lines removed as generated by Listing 5 should be viewed with red/blue glasses.

```

REM SURFACE (HIDDEN LINES REMOVED)-----1024x768
'$INCLUDE: 'gxlib.bas'
'$INCLUDE: 'grlib.bas'
retcode% = gxSetDisplay%(gxTS.38)
retcode% = gxSetMode%(gxTEXT)
PI = 3.1416: OOB = 0
INPUT "E, D, A, B, XI, XF, DX, YI, YF, DY "; E, D, A, B, XI, XF, DX, YI,
      YF, DY
INPUT "Amp, Dec, Freq "; TI, U, V
A = PI * A / 180: B = PI * B / 180
cosa = COS(A): cosb = COS(B): sina = SIN(A): sinb = SIN(B)
retcode% = gxSetMode%(gxGRAPHICS)
retcode% = grSetViewPort%(0, 0, 1023, 767)
retcode% = grSetViewWorld%(-511, -383, 511, 383)
retcode% = grSetWorld%(gxTRUE)
retcode% = grClearViewPort%
FOR mesh = 1 TO 2
FOR X = XI TO XF STEP DX: XSQ = X * X
FOR Y = YI TO YF STEP DY: YSQ = Y * Y

Z1 = TI * (EXP(-(U * ((XSQ) + (YSQ))))))
Z2 = COS(V * (SQR((XSQ) + (YSQ))))
Z = Z1 * Z2

XAB = X * cosa * cosb - Y * sina * cosb t Z * sinb
YAB = X * sina + Y * cosa
ZAB = -X * cosa * sinb t Y * sina * sinb + Z * cosb

TL = D / (D - XAB)
YP = CINT(E + ((YAB - E) * TL))
ZP = CINT(ZAB * TL)

pcolor% = grGetPixel%(YP, ZP)
IF pcolor% = grRED THEN GOTO 7

dist = SQR(((XAB - D) * (XAB - D)) + ((YAB - E) * (YAB - E)) +
          (ZAB * ZAB))

```

(continued)

listing 4—Removing hidden lines from the surface plot results in a more realistic-looking object. It also enhances the three-dimensionaleffect. The hidden-lineremovaltechniques used here are unique and work well.


```

STP = -(30 / dist): RES = 1
TAL = 0

222 FOR t = 1 TO 0 STEP STP
TAL = TAL t 1
XL = D t ((XAB - D) * t)
YL = E + ((YAB - E) * t)
ZL = ZAB * t

sina = -sina: sinb = -sinb
XBA = XL * cosa * cosb - YL * sina + ZL * cosa * sinb
YBA = XL * sina * cosb + YL * cosa + ZL * sina * sinb
ZBA = -XL * sinb + ZL * cosb
sina = -sina: sinb = -sinb

ZUNA = TI * (EXP(-(U * ((XBA * XBA) + (YBA * YBA))))))
ZUNB = COS(V * (SQR((XBA * XBA) + (YBA * YBA))))
ZUN = ZUNA * ZUNB

DIFF = SGN(CINT(ZBA) - CINT(ZUN))
IF TAL < 3 THEN GOTO 22
IF TAL = 3 THEN ref = DIFF
IF DIFF - ref <> 0 THEN GOTO 7
IF ((XBA >= XF) OR (XBA <= XI) OR (YBA >= YF) OR (YBA <= YI))
THEN OOB = 1
IF (OOB = 1) AND (RES = 1) THEN STP = STP / 64: TAL = 0: RES =
0: GOTO 222
IF (OOB = 1) AND (RES = 0) THEN retcode% = grPutPixel%(YP, ZP,
grRED): OOB = 0: EXIT FOR
22 NEXT t
7 NEXT Y, X
SWAP DX, DY
NEXT mesh
BEEP
DO: LOOP WHILE INKEY$ = ""
retcode% = gxSetMode%(gxTEXT)
END

```

listing 4-continued

```

REM ANAGLYPH (HIDDEN LINES REMOVED)-----1024x768
'$INCLUDE: 'gxlib.bas'
'$INCLUDE: 'grlib.bas'
retcode% = gxSetDisplay%(gxTS.38)
retcode% = gxSetMode%(gxTEXT)
PI = 3.1416: OOB = 0
INPUT "E,D,A,B,XI,XF,DX,YI,YF,DY "; E, D, A, B, XI, XF, DX, YI,
YF, DY
INPUT "Amp,Dec,Freq "; TI, U, V
A = PI * A / 180: B = PI * B / 180
cosa = COS(A): cosb = COS(B): sina = SIN(A): sinb = SIN(B)
retcode% = gxSetMode%(gxGRAPHICS)
retcode% = grSetViewPort%(0, 0, 1023, 767)
retcode% = grSetViewWorld%(-511, -383, 511, 383)
retcode% = grSetWorld%(gxTRUE)
retcode% = grClearViewPort%

FOR image = 1 TO 2 ' two different perspectives
FOR mesh = 1 TO 2
FOR x = XI TO XF STEP DX: XSQ = x * x
FOR y = YI TO YF STEP DY: YSQ = y * y

IF image = 1 THEN COLOUR = 4 ELSE COLOUR = 1

I***** surface equation *****
21 = TI * (EXP(-(U * ((XSQ) + (YSQ))))))
22 = COS(V * (SQR((XSQ) + (YSQ))))
Z = Z1 * Z2

I***** Alpha/Beta rotation equations *****
XAB = x * cosa * cosb - y * sina * cosb + Z * sinb
YAB = x * sina + y * cosa
ZAB = -x * cosa * sinb + y * sina * sinb + Z * cosb

I***** screen projections *****
TL = D / (D - XAB)
YP = CINT(E t ((YAB - E) * TL))
ZP = CINT(ZAB * TL)

```

(continued)

Listing 5—Adding the hidden-line removal routines to the anaglyph program results in the final image.

occurring digitally in the surface equation at 7.3614 and on the line equation at 7.3616. The omission would allow a hidden point to remain visible.

This problem exists because you must do exactly what you want to avoid: you must find exact intersections of the line with the surface. The answer is the reduction of the intersection-location requirement to determine whether a line point is either above or below the surface. This solution would be simple if the surface were unrotated, then you could just test if each line point is either greater than (above) or less than (below) the surface by comparing the line point with the surface equation evaluated at the same point. But you can't just test a point's position regarding a rotated surface because a vertical line may cut the surface many times. Any point of a vertical line intersects the surface at only one place in a true (unrotated) mathematical function; therefore, all other points of the line must lie above or below the surface, so you need only locate a sign change. How do you determine if a given point on the view line is located above or below the rotated surface? Just unrotate the surface point in question (remember, you define a particular surface point of the wire-frame model and test it), which you can operate as a true mathematical function. But be careful; you must also unrotate the point on the view line (effectively unrotating your viewpoint), so the entire surface and line perspective are preserved in the unrotated translation.

You can now perform an easy sign comparison for the entire view line or until the surface point is revealed as hidden, then rotate the point back and move on to the next one. Now you should know why you don't need to test any particular surface points; all you have to do is test the general surface equation for a signed magnitude relative to any viewpoint.

Next the question of how the surface (point) is unrotated arises. Can you simply swap the α and β parameters and reverse their signs? No! Order of rotation is significant (think

```

***** Don't waste time replotting *****
PCOLOR% = grGetPixel%(YP, ZP)
IF image = 1 AND PCOLOR% = 4 THEN GOTO 7
IF image = 2 AND PCOLOR% = 1 THEN GOTO 7
IF image = 2 AND PCOLOR% = 4 THEN COLOUR = 5
IF image = 2 AND PCOLOR% = 5 THEN GOTO 7

dist = SQR(((XAB - D) * (XAB - D)) + ((YAB - E) * (YAB - E)) +
(ZAB * ZAB))
STP = -(30 / dist): RES = 1 'initially coarse step
TAL = 0
222 FOR t = 1 TO 0 STEP STP 'scan in surface-to-eye direction
TAL = TAL t 1

***** 3D line equations *****
x1 = D t ((XAB - D) * t)
y1 = E t ((YAB - E) * t)
z1 = ZAB * t

***** unrotate: Beta/Alpha sequence *****
sina = -sina: sinb = -sinb
XBA = x1 * cosa * cosb - y1 * sina t z1 * cosa * sinb
YBA = x1 * sina * cosb t y1 * cosa + z1 * sina * sinb
ZBA = -x1 * sinb + z1 * cosb
sina = -sina: sinb = -sinb

***** unrotate surface point *****
zuna = TI * (EXP(-(U * ((XBA * XBA) + (YBA * YBA))))))
zunb = COS(V * (SQR((XBA * XBA) t (YBA * YBA))))
zun = zuna * zunb

diff = SGN(CINT(ZBA) - CINT(zun)) 'reference line point to
surface
IF TAL < 3 THEN GOTO 22 'escape surface tension
IF TAL = 3 THEN ref = diff
IF diff - ref <> 0 THEN GOTO 7 'point is hidden

**** set hi-res line scan and check for out of bounds (OOB) ****
IF ((XBA >= XF) OR (XBA <= XI) OR (YBA >= YF) OR (YBA <= YI))
THEN OOB = 1
IF (OOB = 1) AND (RES = 1) THEN STP = STP / 64: TAL = 0: RES =
0: GOTO 222
IF (OOB = 1) AND (RES = 0) THEN retcode% = grPutPixel%(YP, ZP,
COLOUR): OOB = 0: EXIT FOR
*****
22 NEXT t

7 NEXT y, x
SWAP DX, DY
NEXT mesh
E = -E 'switch eyes
NEXT image
BEEP
DO: LOOP WHILE INKEY$ = ""
retcode% = gxSetMode%(gxTEXT)
END

```

listing 5—continued

about it) and a β/α (tilt then twist) rotation is found in a manner similar to that for the original rotation. If you're following closely, you may be thinking for every surface point you have to do multiple rotations and test every point in a line for that plotted surface point—that's a lot of number crunching. Well, I lucked out here, too. Notice in the rotation formulas that α and β are fixed from the start of the program, which means no trigonometric functions need be evaluated in the rotation formulas if you assign α and β to fixed variables. This action

results in a dramatic speed increase. As far as testing the line points, if you find a hidden line, then you need test that view line no more. To take advantage of this fact, you can originally step in large increments along the line while looking for a sign change. If you find the change, quickly move to the next viewpoint. If the coarse run shows no sign change, then you must fine test. This procedure also greatly improves drawing speed because a typical surface contains a large percentage of hidden points.

One other trick to speed things up: you never have to evaluate the entire length of the viewing line if, in the unrotated evaluation, you simply test the current point on the view line as being inside the domain (xy) of the surface definition. This test will normally yield great speed improvement because viewing distance usually extends far beyond surface domain. These features can be seen in Listing 4, which draws a parallel perspective surface with the hidden lines removed. Watching this drawing form is interesting.

Listing 5 draws anaglyphic images with the hidden lines removed. Be sure you don't reverse the red and blue filters when viewing this one!

THE FUTURE

It's surprising how simple the final code ends up being to generate threedimensional images on the computer screen. I have more ideas that I want to try along the same lines. I'll let you know if I come up with anything interesting. ❖

SOURCE

All the programs listed in this article are written in QuickBASIC with a third-party graphics library to achieve resolutions higher than the standard 640 x 480. For information on the GX Graphics library used with these programs, contact

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Dale Nassar has a B.S. in physics from Southeastern Louisiana University (SLU). His hobbies include gymnastics (university team) and springboard diving.

IRS

401 Very Useful
402 Moderately Useful
403 Not Useful

FEATURE ARTICLE

Chris Garcia

PC-Based Optical System Design

Using Your PC to Design a Lens

My normal 8-to-5 job requires that I work in an environment where there are over 7000 scientists and engineers, of which more than 3000 have Ph.D.s; and we all rub shoulders and work together in a small town on the side of a mountain. In such a "brilliant" atmosphere one would expect to find a world of creativity, imagination, and constructive innovation. But in reality one often finds politics, professional suspicion, and an enormous amount of inertia. I suspect the first two are just

manifestations of man's basic nature, but the presence of a great deal of resistance to progressive change makes me wonder why most of us spent ten years in graduate school "learning to think."

Of course it's not as bad as I imply. There are lots of scientists and engineers doing outstanding work in their fields. But from my experience within the field of computational science and engineering, most of the professionals I know wouldn't even consider starting a project without hun-

dreds of thousands of dollars and unlimited access to some super mainframe computer. And if one is crazy enough to suggest that the PC on their desk (which is primarily used as a terminal and word processing system) might provide them with a powerful tool to complete a large portion of their task, you can expect to become very unpopular in the group office, especially while they're trying to justify their latest big budget.

There just seems to be this ever present inertia against reapplying old (tried and true, so there must be some thing better) techniques, using new instrumentation and using one's own mind to create "simple" straightforward models of complex systems. Perhaps this is because the latter requires a level of understanding and effort on the part of the individual not all that common today?

So with these thoughts in mind I take pen (keyboard) in hand and try to explain how you can use your desktop PC to model a real-world system, without needing to call on the resources of a mainframe. Much of the thought and inspiration that enabled the last generation of scientists and engineers to creatively "model" a problem on the restaurant napkin can be usefully employed by experimenters today. They can use the new slide-rule-the PC-to enable a whole new dimension of 2-D visualization and calculation.

DESIGNING A LENS

One of the primary components of most optical systems is the lens. Most of the time we employ off-the-

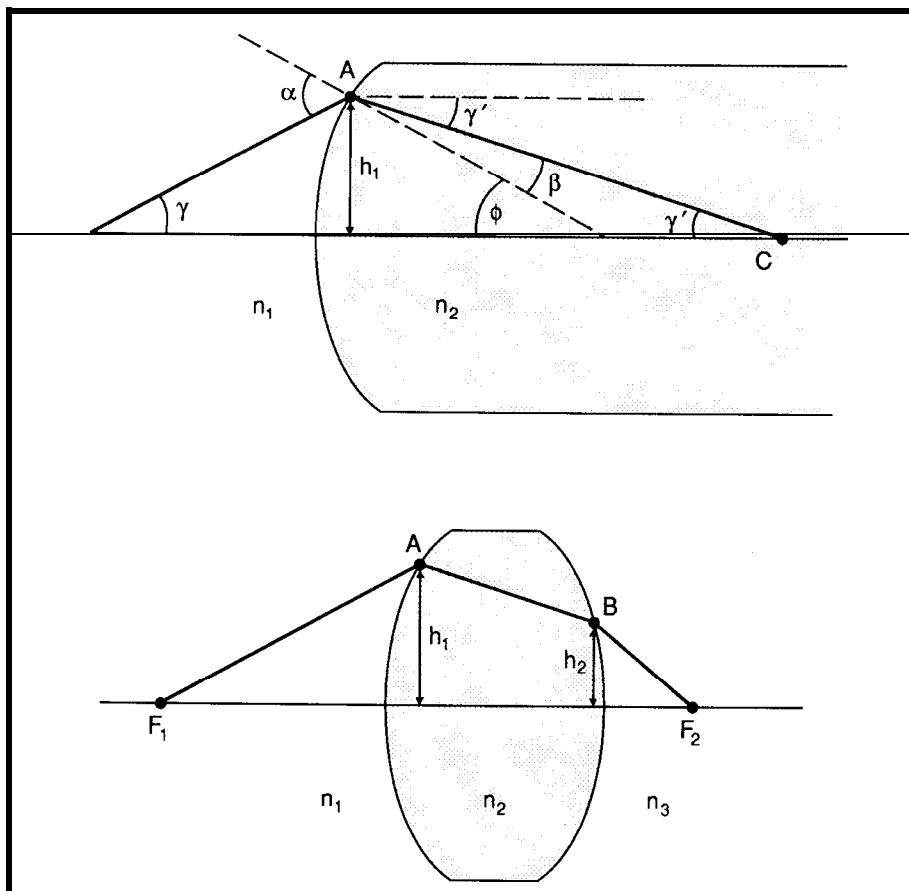


Figure 1 --Interaction of a light ray with a refracting lens. Points A and B define the locations of the associated angles, heights, and focal points of the system.

shelf optics to save on design and fabrication costs, but occasionally one needs to develop customized optics to get around some sort of design peculiarity or mechanical obstruction. In this case, laying out a simple geometrical design of the required lens becomes very useful. We need to choose basic parameters and specify requirements. Once this is accomplished, we can always go to the local optical fabrication shop to have our basic design optimized and built for us.

Doing this first "envelope-effects" calculation on our PC enables us to integrate our total design while we define operating limits. In spite of what you've heard, you don't need to use a mainframe to develop simple lens designs. Your PC is quite capable of doing matrix algebra, so it can be easily used for configuring, ray tracing, and estimating basic optical aberrations.

To start such a lens design, we must first examine the experimental environment and then determine the nature of the image light source, its optical frequency signature, the imaging plane, and the mechanical limitations inherent within the system. From this information we can make quick estimates of the necessary entrance and exit aperture sizes, optical path distances, the required focal lengths, the optical magnification (or reduction ratio), the F/number, the amount of allowed aberrations (input vs. output resolution), and so on. Once we have decided the basics, we need to create a simple model on the PC and trace light rays through the system to determine its overall abilities. This model should allow us to select specific light rays, add or remove elements, and change the element spacings or glass types (which affects index of refraction), so that we can modify and optimize to our particular requirements.

To do all of the above, we don't need to be optical engineers. We only need to understand a few optical basics, a little matrix algebra, and how to program our PC. Following such a matrix algebra procedure, we can create a simple program that will trace

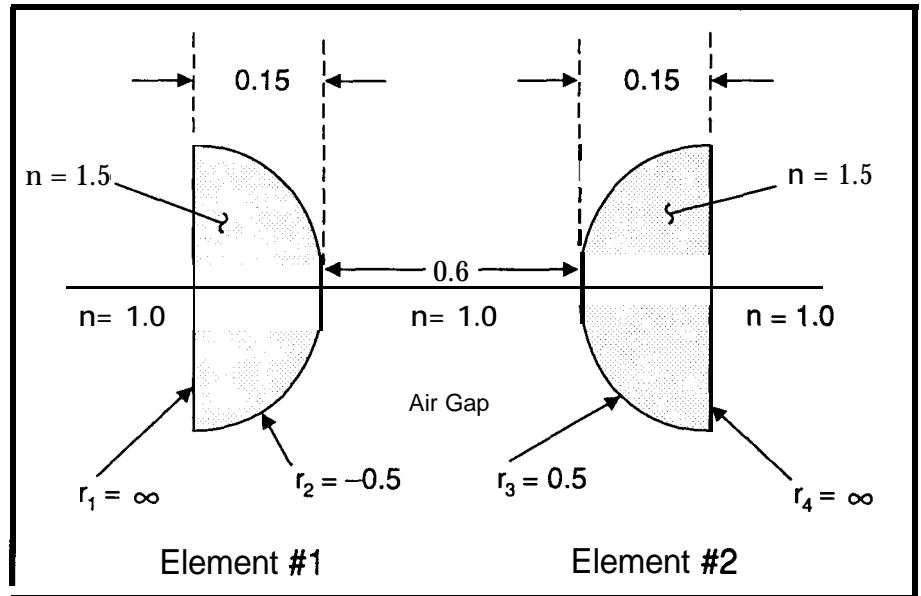


Figure 2-A two-element symmetrical lens system called the Ramsden eyepiece.

the progress of a ray as it passes through one refracting surface after another in order to determine the height and direction it takes as it exits the last surface.

The implementation of such a design approach is based on the creation of two types of matrix operators, which represent the interaction of the light ray with the various interfaces within a lens. These are called the refraction (R) and translation (T) matrices. From these we can create a simple set of equations that are easily programmable, even for very complex compound lens systems.

USING MATRIX ALGEBRA IN LENS DESIGN

To understand how to implement the technique I just described, consider the lens shown in Figure 1. Here we wish to follow a ray passing through the lens at points A and B. Just prior to entering the lens, the ray has an initial slope angle of γ (as subtended with the optic axis). After refraction and while it is within the glass, it has a slope angle of γ' with the ray intersecting the two surfaces at heights h_1 and h_2 , respectively.

If we now define the angle ϕ as the angle between our incident ray and the normal to the radius of curvature (R) of the lens at point A, then the angle ϕ can be defined as

$$\sin \phi = \frac{h_1}{R}$$

or in a first-order approximation

$$\phi = \frac{h_1}{R}$$

Now, according to Snell's Law and geometrical construction (see Figure 1a),

$$n_1 \sin \alpha = n_2 \sin \beta$$

$$\alpha = \gamma + \phi$$

$$\beta = \gamma' + \phi$$

then Snell's Law can be rewritten in the form

$$n_1 \left(\gamma + \frac{h_1}{R} \right) = n_2 \left(\gamma' + \frac{h_1}{R} \right)$$

If we now solve the above equation for $n_2 \gamma'$, then

$$n_2 \gamma' = n_1 \gamma + \frac{n_1 h_1}{R} - \frac{n_2 h_1}{R}$$

$$= n_1 \gamma + \frac{(n_1 - n_2) h_1}{R}$$

and since $(n_2 - n_1)/R$ is the refractive power P ,

$$n_2 \gamma' = n_1 \gamma - P h_1 \quad (1)$$

and using the identity

$$h_2 = h_1 \quad (2)$$

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we can construct the refraction matrix by writing Equations 1 and 2 in matrix form:

$$\begin{vmatrix} 1 & -P \\ 0 & 1 \end{vmatrix} \begin{vmatrix} nr\gamma \\ h_1 \end{vmatrix} = \begin{vmatrix} nr\gamma \\ h_1 \end{vmatrix}$$

where, as a 2 x 2 matrix, it can be written as

$$\begin{vmatrix} 1 & -P \\ 0 & 1 \end{vmatrix} = R$$

All ray interactions with the surface of a lens element can now be characterized using this refraction matrix. But we must now consider the motion of the ray as it passes through the glass (or an air gap) going from point A to B. If d is the horizontal distance between A and B then,

$$h_2 - h_1 = d \tan \gamma'$$

and for paraxial rays (a ray trace based on the paraxial approximation in which all angles are assumed equal to their sines and tangents) this equation becomes,

$$h_2 = h_1 + d\gamma' \quad (3)$$

At A, the ray emerges in a direction $n_2\gamma'$ with height h_1 above the optic axis; while at B the angle of incidence is equal to the emergent angle

from A. Realizing that γ' is the same at A and B, then we can again write an identity equation like that in Equation 2 where,

$$n_2\gamma' = n_2\gamma' \quad (4)$$

now, writing these two equations in a simple matrix form,

$$\begin{vmatrix} 1 & 0 \\ d/r_2 & 1 \end{vmatrix} \begin{vmatrix} nr\gamma \\ h_1 \end{vmatrix} = \begin{vmatrix} nr\gamma \\ h_2 \end{vmatrix}$$

which becomes our translation matrix T:

$$\begin{vmatrix} 1 & 0 \\ d/m & 1 \end{vmatrix} = T$$

If we now follow our selected ray through the lens in a step-by-step fashion, we can create a composite matrix that incorporates the total action of the lens. For this example, the system matrix is a combination of the two refraction matrices resulting from ray interaction with the front and rear surfaces of the lens and the one translation matrix as it passed through. This is defined as the matrix product of each operation matrix ordered from right to left,

$$S = R_2 T R_1 \quad (5)$$

If there is more than one lens, then these matrices are cascaded to-

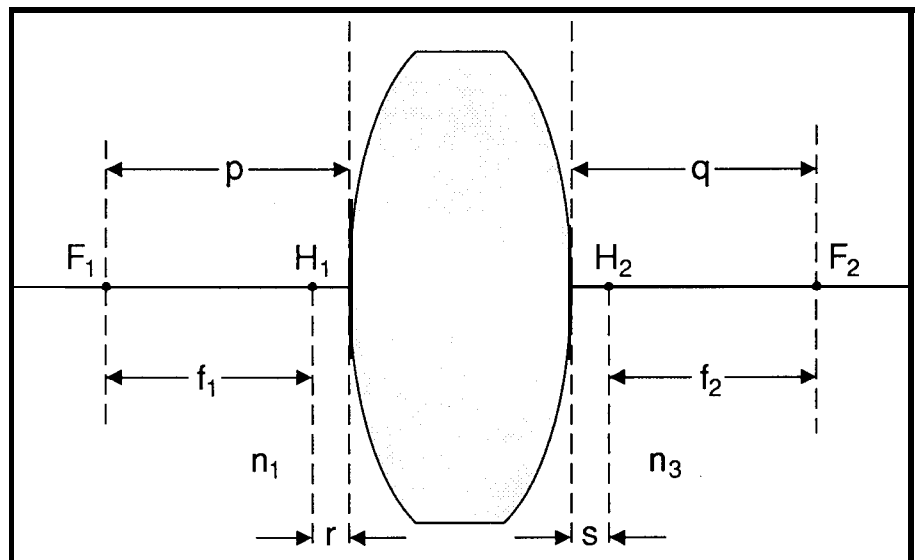


Figure 3—Definition of the principal planes (H) and the focal planes (F) of an optical system.


```

$debug
c      A,B,C,T,SE are 2x2 matrices used for temporary storage
c      of the translation and refraction matrices of the lens,
c      S = system matrix
c      surf,radius,thk,index are the lens design data from the
c      input file
c      p,q,r,sz,fl,f2,h1,h2 are geometrical parameters
c      a_in = gamma, a_out=gamma'
c      ne = number of elements and nk=number of records in the
c      design file
c      lname is the lens design filename

real*4      A(2,2),B(2,2),C(2,2),T(2,2),S(2,2),SE(2,2)
real*4      surf(100),radius(100),thk(100),index(100)
real*4      p,q,r,sz,fl,f2,h1,h2,a_in,a_out
integer*2   ne,nk
character*22 lname

write(*,1)
1  format(1x,'Input lens data filename: ',\ )
   read(*,'(a22)')lname
   write(*,5)
5  format(1x,'Input incident ray height and slope angle.',/,
*   1x,'h1,gamma: ',\ )
   read(*,*)h1,a_in

open(1,file=lname,status='old')
k=1
10 read(1,*,err=20) surf(k),radius(k),thk(k),index(k)
   k=k+1
   goto 10
20 close(1,status='keep')

k=k-1      ! decrement record counter
nk=k      ! save number of records
ne=k/3    ! number of elements
k=k-1     ! set to last element surface

print *,''      ! R = refraction matrix
                    ! T = translation matrix
do j=1,ne
*RT *****
A(1,1) = 1
A(2,2) = 1
A(2,1) = 0
if(radius(k).eq.0)then
  A(1,2)=0
else
  A(1,2) = (index(k)-1.0)/radius(k)
endif
B(1,1) = 1
B(2,2) = 1
B(1,2) = 0
B(2,1) = thk(k)/index(k)
call mult(A,B,C)
* RTR *****
A(1,1) = 1
A(2,2) = 1
A(2,1) = 0
if(radius(k-1).eq.0)then
  A(1,2)=0
else
  A(1,2) = - (index(k)-1.0)/radius(k-1)
endif
call mult(C,A,B)      ! RTR
* RTRTa *****
A(1,1) = 1
A(2,2) = 1
A(1,2) = 0
A(2,1) = thk(k-2)/index(k-2)
if(ne.eq.1)then      ! if only 1 element
  call mult(B,A,s)
endif
if(j.eq.1)then      ! if more than 1 element
  call mult(B,A,se)
else
  call mult(B,A,t)
endif
*****
k=k-3
if(j.gt.1)then
  call mult(se,t,s)
  do m=1,2

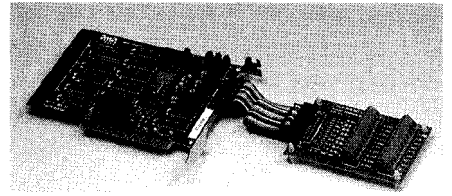
```

(continued)

Listing 1 -A FORTRAN program for simple lens design

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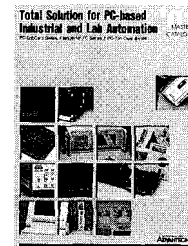
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gether and multiplied out to create the total system matrix for a set of individual elements within a compound lens.

Multiplication of these 2 x 2 matrices is very simple and easy to code, as shown below. Note that the product of any number of 2 x 2 matrices is by itself a 2 x 2 matrix.

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} \begin{vmatrix} e & f \\ g & h \end{vmatrix} = \begin{vmatrix} ae + bg & af + bh \\ ce + dg & cf + dh \end{vmatrix}$$

The path of a ray can be determined at each interface, or at the exit surface of the last element by applying the system matrix in the following manner:

$$S \begin{vmatrix} n_1 \gamma \\ h_1 \end{vmatrix} = \begin{vmatrix} n_n \gamma' \\ h_n \end{vmatrix}$$

where h_1 and γ are the height and slope angle of the incident angle striking the first element in a compound lens, and h_n and γ' are the height and slope angle of the ray exiting the last element.

To demonstrate how simple this matrix technique is to apply, consider the example shown in Figure 2, called a Ramsden eyepiece. If we apply our matrix forms defined above, the system for this compound lens becomes

$$R_4 T_2 R_3 T_4 R_2 T_1 R_1 = S \quad (6)$$

here, T_a is the translation matrix for the air gap between elements 1 and 2. Solving for the refractive power for each surface and substituting these into Equation 6, the system matrix for this two-element lens becomes,

$$S = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} \begin{vmatrix} 1 & 0 \\ 0.1 & 1 \end{vmatrix} \begin{vmatrix} 1 & -1 \\ 0 & 1 \end{vmatrix} \begin{vmatrix} 1 & 0 \\ 0.6 & 1 \end{vmatrix} \begin{vmatrix} 1 & -1 \\ 0 & 1 \end{vmatrix} \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} \\ = \begin{vmatrix} 0.260 & -1.400 \\ 0.666 & 0.260 \end{vmatrix}$$

But this system matrix can be used for other purposes than just finding the path of a ray through a compound lens. It can be used to find much of the geometry of the system (e.g., the focal planes [F] and the principal planes [H]).

The four elements of a system matrix compose what is known as the Gaussian constants--u, b, c, d--of a system. They are arranged as

$$S = \begin{vmatrix} b & -a \\ -d & c \end{vmatrix}$$

These constants relate to the above mentioned physical dimensions (see Figure 3). The distances between the two focal planes, F, and the respective lens surfaces are

$$p = -\frac{bn_1}{a} \quad b \quad f \\ q = \frac{cn_3}{a}$$

```

do n=1,2
  se(m,n)=s(m,n)
enddo
endif
enddo

***** geometry *****

r = index(1)*((1-s(1,1))/(-1.0*s(1,2)))
sz = index(nk)*((s(2,2)-1)/(-1.0*s(1,2)))
p = -1.0*s(1,1)*index(nk)/(-1.0*s(1,2))
q = s(2,2)*index(nk)/(-1.0*s(1,2))
f1 = p-r
f2 = q-sz

a_out = s(1,1)*index(1)*a_in + s(1,2)*h1
a_out = a_out/index(nk)

h2 = s(2,1)*index(1)*a_in + s(2,2)*h1

***** output *****

print *,''
call out(s)

print *, 'System Geometry'
print *, '-----'
print *, 'r = ', r
print *, 's = ', sz
print *, 'p = ', p
print *, 'q = ', q
print *, 'f1 = ', f1
print *, 'f2 = ', f2
print *, '-----'
print *, 'ray incident angle = ', a_in
print *, 'ray exit angle = ', a_out
print *, 'ray incident height = ', h1
print *, 'ray exit height = ', h2
print *, '-----'
end

subroutine mult(m1,m2,m3)
this subroutine multiplies 2 matrices m1xm2
output of operation = m3
real*4 m1(2,2),m2(2,2),m3(2,2)
m3(1,1)=m1(1,1)*m2(1,1) + m1(1,2)*m2(2,1)
m3(2,1)=m1(2,1)*m2(1,1) + m1(2,2)*m2(2,1)
m3(1,2)=m1(1,1)*m2(1,2) + m1(1,2)*m2(2,2)
m3(2,2)=m1(2,1)*m2(1,2) + m1(2,2)*m2(2,2)
return
end

subroutine out(m)
this subroutine prints out the system matrix
real*4 m(2,2)
print *, 'System Matrix (Gaussian constants)'
print *, ''
print *, ' b -a'
print *, '-----'
do i=1,2
  print *, (m(i,j),j=1,2)
enddo
print *, '-----'
print *, ' -d c'
print *, ''
return
end

```

listing 1 - continued

The distances between the principal planes, H , and the lens vertices are

$$r = n_1 \left(\frac{1-b}{a} \right)$$

$$s = n_3 \left(\frac{c-1}{a} \right)$$

The difference of these two distances on either side, $p-r$ and $q-s$, then gives the focal lengths.

To demonstrate, consider our example lens in Figure 2. To determine the focal length of this compound lens, we start by locating the principal planes of the "total system,"

$$r = n_1 \left(\frac{1-b}{a} \right) = 1.0 \left(\frac{1-0.260}{1.40} \right) = +0.529$$

$$s = n_3 \left(\frac{c-1}{a} \right) = 1.0 \left(\frac{0.260-1}{1.40} \right) = -0.529$$

furthermore,

$$p = \frac{-bn_1}{a} = \frac{-0.260}{1.40} = -0.186$$

$$q = \frac{cn_3}{a} - \frac{0.260}{1.40} = +0.186$$

and the two focal lengths are easily found as

$$f_1 = p - r = (-0.186) - 0.529 = -0.715$$

$$f_2 = q - s = 0.186 - (-0.529) = +0.715$$

with the units given in whatever system used throughout.

Finding the path of any ray through the lens is equally easy. If we assume that a ray is incident at height h_1 and slope angle γ , this ray exits the lens at slope angle

$$\gamma' = 0.260\gamma - 1.4h_1$$

and the exit height is

$$h_2 = 0.666h_1 + 0.260h_1$$

SAMPLE LENS DESIGN CODE

To demonstrate how easy it is for you to do simple lens design on your PC, consider the program (MATRIX) shown in Listing 1. This program is designed to read in a simple lens data

file; find the refraction and translation matrices for each surface, element, and air gap within a compound lens; find the principal planes and focal planes of the optical system; and then the exit height and direction of an incident ray. In its current form it can be easily incorporated into a graphics program which might be designed to draw each surface and graph the path of a ray (or rays) as it (or they) transverse the lens. This would enable you to define the ap-

propriate apertures (F/number) and stops. Its fundamental usefulness lies in its ability (even in its present form) to define the EFL (effective focal length, or the distance from the second or first principal point to the second or first focal point of the optical system) and thereby the system's power (1/EFL), as well as the other geometrical design parameters needed for optical fabrication (without needing a megabuck design program like CODE-V).

| surface | radius | thickness | index | |
|---------|--------|-----------|-------|------------------------|
| 0 | 0.00 | 0.000 | 1.00 | .. entrance |
| 1 | 0.00 | 0.000 | 1.00 | .. 1st surf, element 1 |
| 2 | -0.5 | 0.150 | 1.50 | .. 2nd surf, element 1 |
| 0 | 0.00 | 0.600 | 1.00 | .. air gap |
| 3 | 0.50 | 0.000 | 1.00 | .. 1st surf, element 2 |
| 4 | 0.00 | 0.150 | 1.50 | .. 2nd surf, element 2 |
| | | | | .. air gap |
| | | | | .. 1st surf, element n |
| | | | | .. 2nd surf, element n |
| 0 | 0.00 | 0.000 | 1.00 | .. exit |

Figure 4-A sample of an input file used by MATRIX for the Ramsden eyepiece shown in Figure 2.

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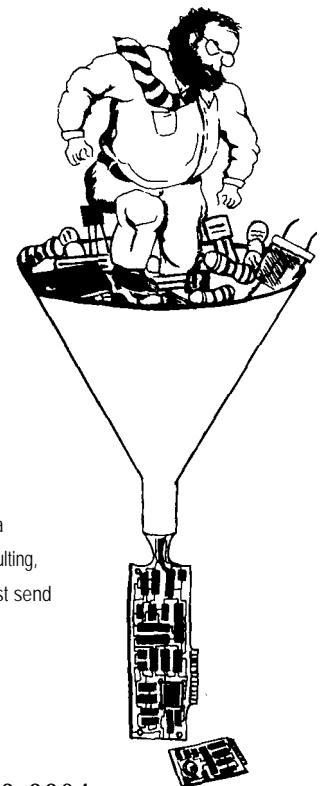
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```

Input lens data filename: lens.dat
Input incident ray height and slope angle.
h1,gamma: 0.3,22.7

```

System Matrix (Gaussian constants)

| b | -a |
|--------------|--------------|
| 2.600000E-01 | -1.400000 |
| 6.6599993-01 | 2.600000E-01 |
| -d | c |

System Geometry

```

r= 5.2857153-01
s= -5.2857143-01
p= -1.8571433-01
q= 1.8571433-01
f1= -7.1428573-01
f2= 7.142857E-01

```

| | |
|-----------------------|--------------|
| ray incident angle = | 22.700000 |
| ray exit angle = | 5.481999 |
| ray incident height = | 3.000000E-01 |
| ray exit height = | 15.196200 |

Figure 5—The output generated by MATRIX when the data is Figure 4 is presented to the program.

A sample of an input file (LENS.DAT) used by MATRIX for the Ramsden eyepiece example described above is shown in Figure 4. When MATRIX reads the data file, it determines the number of elements within the system and then computes the system matrix S. It then computes some of the system geometrical parameters as well as the exit height and slope angle of an input ray. Figure 5 is an example of a MATRIX run for the Ramsden eyepiece example.

ONWARD AND UPWARD

Similar techniques can be used to simulate other portions of a more complex optical system. Taken in combination, the performance of the entire system can be simulated before any part of it is ever fabricated without resorting to complicated Monte Carlo calculations on mainframe computers. Don't underestimate the power of your PC. It may be slower than a Cray, but it has more flexibility (and a lower price tag). I know: I work on Crays 20 to 30 hours a week. Besides, I like playing with my PC. ❖

REFERENCES

1. W. Brouwer. 'Matrix Methods in Optical Instrument Design,' W.A. Benjamin, Inc., New York, 1964.
2. D.P. Feder, "Automatic Optical Design," Applied Optics 2 (1963). pp. 1209-26.
3. W.J. Smith, 'Modern Optical Engineering,' McGraw-Hill, Inc. 1966, p. 308.

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FEATURE ARTICLE Part 2

William J. Kressbach

A Video Editing System

“Standby-quiet on the set—this’ll be a take.”

“Ready announce mic-ready to cue announce-ready to fade in on camera one...”

“Mic--cue-up on one.”

In part one, I talked about how video tape is edited, the control mechanisms that make precision editing possible, building a Z8-based editing controller, and the controller’s software. In this part, I’ll discuss the software for the host computer and describe some rather unconventional ways to make editing easy and convenient.

“Ready talent n-tic-ready cue talent-ready to dissolve to two.”

So here’sssssssssssss Bill.

“Mic-cue-dissolve to two.. .. Kill announce mic.”

Spend some time in the video business and you’ll discover the quality of video equipment is directly related to the number of zeros on the end of the price tag. My objective has been to build a project that will help reduce the number of zeros, while developing quality editing equipment that’s functional and useful. Last time, I showed how to construct a pair of Z8-based controller modules, one for each of the two editing VCRs. The controllers are daisy chained through a serial I/O to a host computer. The host displays relevant information from each controller, and it translates and relays editing instructions to the controllers.

The software for the host computer is written in Z80 machine code and runs on the Radio Shack Model IV. I’ll limit my discussion of software to general terms because you

Spend some time in the video business and you’ll discover the quality of video equipment is directly related to the number of zeros on the end of the price

probably will want to write your own or translate to another system. While I have long since changed over to MS-DOS for most everything, I still do video editing on the trusty (I didn’t say rusty) Model IV. The Model IV is no longer in wide distribution. If you don’t own one, and you’re not into translating machine code, consider looking around for a used one. Thousands of them must be sitting in closets unused and they can sometimes be found reasonably priced at garage sales. If you’re an MS-DOS or CP/M user, you won’t be uncomfortable with the operating system long. Also,

there’s no need for a hard disk, dual floppies will work just fine. You can read and write the disks on an IBM PC with a program called TRS-Cross. [Editor’s Note: Software for this article is available on the Circuit Cellar BBS and on Software On Disk #24. See page 105 for downloading and ordering information.]

ROLLING YOUR OWN

Think about “rolling your own” when it comes to editing control functions. My methods of editing may be considerably different from yours. After all, I free-lance: I write the scripts, run the camera, log the work tapes, and do all the final editing. Your work may not be as extensive, but as long as you’re going to build your own system, make it one to grow into in case you decide to expand later. I’ll explain what I dreamed up and maybe you can improve on it.

The Z80 machine code is divided into eight different modules, each reflecting a different function. MS-DOS users who are unfamiliar with the Model IV will be happy to hear it’s interrupt driven and uses DOS calls (called SVCs) in very much the same

| | IN | OUT | DURATION |
|------|-------------|-------------|--------------------------|
| STOP | 03:02:16-07 | 03:02:18-01 | 03:02:19-03 00:00:01-02 |
| PLAY | 01:02:04-05 | 01:02:10-24 | 01:02:11-26- 00:00:01-02 |

Figure 1 --Editing information is arranged in left to right, top to bottom order. Top is the source VCR, bottom is the destination. Starting at the left is the VCR mode, current tape time, beginning edit point, ending edit point and edit duration. The symbols, P for pause, S for slow, R for record, and I for insert (not shown), are displayed just to the right of the current tape time. The operator may choose either the source or destination VCR for selection of the cut-out point by pressing the hyphen (-) key from the keyboard. The length of the edit for the other is calculated to match. The hyphen (-) to the right of the destination cut-out time indicates which is the entered time code.

fashion as MS-DOS. These aspects, combined with similar processor architecture, make any translating fairly easy.

Before we dig into the software, let's examine what it does. I'll divide the editing process into three basic areas and describe how each is accomplished. These areas are: editing and VCR control, recording and handling of editing information, and logging work tapes.

BASIC EDITING FUNCTIONS

Basic editing and status information is displayed across the bottom two lines of the screen, which leaves plenty of room on the rest of the screen for other uses. The editing portion of the screen display is shown in Figure 1. The layout is in a left-to-right, top-to-bottom configuration. Apply the same layout to the physical location of the editing machines and monitors as well; a good logical layout is the best way to avoid confusion.

Figure 2 lists the keys I've assigned for different control operations. Basic machine control functions, such as play, rewind, and fast forward, use the numerical keypad. The "stop" function is assigned to the <5> key, roughly approximating the relative location of the <stop> key on the VCRs I use. The <2> key is used to put the VCR into the play mode, which seemed logical because it is directly below the <stop> key. Fast forward is to the right of play, and rewind is to the left. Pause and slow are to the right and left of stop. Tapping the space bar is a "kill" command, used to stop both machines and cancel any commands currently in process.

The top row of number keys are assigned to the record functions. The <7> key is used for record, while the <8> and the <9> keys are used for cut-in and cut-out, respectively. When I replaced my original VCRs, the new ones had a reverse feature the old ones lacked. No more pins were left on the controller, so I reassigned the pin used for record over to reverse. If you plan on using the record func-

| | |
|-----------|---|
| / | Enters word processing mode-BREAK exits |
| ^D | Deletes letter if over time code marker deletes time code |
| ^C | Delete to end of file |
| ^E | Produce edit decision list |
| L | Read disk file |
| W | Write disk file |
| Q | Quit |
| n | Trim up--Increments destination cut-in time |
| N | Trim up--Increments source cut-in time |
| ^N | Trim up--Increments tape time under cursor |
| j | Trim down--Decrements destination cut-in time |
| J | Trim down--Decrements source cut-in time |
| ^J | Trim down--Decrements tape time under cursor |
| < | Manual enter-destination cut-in |
| ^ | Manual enter-source cut-in |
| ^ | Manual enter-tape time under cursor |
| > | Manual enter-destination cut-out |
| > | Manual enter-source cut-out |
| P | Move script to agree with tape |
| ^P | Lock script to tape and follow |
| f | Find and stop destination |
| F | Find and stop source |
| ^F | Find string in script |
| t | Enter destination tape time |
| T | Enter source tape time |
| x | Index tape (queries for index start time) |
| ^X | Index tape from current tape time |
| → | Moves cursor right |
| ^→ | Moves to next edit point in script |
| ← | Moves cursor left |
| ^← | Moves to last edit point in script |
| ^L | Locks edit points in script to current edit points |
| ^U | Unlocks edit points in script |
| ^K | Auto edit-(automatically edits list from cursor to EOF) |
| - | Toggles source of edit duration |
| . | Toggles between source = camera, source = tape |
| <clear> i | Preview insert edit |
| <clear> i | Execute insert edit |
| a | Preview assemble edit |
| <clear> a | Execute assemble edit |
| r | Review edit |
| ^F1 | Move to next script marker (next time code in script) |
| F2 | Enter destination tape time into cut-in |
| Shift F2 | Enter source tape time into cut-in |
| ^F2 | Enter source tape time into script |
| F3 | Enter destination tape time into cut-out |
| Shift F3 | Enter source tape time into cut-out |
| ^F3 | Enter destination tape time into script |

Figure 2—The controller supports a large set of editing control codes. Note the difference between upper and lower case in many of the commands. A carat preceding a command indicates a control character. A <clear> preceding a command indicates holdingdown the clearkey. The <clear> key on the Model IV is often used in a similar fashion to the <Alt> key on an IBM PC.

tion or doing any assemble editing, you'll have to find a new pin and key assignment.

The Model IV has three function keys placed just above the numerical keypad. I use these keys for quick entry of cut-in and cut-out locations from off tape. To use this function, put the destination VCR in play and watch for the place where you want the edit to start. When you see it, hit the <F2> key. The current tape time is saved in memory and displayed as the cut-in location on the display. When you come to the location on the tape that you want the edit to stop, press <F3>. The current tape time is then transferred to the cut-out display. Use the shifted <F2> and <F3> keys to mark locations from the source tape.

You can trim the cut-in and cut-out locations up or down, or enter edit numbers directly from the keyboard. Keep in mind that the key assignment should continue the top-to-bottom orientation as much as possible. Pressing the unshifted key always affects the bottom, or destination machine, while pressing the shifted key activates the top, or source machine. Holding down <Ctrl> and pressing a key sends the same command to both VCRs.

KEEPING GOOD NOTES

Keeping good notes on your edit points is important because videos are frequently changed. One day, while I was writing edit points on a copy of a script, it occurred to me that I wrote my scripts on a computer and did my editing on a computer, but I was still using an old fashioned ballpoint pen to record my edit points. This thought led me to the rather unconventional system of inserting and extracting editing information directly to and from the script.

The best way to illustrate this system is through example. When I write a script I have a pretty good idea what it's going to look like and where edits are likely to occur. After the narrator records the script, I convert the script file to ASCII format and load it into the Model IV. Once the tape has been time coded, I go through the script and insert markers at the locations where edits are likely to occur. Simply move the cursor to the edit location and press <control +>. A <+> is automatically inserted into the script with extra spacing to help make it stand out.

Next, I go through the tape listening to the narration, exchanging each "+" for the corresponding time

code from off tape. I've built in some code to make this exchange much easier to do than it sounds. Again the three function keys come into play. <Ctrl F1> is programmed to do a "find next +" function. <Ctrl F3> inserts a time code from the destination VCR into the script. If a "+" is under the cursor at the time, it is removed and replaced with a time code. The time code is enclosed by parentheses to distinguish it from the rest of the script.

You'll discover you can quickly go through a tape using the <F1> key to find markers and <F3> to insert time codes. A source VCR time code may also be inserted by pressing <Ctrl F2>, and it is bracketed by left and right carats. The software interprets a cursor over the left parenthesis of an existing destination time code to mean that video or audio from the source machine is to be inserted there. Therefore, the software assumes the two time codes belong together. The resulting time code pair is formatted in left-to-right orientation and will be interpreted as a pair in future operations. Figure 3 is a script segment showing inserted time codes.

Following this notation takes a bit of getting used to. If you have trouble, press <Ctrl E> to extract the time code pairs from the script and produce a more conventional Edit Decision List (EDL). The EDL is then appended to the end of the script and can be viewed by simply scrolling down. The code for creating the EDL is in the module NONAME. The module can be easily modified to emulate whatever EDL format you're accustomed to using. Figure 4 shows a typical EDL generated by the program.

Sometimes when marking time codes, you have to mark the location several times before you get it just right. The software is smart enough to recognize when a time code already exists

```

<06:03:58-15> (01:01:35-10) FIRST, THIS MACHINE HAS TWO-HAND BUTTON
CONTROLS. IT <06:02:34-17> (01:01:38-26) REQUIRES TWO BUTTONS TO BE PRESSED
BEFORE THE MACHINE WILL OPERATE. <06:03:58-29> (01:01:42-25) THIS PREVENTS
THE OPERATOR'S HANDS FROM BEING CAUGHT WHILE THE MACHINE IS CYCLING.
<06:06:55-17> (01:01:46-03) THIS SEAM WELDER HAS AN ELECTRIC EYE.
<06:07:48-27> (01:01:49-10) WHEN A HAND OR ANY OTHER OBJECT IS INSERTED INTO
THE CAGE, THE BEAM IS BROKEN, STOPPING THE ROTATING TABLE. <06:06:56-18>
(01:01:55-29) THIS ALLOWS THE <06:07:23-27> (01:01:57-29) TABLE TO BE LOADED
WHILE PREVENTING ANY INJURIES FROM THE ROTATING ARM.
<02:04:36-19> (01:02:00-28) MANY MACHINES HAVE A DOOR THAT MUST BE
CLOSED BEFORE THEY CAN BE OPERATED. <06:00:19-01> (01:02:05-04) THIS ONE HAS
A GUARD WHICH PREVENTS FLUIDS FROM BEING SPLASHED ON THE OPERATOR.
<03:02:21-01> (01:02:08-28) ALL OVER THE PLANT YOU WILL FIND CAGES,
<06:17:31-01> (01:02:11-17) FENCES, <06:06:56-26> (01:02:12-11) SIGNS,
<06:12:21-24> (01:02:12-29) LINES, <02:07:24-19> (01:02:13-21) MIRRORS,
<06:03:55-17> (01:02:14-14) GATES, AND <06:10:34-29> (01:02:15-03) GUARDS,
ALL OF WHICH <10:04:44-05> (01:02:16-19) ARE DESIGNED TO KEEP YOU SAFE FROM
INJURIES AND ACCIDENTS. PHOTOGRAPH SIGN COMING INTO PLANT - GATE 1 SAFETY
SIGN)
-----IN-----OUT-----DURATION-----
STOP 06:17:29-03      06:17:31-01      06:17:31-25      00:00:00-24
STOP 01:02:00-06      01:02:11-17      01:02:12-11-    00:00:00-24
-----

```

Figure 3-A sample screen dump shows a typical script with time stamps. <06:17:31-01> indicates that a segment from tape number 06 starting at 17:31 frame 01 is to be copied to (01:02:11-17) tapenumber 01 starting from 02:11 frame 17 and stopping at (01:02:12-11) 02:12 frame 11. The ending time code not only indicates the ending of the segment, it also is the beginning of the next segment.

under the cursor, and it will delete the old time code and replace it with the new. This capability allows you to mark a tape location as many times as you like without entering a string of time codes.

GETTING THE PICTURE

Once you have entered the source time code, you have all the elements you need to make an edit. The source and destination beginning time codes are still under the cursor, and the ending time code is the next edit location on the script. When you press <Ctrl L> the source and destination time codes are loaded into the command lines at the bottom of the screen. The next time code in the script is found and loaded as the cut-out point. The selected codes are highlighted in reverse video and are locked to the codes in the command line. Therefore, any changes made to the code on the command line will be reproduced on the script. You can now perform any of the edit commands listed. You can make trial edits and previews, and automatically record changes as you make them. When you're done, press <Ctrl U> to unlock the command line from the script, or press <Ctrl L> to unlock and lock onto the next pair.

After you have entered enough edit points, the software relates the current VCR tape time to the editing locations entered into the script as best it can. Pressing <P> scrolls the script and displays the computer's guess at the current tape time's location in the script. Pressing <Shift P> locks the screen display to the tape. You can play, rewind, or fast forward a tape and watch the script scroll in perfect sync. I haven't found any practical uses for this feature, but it's fun to watch.

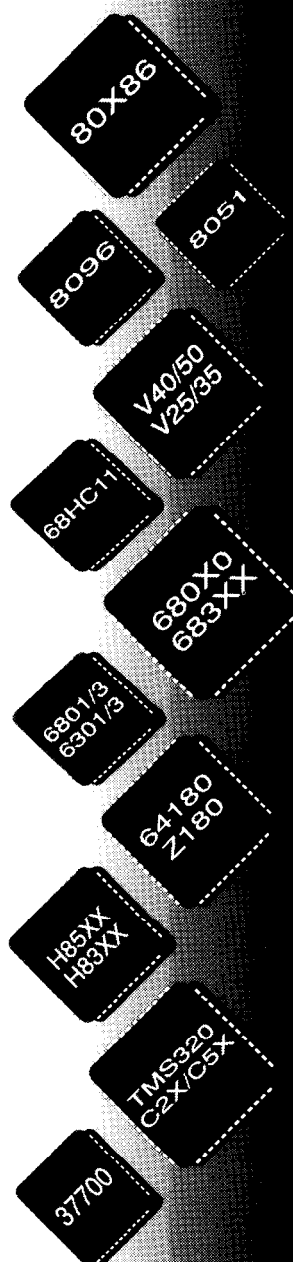
TAKE YOUR BEST SHOT

My method for logging work tapes arose while I was assembling "best-takes lists." What's a best-takes list? Well, when you go out on a "shoot" you don't come back with Shot #1 on Tape #1 and Shot #2 on

Tape #2. Shots are never taken in order and are often retaken several times. It is far better to come back with more footage than you need, than to come up short, especially if you're in Michigan and your shoot's in Mississippi. I once did a video for the American Cancer Society that had 22 work tapes, each consisting of about 40 to 50 shots. I had about a thousand shots to keep track of. Large studios have people who do nothing but review work tapes. They pick the segments that are needed, copy them onto a best-takes reel, then pass them along to another person who does the

editing. Free lancers usually don't have that luxury. When I assemble a best-takes reel, I log in a tape and then use that log to find the shots I need.

Once again the old ballpoint pen came into play. Logging a work tape consisted of viewing a segment, then jotting down a time code and a short notation of the scene. Because I had to take my eyes off the screen to write, I had to stop frequently and rewind. The whole process was cumbersome and time consuming. Well, the old Model IV came to the rescue again. The solution was to add rudimentary



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| | | | | | |
|-----------------------------------|-------------|----------|-------------|--------------|-------------|
| EVENT # | 9 | IN: | 01:02:05-04 | SRC: | 06:00:19-01 |
| | | OUT: | 01:02:08-28 | | |
| | | DUR: | 00:00:03-24 | | |
| | | PGM LEN: | 00:00:33-18 | | |
| EVENT # | 10 | IN: | 01:02:08-28 | SRC: | 03:02:21-01 |
| | | OUT: | 01:02:11-17 | | |
| | | DUR: | 00:00:02-19 | | |
| | | PGM LEN: | 00:00:36-07 | | |
| EVENT # | 11 | IN: | 01:02:11-17 | SRC: | 06:17:31-01 |
| | | OUT: | 01:02:12-11 | | |
| | | DUR: | 00:00:00-24 | | |
| | | PGM LEN: | 00:00:37-01 | | |
| EVENT # | 12 | IN: | 01:02:12-11 | SRC: | 06:06:56-26 |
| | | OUT: | 01:02:12-29 | | |
| | | DUR: | 00:00:00-18 | | |
| | | PGM LEN: | 00:00:37-19 | | |
| -----IN-----OUT-----DURATION----- | | | | | |
| STOP | 06:17:29-03 | | 06:17:31-01 | 06:17:31-25 | 00:00:00-24 |
| STOP | 01:02:00-06 | | 01:02:11-17 | 01:02:12-11- | 00:00:00-24 |
| ----- | | | | | |

Figure 4—The Edit Decision List is a more conventional and easier to read method for displaying the control sequence.

word-processing capability. Now, you might ask if I can type faster than I can write. I can't. But, I can enter a time code with one key press, and I don't have to take my eyes off the monitor. Best of all, my notes are legible when I'm finished. All in all, there

is enough speed improvement that I rarely need to stop a tape. The software module that supports word processing is called WORD, which is invoked from the keyboard by pressing the </> key, and is designed for fast note taking and nothing else.

When active, WORD is always in the insert mode. Going back and making changes can be done, but that's a real pain.

To use WORD, put the VCR into the play mode and then press </>. Originally, you used the three function keys of the Model IV to enter time code; now you're going to use them again, but this time with one important difference. As before, pressing <F3> enters the current tape time, but now the cursor automatically moves to the right of the time code instead of staying put, and it is ready for you to add notes. Enter notes as you would on any word processor. When you're finished with a note, press <Enter> to move to a new line that is ready for the next time code. Both the source and destination machines may be used in note taking. The <F2> key is for the source machine, and <F3> enters the time code for the destination machine. I generally use the <F3> key. <F1> pauses both machines in case you need more time.

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A PICTURE OF THE SOFTWARE

The software for the Model IV is written in machine code and is divided into eight modules.

MAIN handles the machine start-up functions. It contains the command interpreter for functions other than word processing. Upon start-up, MAIN issues a series of wake-up commands to the modules that ready them for use. It also handles some of the time code entry and delay timing for editing functions.

SUBS contains frequently used subroutines, including those used for transmitting edit information and machine commands to the modules, and the code for calculating edit durations.

DISKIO loads and saves files from and to disk. When you're queried for a file name you can type it in or press the right arrow key and let the computer leaf through the available files for you. DISKIO automatically adds the file extension ".VT" to the file name for easy identification.

EDITOR interprets basic machine commands. It's the real heart of the editing system and acts as an interface between you and the VCR modules. It interprets and translates your commands into something a VCR module can understand. EDITOR decides whether you are asking for a preview, an edit, or a review. It can also instruct the VCR modules to do a tape-to-tape edit or a camera-to-tape edit. It decides how long an edit will last and transmits that information to the VCRs. Finally, EDITOR contains the code necessary for videotape indexing.

INTERRUPT takes care of information coming from the VCRs. The actual interrupt routine is very short, only a few lines long (see Listing 1). INTERRUPT takes data from the serial stream emitted by the modules and inserts it into a ring buffer. After saving the data, it notifies the rest of the software that data has arrived in need of processing. When the computer has time, it polls to see if there is data to be processed. If there is, it picks the data out of the ring buffer and decides what to do.

INTERRUPT is optimized for speed. Instead of doing a linear series of tests to interpret the data, this module conducts branch testing. It checks for the most likely possibility: time code. If time code is in the process of being received, the module then stores it in a buffer. If no time code is found, INTERRUPT looks for commands in order of those most likely to occur. It also is responsible for updating the display with the latest information. While this module is reasonably fast, it can trip up if information is received too quickly. If you have trouble, slowing down the baud rate should help.

WORD handles the bulk of the word-processing functions. It's designed to handle basic input and nothing else. While it can be used for some word processing, it's really for quick note taking and other types of minor data entry. WORD follows the conventions set up for most other word processors on the Model IV. The arrow keys move the cursor right, left, up, and down; shifted arrows move it to top of file, bottom of file, end of line, or beginning of line. When a file is loaded from disk or typed in from the keyboard, WORD formats it by marking the end of each line of text with the removal of a space and the insertion of 80h. This marker eliminates the need for the program to reformat lines as the screen scrolls, free-

ing processor time for more demanding functions. The markers are removed when the file is saved to disk, so the text remains flat ASCII.

WORD also recognizes and manipulates embedded time codes, inserting them with the proper formatting. When deleting characters, WORD recognizes when the cursor is positioned over a valid time code and deletes the entire time code at once. WORD also handles time code trimming and maintains other screen information.

GLOBAL is a module that requires some explaining (see Listing 2). It contains no assembly language instructions as such, but it does contain instructions to the assembler for calculating screen locations. I needed this module because I often experimented with different display layouts during the development of the program. This experimentation was useful, but cumbersome and time consuming to implement. I needed to have all the screen references in one location to be easily tweaked, but the last thing I wanted was for the program to waste time calculating a reference point every time it had to write to the screen. My solution was to build instructions in the assembler to calculate screen locations and then load them where needed at assembly time.

The fastest way to do screen I/O on the Model IV is to build a work

```
; $INTER INTERRUPT ~ PUTS RECEIVED BIT INTO
; RING BUFFER AND UPDATES POINTER

INTER   LD    HL, (RINGIN)      ; GET RING IN POINTER
        INC  L                  ; POINT TO NEXT
        LD   (HL), C            ; SAVE RECEIVED DATA
        LD   (RINGIN), HL      ; SAVE
        RET

; $INTERUP INTERRUPT ROUTINE
; DETERMINES MODE OF VCR
; AND UPDATES TAPE NOW COUNTER

; FETCH DATA FROM RING COUNTER AND UPDATE DATA
; NOTE: NO REGISTERS SAVED USE CAUTION WHEN CALLING

INTERUP LD   DE, (RINGIN)      ; RING IN POINTER
        LD   HL, (RINGOUT)    ; RING OUT POINTER
        LD   A, L
        CP   E
        RET Z                  ; RET IF NOTHING RECEIVED
```

listing 1 -To save processor time, the interrupt routine is very short and simply inserts received information into a ring buffer. Later the software polls to see if the "in pointer" is different from the "out pointer." If the pointers are different, the incoming data is processed and distributed.

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PSECT

PUBLIC SCREEN, COMLIN, TOP, MODLIN, DSPFOL, DSPSIN, DSPSOUT
PUBLIC DSPMIN, DSPMOUT, CURENT, BURENT, DSPDUR, DSPMST, DSPSST
PUBLIC DSPMMD, DSPSMD, NOLINES, DSPDURM, DCURENT, DBURENT
PUBLIC DDSPSST, DDSPMST, DDSPMMD, DDSPSMD

SCREEN EQU 0F800H
WSCREENEQU 3000H ; WORK SCREEN
NOLINESEQU 19 ; NUMBER OF LINES OF TEXT ON SCREEN

; SET COMLINE
LINE DEFL 23
CHAR DEFL 15
COMLIN EQU WSCREEN+(LINE*80)+CHAR

; SET MODLIN
LINE DEFL 23
CHAR DEFL 0
MODLIN EQU WSCREEN+(LINE*80)+CHAR

; SET DSPSIN
LINE DEFL 21
CHAR DEFL 28
DSPSIN EQU WSCREEN+(LINE*80)+CHAR

; SET DSPSOUT
LINE DEFL 21
CHAR DEFL 43
DSPSOUTEQU WSCREEN+(LINE*80)+CHAR

; SET DSPMIN
LINE DEFL 20
CHAR DEFL 28
DSPMIN EQU WSCREEN+(LINE*80)+CHAR

; SET DSPMOUT
LINE DEFL 20
CHAR DEFL 43
DSPMOUTEQU WSCREEN+(LINE*80)+CHAR

; SET DSPFOL
LINE DEFL 22
CHAR DEFL 3
DSPFOL EQU WSCREEN+(LINE*80)+CHAR

; SET TOP OF SCREEN
LINE DEFL 0
CHAR DEFL 0
TOP EQU WSCREEN+(LINE*80)+CHAR

; SET SLAVE TAPE POINTER CURRENT
LINE DEFL 21
CHAR DEFL 9
CURENT EQU WSCREEN+(LINE*80)+CHAR
DCURENTEQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

; SET MASTER TAPE POINTER CURRENT
LINE DEFL 20
CHAR DEFL 9
BURENT EQU WSCREEN+(LINE*80)+CHAR
DBURENTEQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

; SET MASTER DURATION LOCATION
LINE DEFL 20
CHAR DEFL 58
DSPDURMEQU WSCREEN+(LINE*80)+CHAR

; SET SLAVE DURATION LOCATION
LINE DEFL 21
CHAR DEFL 58
DSPDUR EQU WSCREEN+(LINE*80)+CHAR

; DISPLAY MASTER STATUS (PAUSE ETC.)
LINE DEFL 20
CHAR DEFL 21
DSPMST EQU WSCREEN+(80*LINE)+CHAR
DDSPMSTEQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

(continued)

Listing 2—Global is used for experimentation with screen displays without consuming valuable processor time. The assembler translates the instructions into screen references used by the program. For example, COMLIN sets the screen position for the comment line; in this case, line 23, column 15. Changing these references can position the comment line anywhere on the screen without requiring any processor overhead.

```

; DISPLAY SLAVE STATUS (PAUSE ETC.)
LINE DEFL 21
CHAR DEFL 21
DSPSST EQU WSCREEN+(80*LINE)+CHAR
DDSPSSTEQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

; DISPLAY MASTER MODE (PLAY ETC.)
LINE DEFL 20
CHAR DEFL 0
DSPMMD EQU WSCREEN+(80*LINE)+CHAR
DDSPMDEQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

; DISPLAY SLAVE MODE (PLAY ETC.)
LINE DEFL 21
CHAR DEFL 0
DSPSMD EQU WSCREEN+(80*LINE)+CHAR
DDSPSMD EQU (SCREEN+(80*LINE)+CHAR).XOR.0400H

END

```

Listing P-continued

screen in memory and then switch it to the display when needed. GLOBAL fixes a start location for the work screen, then it sets a row and a column for each element to be displayed based on that reference. I can now move any element to any screen location simply by changing a variable in the GLOBAL file and reassembling the code.

In the module NONAME you'll find a hodgepodge of misfits, pieces, and recent developments. All the experi-

mental work goes on here. You'll find the code for creating EDLs, locking and unlocking script time codes, and screen follows and searches. You'll also find some experimental segments. For example, the autedt function performs any automatic editing. Beginning at the cursor location, autedt extracts editing information from the script and then automatically executes it. You can use this routine to automatically edit an entire tape.

READY TO FADE SOUND AND PICTURE OUT...

There are a number of new and inexpensive video tape formats available that give impressive results. With a little bit of skill and knowledge you should be able to adapt the modules to control many different VCRs. Whether you're an amateur or a professional, I hope I've given you some new ideas and a different direction to follow when you build your own video editing controller.

"Fade sound and picture... Kiss black, and go to commercial." ❖

Bill Kressbach holds a Master's degree in Instructional Media and Technology from the University of Toledo. When he's not shooting videos, he does some computer programming and is chief engineer for a college radio station.

IRS

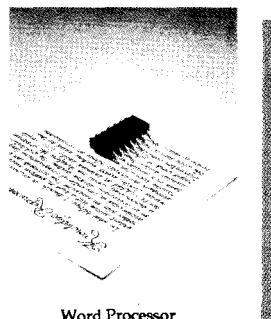
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- 408 Moderately Useful
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High-Resolution Timing on A PC

In his article "A PC Stopwatch, Improved Timing for Acquisition and Control" (issue 19, page 22), David Schulze wrote that often PCs are incapable of high-resolution timing in a control or instrumentation project. Normally, timing is approached using either software loops or the tick timer. Software loops need to be calibrated against the tick timer before they are used, and not only tie up the processor, but can be grossly inaccurate as well. The tick timer's advantage is its ability to interrupt your software, but it's coarse by itself and in need of refining. I will explain these refinements, which extract a highly accurate timer with resolution greater than 1 μ s from any PC, XT, or AT, with almost no additional system overhead and no additional hardware.

THE TICK TIMER

The Intel 8253 (8254 for the AT) programmable interval timer is the source of the clock ticks. The 8253 has three independent channels that perform various rate divisions or other functions on its 1.19318MHz clock. Channel 0 generates the timer ticks, channel 1 clocks the dynamic RAM refresh, and channel 2 can be connected to the speaker.

Channel 0, utilized in this project, is normally set in the 8253's "mode 3," which is a frequency divider producing a symmetrical square wave.

The 8253 has a 16-bit countdown register that causes the output pin to be high during the first half of the count and low during the second. The count register is initialized to 0, which acts like 65536, and is the factor by which the 1.19318-MHz clock is divided. The interrupt line is pulled by the 8253 output and generates 18.20648-Hz ticks.

The hardware interrupt vectors to the processor's interrupt 8, where the BIOS code resides to increment a 32-bit number in low memory (at location 0040:006C) and to handle disk-drive motor timing or any other

chores a BIOS may have. The BIOS code also chains to a second interrupt, INT 1Ch, which usually contains only an IRET instruction. This 1Ch vector is the easiest to put your own interrupt handler on, should you want to be interrupted every tick. When your program exits (normally or abnormally), it must restore the original vector, or the system will crash.

FASTER INTERRUPTS

At this point, you can increase the 18.2-Hz tick rate by simply changing the count register from 0 (65536) to some lower value. For example, a count of 59659 changes the tick timer to 20 Hz, which is handy simply because it's a whole number. (Of course, if we humans had 18.2 fingers.. .) This change will affect other software on the system, such as the time of day (your clock will run a little fast) and floppy disk drive timing (the time the motor is allowed to come to speed and the time it runs after an access), but in my experience the change from 18.2 to 20 Hz has never caused a problem. You can correct the time of day after you return the tick timer to its normal rate at the end of a program: keep track of the number of ticks that occurred at the faster rate and decrement the BIOS counter appropriately. The `set 8253 ()` function shown in Listing 1 reprograms the tick rate.

What if you want even faster interrupts? Running the BIOS routine at 16 times the normal tick rate would be a bad practice; if you are writing code that will be on a variety of machines, you don't know what other

```

/*Sets the 8253 channel 0 tick interval, putting the channel in
the standard mode 3, the same mode that the BIOS initializes
it to. The tick interval is normally 0, which is treated as
65536, for 18.2 Hz, but may be set to, for example, 59659 for
a 20-Hz clock*/

```

```

void set8253(unsigned cnt)
{
asm mov al,036h
asm out 43h,al          /*control reg: mode 3*/
asm mov ax,cnt
asm out 40h,al
asm mov al,ah
asm out 40h,al          /*16-bit counter*/
}

```

Listing 1 - Reprogramming the 8253 for a new tick interval is very straightforward.

things (e.g., battery management, TSRs) may be affected. At the very least, the time of day would start to look ridiculous. Therefore, in order to get the interrupt rate this high, pro-

gram the 8253 for 16 times the normal rate ($65536/16 = 4096$), and install an interrupt handler on the INT 08 vector (not the 1C secondary vector). The handler performs the de-

```

#pragma inline

/*Sets the 8253 channel 0 to use mode 2, so the count value only
counts down once per tick so we can read it unambiguously.*/

void timer_open(void)
{
asm mov al,034h
asm out 43h,al          /*control reg: mode 2*/
asm xor al,al
asm out 40h,al          /*count value 0 (65536)*/
asm out 40h,al
}

/*This function reads our 1.19318-MHz timer, assuming that we
have called timer_init() beforehand to set it up.*/

unsigned long timer_read(void)
{
unsigned long count;

asm mov ax,0040h
asm mov es,ax
asm mov bx,es:006Ch     /*get BIOS counter*/

asm mov al,06h
asm out 43h,al          /*latch the count value*/
asm in al,40h           /*read LS byte*/
asm mov ah,al
asm in al,40h           /*read MS byte*/
asm xchg al,ah          /*put them where they belong*/
asm not ax
asm inc ax              /*convert from upcount to downcount*/

asm mov cx,es:006Ch
asm cmp bx,cx
asm je rtn              /*if BIOS counter didn't change, done*/
asm cmp ax,8000h        /*decide which to use based on whether 8253*/
asm jb rtn              /*count was above or below its midpoint*/
asm mov cx,bx

rtn:
asm mov word ptr count,ax
asm mov word ptr count+2,cx
return count;
}

void timer_close(void)
{
asm mov al,036h
asm out 43h,al          /*control reg: mode 3*/
asm xor al,al
asm out 40h,al          /*count value 0 (65536)*/
asm out 40h,al
}

```

Listing 2-Using the 8253 in mode 2 allows more accurate intermediate count values to be read.

sired function at this high speed, and then chains to the BIOS routine every sixteenth call, with a far jump to the original location of the INT 08 vector. On the other 15 calls, simply reset the interrupt controller (MOV AL,20h; OUT 20h,AL) and do an IRET.

MUCH HIGHER RESOLUTION

There are limits to the clock rate that you can get by reprogramming the tick speed; an extremely high rate will load down the processor with interrupts. To get a truly high-resolution timer, you must take a different approach.

If you could read the current count from within the 8253 while it's counting, you would expect to see a 16-bit number that counts down at 1.19318 MHz. With the 8253 programmed in its default configuration so it counts through the full 65536, the BIOS tick counter in low memory serves as the 32 most-significant bits of a whopping 48-bit counter.

Alas, this technique has a problem (don't they all?). As I said earlier, the default "mode 3" operation of the 8253 channel 0 emits a symmetrical square wave: up for the first half of the countdown period and down for the second. The exact way the chip does this operation is curious. It counts down by two counts at a time rather than by one, holding the line high as it does; then it again counts down by two, this time holding the line low. While this way is fine for the 8253 to produce a symmetrical output, it causes a problem for us: when you look at the count, you'll see the chip count down by twos twice, but you'll have no way of knowing whether it's on the first or second half of the cycle.

You don't really need a symmetrical output, though! After all, the only function of the output line is to yank the interrupt periodically. So you can reprogram channel 0 in "mode 2," which only produces a low output for one period and then the other 65535 are high. This mode works fine for generating interrupts and uses a simple down-counter. The count starts at 0, wraps around to FFFFh,


```

#pragma inline
unsigned long hrt_count;          /*the 32-bit time*/

/*This function is the first one to call before using the 8253
high-resolution timer. It sets the 8253 channel 0 to use mode
2, and installs an interrupt handler on int 1C. Therefore the
companion function hrt_close() *MUST* be called before the
program exits!*/

void hrt_open(void)
{
asm mov al,034h
asm out 43h,al                    /*control reg: mode 2*/
asm xor al,al
asm out 40h,al                    /*count value 0 (65536)*/
asm out 40h,al

asm mov ax,351Ch
asm int 21h                      /*DOS get vector call*/
asm mov word ptr cs:oldvect,bx
asm mov word ptr cs:oldvect+2,es

/*Install one of our handlers, which one depending on whether
the old handler was just an IRET or if it did anything more.
If it was just IRET, we save time by not chaining back to it*/

asm mov dx,offset intrupt1
asm cmp byte ptr es:[bx],0CFh    /*CFh is the IRET opcode*/
asm je use1
asm mov dx,offset intrupt2
use1:
asm push ds
asm mov ax,cs
asm mov ds,ax
asm mov ax,251Ch
asm int 21h                      /*set int 23 vector*/
asm pop ds
asm jmp short retn

/*Here are the interrupt handlers themselves*/

asm oldvect dd 0                  /*storage for the old 1C vector*/
asm tickcnt dw 0                 /*the 16-bit tick counter*/

asm intrupt1:
asm inc cs:tickcnt
asm iret                        /*do our own return*/

asm intrupt2:
asm inc cs:tickcnt
asm jmp dword ptr cs:oldvect    /*chain to the old handler*/

retn: ;
}

/*This function which reads our 1.19318-MHz timer, assuming that
we have called hrt_open() beforehand to set it up.*/

unsigned long hrt_read(void)
{
asm mov bx,cs:tickcnt           /*get initial tick reading*/

asm mov al,06h
asm out 43h,al                  /*latch the count value*/
asm in al,40h                   /*read LS byte*/
asm mov ah,al
asm in al,40h                   /*read MS byte*/
asm xchg al,ah                  /*put them where they belong*/
asm not ax
asm inc ax                      /*convert from upcount to downcount*/

asm mov cx,cs:tickcnt
asm cmp bx,cx
asm je retn                     /*if BIOS counter didn't change, done*/
asm cmp ax,8000h                /*decide which to use based on whether 8253*/
asm jb retn                     /*count was above or below its midpoint*/
asm mov cx,bx

retn:
asm mov word ptr hrt_count,ax
asm mov word ptr hrt_count+2,cx
return hrt_count;
}

```

(continued)

Listing 3—A complete implementation of the high-resolution timer using the interrupt handler technique.

and proceeds back down to 0. As you read this count you can convert it to an up-counter from 0 to FFFFh.

Reading the 8253 on the fly is actually easier than it sounds because the chip has a command to latch the current count and return it, one byte at a time, on the next two reads. Note that the counter may turn over as you read, generating an interrupt. You must be careful to read the BIOS tick counter both before and after you read the 8253, and make sure to choose the proper value if you find them different.

The code shown in Listing 2 implements this scheme. I have written it for Borland's Turbo C, using the in-line assembler capability of that compiler. Calling timer_open () puts channel 0 in "mode 2." At any time thereafter, a call to timer_read () returns a 32-bit number. This number, derived from the low 16 bits of the BIOS timer count and from the 8253, appears as a 32-bit up-counter running at 1.19318 MHz. Before your program exits, call timer_close () to put things back as you found them, although if you don't it probably won't be noticed.

THE MIDNIGHT BUG

The BIOS tick timer, as every avid reader of IBM documentation knows, resets itself every midnight. This assumes that the clock is set correctly; if not, "midnight" occurs whenever the BIOS count reaches the number of ticks there are in a day.

Many timing schemes on the PC are vulnerable to this midnight time warp. If you are using the high-resolution timer when this unfortunate event occurs, you will get a reading that is about 10 seconds off. I looked at work-arounds for this code and decided that most of them were too time-consuming at the high-resolution timer's reading point. You don't want to be doing BIOS calls or excessively complex code at this time because it will throw your readings off. There's little use having a 1- μ s timer that takes 100 μ s to sample.

The one fix that does not load the system appreciably is ignoring the

```

/*This function MUST be called before the program exits, after
all use of the high-resolution timer is completed, to
uninstall our interrupt handler from the 1C vector*/

void hrt_close(void)
{
asm mov al,036h
asm out 43h,al          /*control reg: mode 3*/
asm xor al,al
asm out 40h,al         /*count value 0 (65536)*/
asm out 40h,al

asm push ds
asm lds dx,cs:oldvect
asm test dx,dx        /*if dx is 0, ours was never installed*/
asm jz skipit
asm mov ax,251Ch
asm int 21h           /*DOS reset the vector*/
skipit: asm pop ds
}

```

Listing S-continued

BIOS tick count entirely and implementing your own tick counter! Install your own interrupt handler on INT 1Ch, the secondary tick interrupt, which increments a 16-bit number in your own code segment. This number is the one used for the high 16 bits when you read your high-resolution timer.

Being somewhat obsessed with efficiency, especially in this situation where I might be using the timer for a system profiler and I want to avoid any extra load on the system, I've even gone to the trouble of optimizing the interrupt handler a bit. When you install the handler, look at the address pointed to by the original 1Ch vector. If the first byte of that code is an IRET instruction, then you know that you're at the end of your 1Ch handler, and you don't need to jump back to the original handler. In this case, you just finish up with your own IRET, which does the same thing.

A COMPLETE EXAMPLE

Listing 3 is a complete implementation using the interrupt handler technique. Remember, your system is in danger of crashing if you don't include a provision to remove the interrupt handler on any sort of exit, normal or abnormal. The easiest way to clean up your alterations after the program finishes is by installing a dummy handler at the INT 23h vector, which is where the DOS code that aborts your program on Ctrl-C resides. The handler prevents the user

from aborting your program, which gives you control over how the machine will be left when you're finished.

If you want to see an example of this Ctrl-C trapping technique, as well as play with the high-resolution timer, download the code for this article from the Circuit Cellar BBS. *[Editor's Note: Software for this article is available from the Circuit Cellar BBS and on Software On Disk #24. See page 105 for downloading and ordering information.]*

The 32-bit count rolls over approximately every hour. The timer also works fine for intervals less than one hour because the subtraction of two count values yields the correct interval even if it goes around a roll-over. Treat the 32-bit numbers as unsigned when subtracting them.

Too bad we aren't counting a nice round rate like 1 MHz, but with this high resolution, converting the intervals you wish to measure from microseconds to the rate at which this timer runs isn't hard. For example, look for 1193 counts when you're timing a millisecond. ❖

Bruce Ackerman specializes in instrumentation and process control, writing software and designing hardware. He studied Computer Science at MIT and now works in research and manufacturing environments as well as product design.

IRS

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4 12 Not Useful

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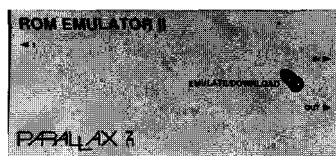
Reset outputs restart target after downloading.

Downloads 32K in 2 sec.
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Reader Service # 178

**SPECIAL
SECTION**

Frank Swiger
& Joe Glover

The K-100 MC68HC11 -based Single-Board Computer

*On-board keyboard and video interfaces
complete this single-board powerhouse*

You've heard the story before; you have a design that requires a computer and some I/O. Do you use off-the-shelf components to minimize design time and expense, possibly compromising on features, or do you design something specifically suited to the task?

We recently had a job to put together a custom communication and control system. Typically, such a system utilizes a PC and five or six boards. Even with dropping PC prices, we still felt there had to be a cost-effective alternative to all this hardware. So we decided to look for an inexpensive microcomputer that

would function more efficiently. When we started looking through ads, we soon realized finding the right processor was going to be tough. Most boards required a terminal or didn't have the features we needed. Sometimes you just have to build your own.

The search for a suitable micro-processor on which to base our board

brought us to Motorola and their MC68HC11EVB evaluation board. What impressed us about the MC68HC11 were its features and the extensive amount of development software available free from Motorola. We chose MC68HC11F1 chip over the MC68HC11A1 because it is nonmultiplexed, has more internal RAM (1K), has eight additional I/O pins, plus has all the other standard goodies.

Our single-board solution, dubbed the FS-100, includes the MC68HC11F1 processor, one RS-232 serial port, 64K of RAM, up to 32K of EPROM, an interface for a standard IBM PC-type keyboard, a TTL monochrome video interface, and a STD bus interface should expansion be necessary in the future. Figure 1 shows a block diagram of the board. Figure 2 shows a complete schematic for the board.

Figure 1 — The FS-100 single-board computer includes a Motorola MC68HC11F1 processor, RS-232 serial port, 64K of RAM, up to 32K of EPROM, IBM PC-type keyboard interface, TTL monochrome video interface, and STD bus interface.

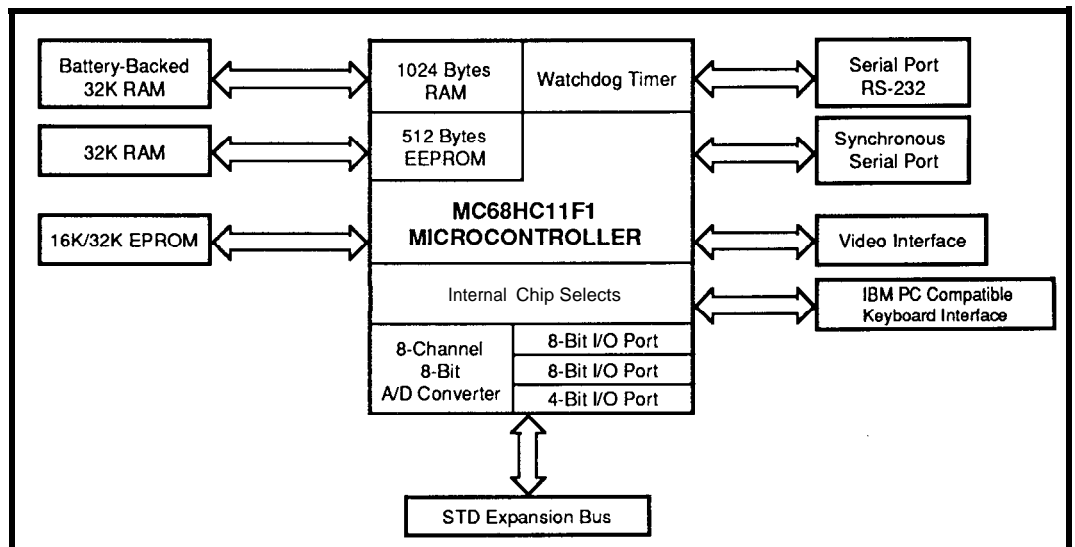
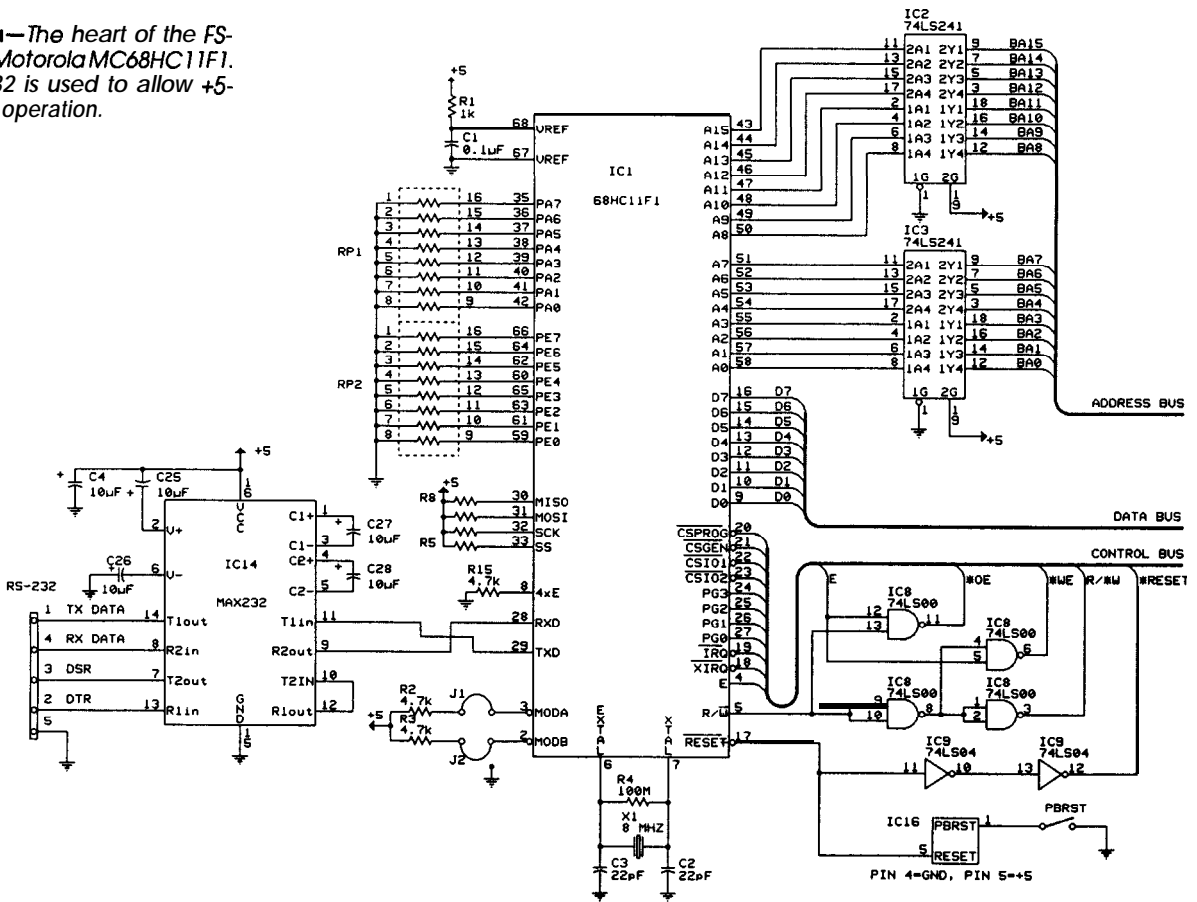


Figure 2a—The heart of the FS-100 is the Motorola MC68HC11F1. A MAX232 is used to allow +5-volt-only operation.

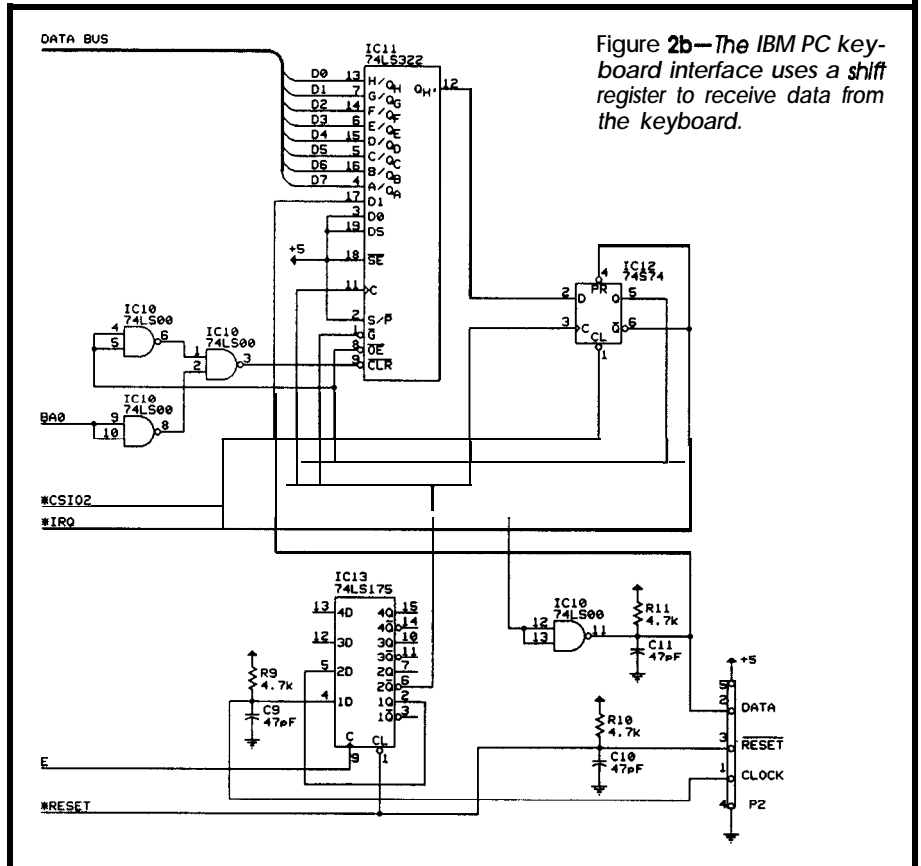


MC68HC11 PROCESSOR

The Motorola MC68HC11 micro-processor has proven itself time and time again in the embedded application arena as a highly capable player. Figure 3 summarizes the chip's features. In their article "Using the Motorola MC68HC11" in issue #18 of CIRCUIT CELLAR INK, Steve Ciarcia and Burt Brown did an excellent job of describing the processor, so we won't rehash it here.

Some elaboration of how the chip's ports are used is needed. In its expanded, nonmultiplexed mode, our MCU can address up to 64K bytes of address space. Port F is for high-order address bits output. Port C is where the bidirectional data bus appears. Port E can be used for general-purpose static inputs, A/D channel inputs, or both. Ports A, D, and G can be used for general-purpose I/O, although each has an alternate function. For example, port A bits control timer functions and port D handles

Figure 2b—The IBM PC keyboard interface uses a shift register to receive data from the keyboard.



serial I/O. Also, ports A and E are terminated with resistor packs that can be replaced with 0.1" header pins for external use.

Total board power consumption is 300 mA. The IS-100 runs a 2-MHz MC68HC11F1, however Motorola now has a 4-MHz version available.

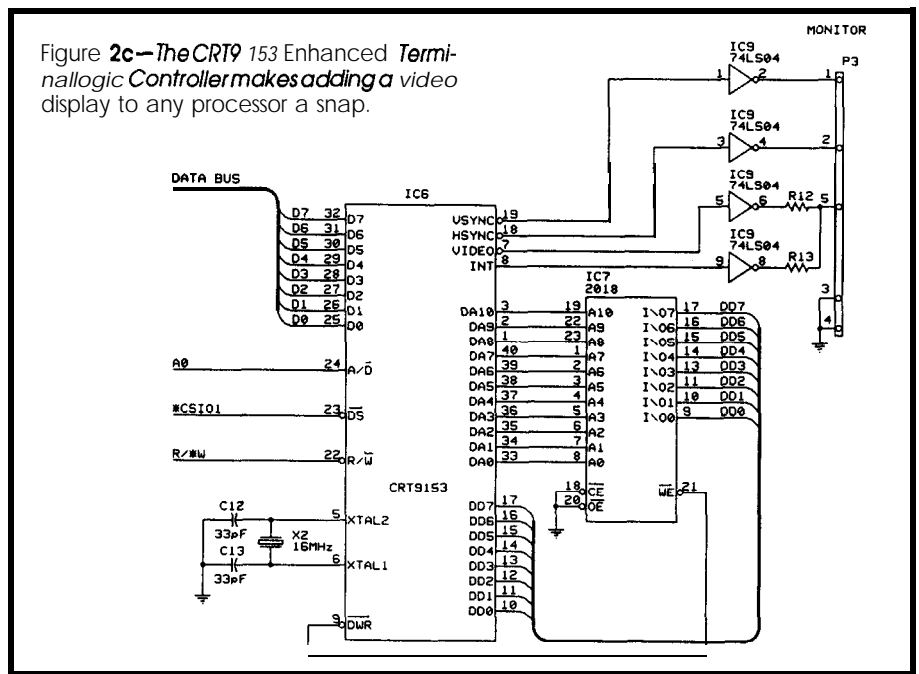
MEMORY

The FS-100's main RAM is mapped at \$0000-\$7FFF and its ROM at \$8000-\$FFFF. An additional 32K of optionally battery-backed RAM is mapped into the \$0000-\$7FFF range and used as a RAM disk. BASIC11's ESAVE and ELOAD commands, which are used to save and reload autostart programs, were modified to use the RAM disk. Either a 32K x 8-bit RAM or a Dallas DS1230AB battery-backed RAM can be used.

The MC68HC11F1 has four programmable chip selects: two for I/O (CS101 for keyboard and CS102 for video), one for main RAM (CSGEN), and one for ROM (CSPROG). The chip select control register enables the chips so they don't conflict with each other or with the processor's internal memory. The processor's PG2 output is used to select between the main RAM and the RAM disk.

KEYBOARD AND VIDEO

With cost effectiveness still in mind, we provide interfaces for a



standard IBM PC-type keyboard and a TTL-type monochrome monitor. The keyboard generates scan codes that must be converted by software to ASCII codes, as shown in Listing 1. We've made no attempt to fully support all the function keys and other extras supported by the keyboard. Feel free to expand on the software if such features are important to you.

The keyboard sends the scan codes back to the computer synchronously using a data line and a clock line. The data line feeds a shift register (IC11) clocked by the keyboard via IC13. When the last bit has been received, IC12 generates an interrupt (*IRQ), and the software puts the ASCII character in a RAM scratch

pad. The interrupt and shift register are cleared when the data is read from the shift register.

We used the CRT9153 Enhanced Video Terminal Logic Controller from Standard Microsystems Corp. for video output. It is a programmable 40-pin chip that combines video timing, video attributes, alphanumeric generation, and block graphics generation (a block diagram is shown in Figure 4). This chip (IC6), coupled with a 2K x 8-bit static RAM (IC7), gave us the features we needed for our control system. Most importantly, we needed reverse video, intensity control, underline, and block-type graphics with four to six independently addressable segments per

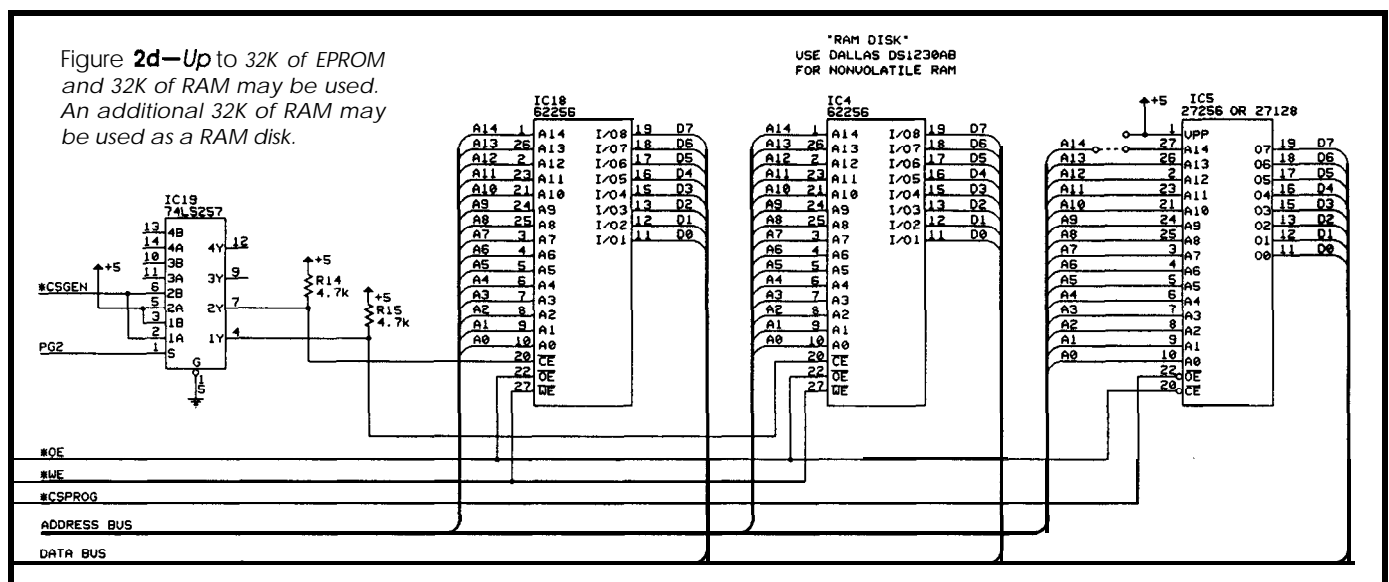
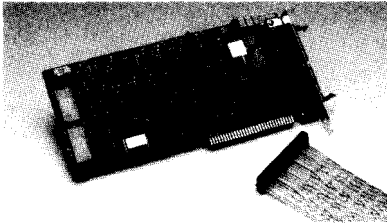


Figure 2d—Up to 32K of EPROM and 32K of RAM may be used. An additional 32K of RAM may be used as a RAM disk.

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Reader Service # 186

SINGLE-BOARD SOLUTIONS

| | | | |
|--|------|---------|--|
| CLRKEY | EQU | \$1800 | a read here resets the interface |
| KEY | EQU | \$1801 | read keystroke data here |
| JIRQ | RMB | 3 | irq jump vector is put into RAM |
| KPAD | RMB | 1 | keyboard interface scratch pad |
| START | LDAA | #\$7E | opcode for jump |
| | STAA | JIRQ | next 3 lines load jump vector |
| | LDX | #SCAN | for irq |
| | STX | JIRQ+1 | |
| | LDAA | CLRKEY | reset interface |
| | CLI | | clear all interrupt flags |
| * The MPU is put in a loop, waiting for irq from the interface | | | |
| SCAN | LDAA | KEY | read key (on irq, program jumps here) |
| | STAA | KPAD | |
| | ANDA | #\$80 | test for make or break code |
| | CMPA | #\$80 | is it break code? |
| | BNE | SCAN1 | no it is make code branch to scan1 |
| | LDAA | CLRKEY | yes it is a break code throw it away |
| | RTI | | return from interrupt; go back to loop |
| SCAN1 | LDAA | KPAD | get scan code |
| | LDX | #ATABLE | |
| | ABX | | |
| | LDAA | 0, X | convert to ascii |
| | STAA | KPAD | store ascii in scratch for later use |
| | RTI | | return from interrupt; go back to loop |
| ATABLE | EQU | * | |
| | FCC | " " | |
| | FCC | " " | |
| | FCC | "1" | |
| | FCC | "2" | |
| | FCC | "3" | |
| | FCC | "4" | |
| | FCC | "5" | |
| | FCC | "6" | |
| | FCC | "7" | |
| | FCC | "8" | |
| | FCC | "9" | |
| | FCC | "0" | |
| | FCC | "-" | |
| | FCB | \$7F | |
| | FCB | \$17 | |
| | FCC | " " | |
| | FCC | "Q" | |
| | FCC | "W" | |
| | FCC | "E" | |
| | FCC | "R" | |
| | FCC | "T" | |
| | FCC | "Y" | |
| | FCC | "U" | |
| | FCC | "I" | |
| | FCC | "O" | |
| | FCC | "P" | |
| | FCC | "[" | |
| | FCC | "]" | |
| | FCB | \$0D | |
| | FCB | \$5E | |
| | FCC | "A" | |
| | FCC | "S" | |
| | FCC | "D" | |
| | FCC | "F" | |
| | FCC | "G" | |
| | FCC | "H" | |
| | FCC | "J" | |
| | FCC | "K" | |
| | FCC | "L" | |
| | FCC | "," | |
| | FCC | ":" | |
| | FCC | " " | |
| | FCC | " " | |
| | FCC | " " | |
| | FCC | "Z" | |
| | FCC | "X" | |
| | FCC | "C" | |
| | FCC | "V" | |
| | FCC | "B" | |
| | FCC | "N" | |
| | FCC | "M" | |
| | FCB | \$18 | |
| | FCB | \$06 | |
| | FCC | " " | |
| | FCC | " " | |

For lower case letters you would have to set up another table and write a routine that would shift between the two. BASIC11 automatically converts lower case to upper case, so for our application lower case was not needed.

listing 1 — The scan codes from the IBM PC keyboard must be converted to ASCII.

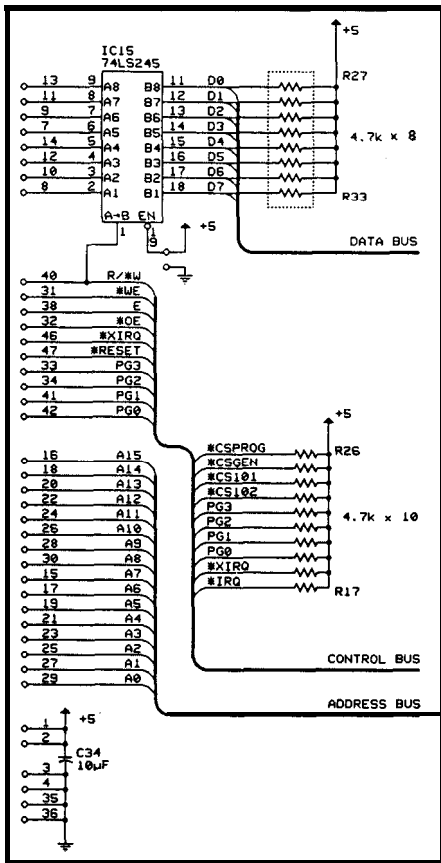
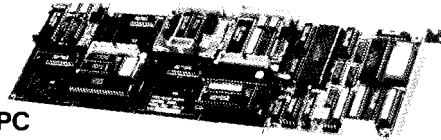


Figure 2e—The FS-100 STD bus connections.

Position and/or Velocity

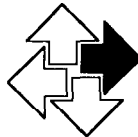
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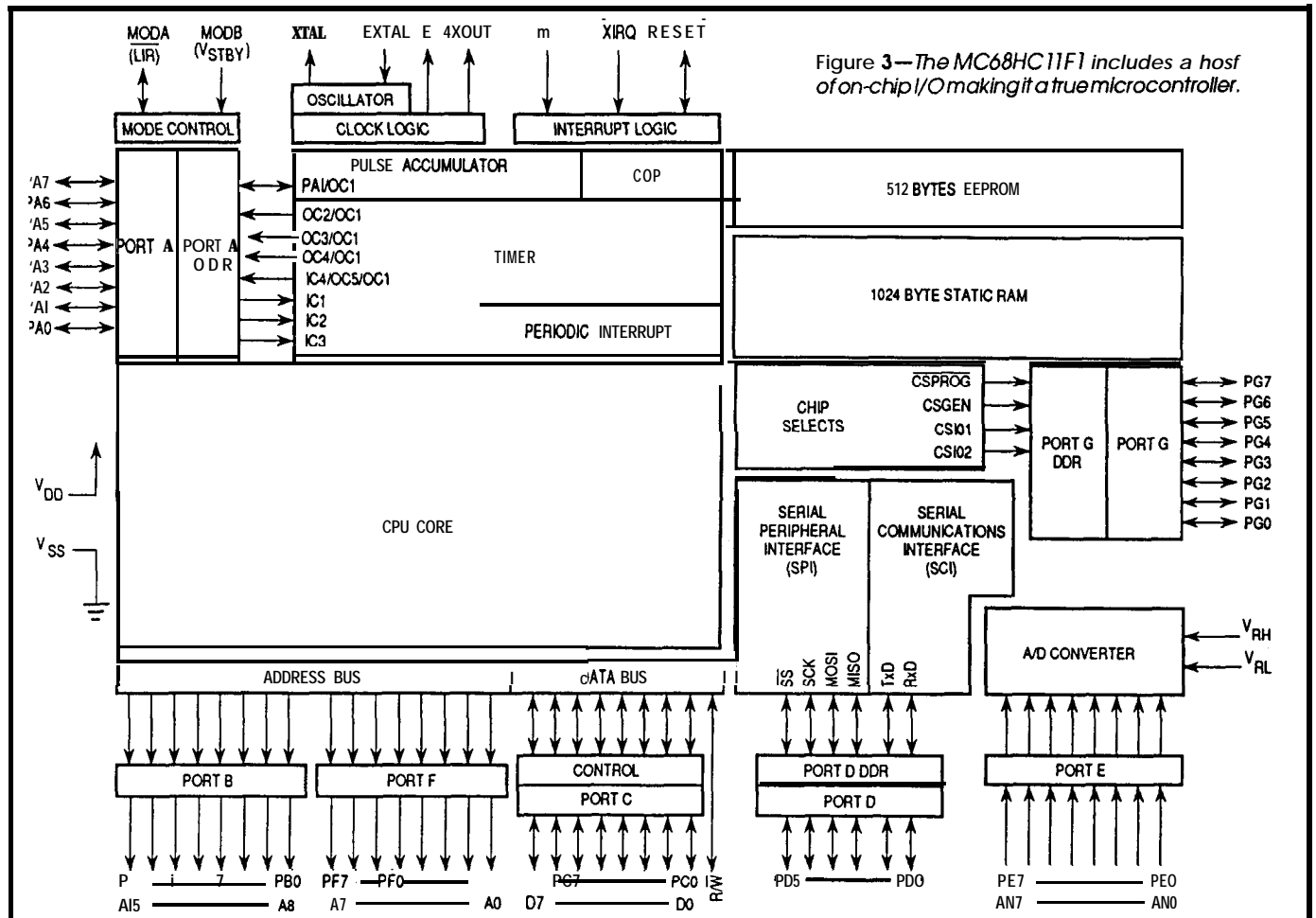


Figure 3—The MC68HC11F1 includes a host of on-chip I/O making it a true microcontroller.

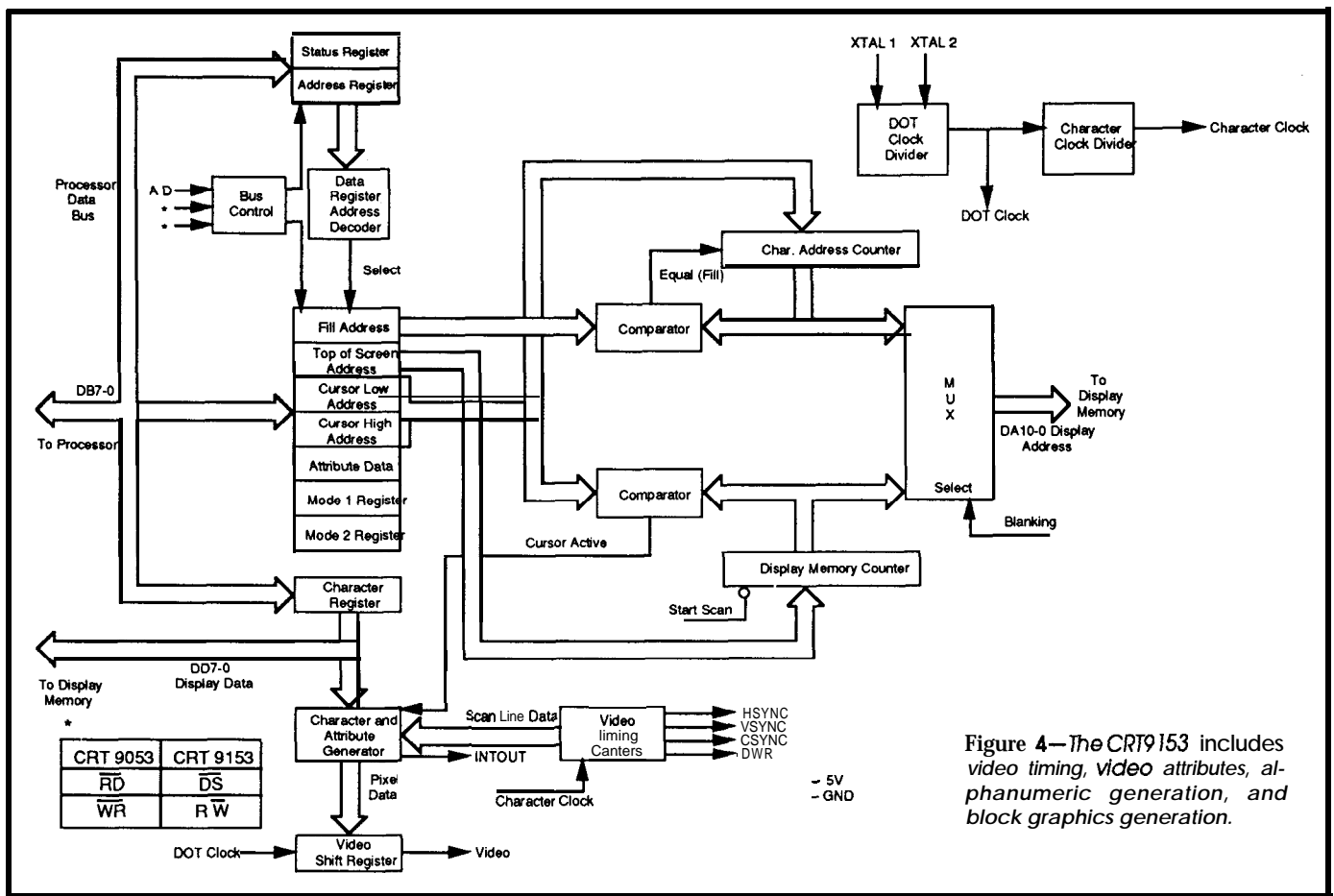
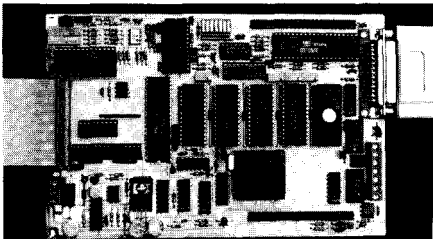


Figure 4—The CRT9153 includes video timing, video attributes, alphanumeric generation, and block graphics generation.

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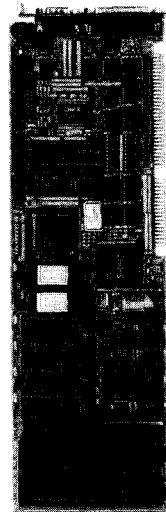
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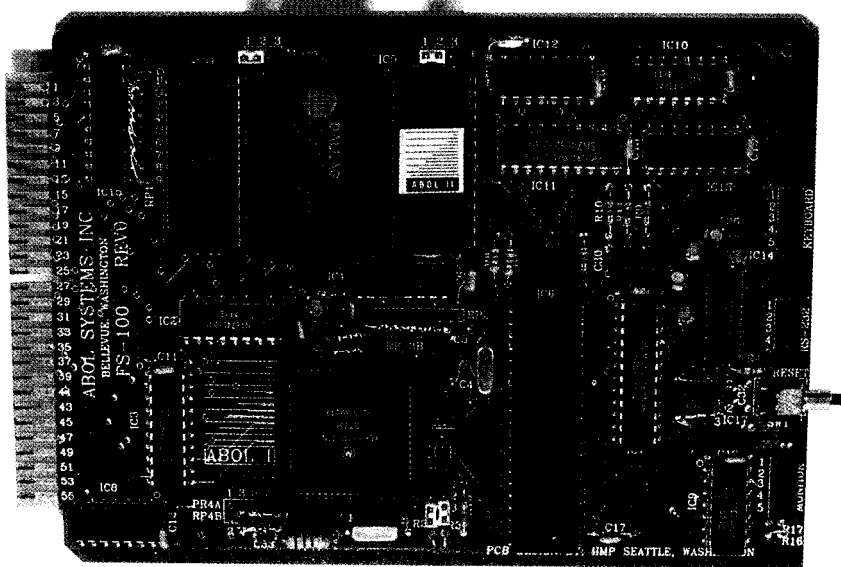


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character space. We used a 17.1072-MHz crystal for the video, but any crystal between 16 and 18.7 MHz should work fine.

The CRT9153 also supports RS-170 composite video output, so if you're looking for a display controller for a future product, be sure to keep this chip in mind.

SOFTWARE

Two pieces of software available from Motorola, the Buffalo monitor and BASIC 1, are all that is necessary to develop working code for the FS-100. Both programs were described in detail by Steve and Burt in the article we mentioned earlier, so, again, we're not going to repeat the discussion here. Since the software from Motorola uses the MC68HC11's serial port, we had to modify the software to utilize the FS-100's on-board keyboard and video. We also modified BASIC1's ESAVE and ELOAD commands to use the RAM disk, as we mentioned earlier.

CONCLUSION

The idea of a single-board computer is not new. However, it is hard to find one that will do all the tasks you require. After the best part of two years, our efforts resulted in the FS-100, which will serve as the heart of our communication projects and many other applications. Its small size and unique features make it perfect for use as a stand-alone data logger, home automation controller, and many other custom projects. ❖

For more information about the FS-100, contact ABOL Systems Inc., 13240 Northrup Way, Suite 21, Bellevue, WA 98005, (206) 747-8400.

Frank Swiger is the manager of the ABOL Systems Inc. Portland, Oregon office. He is involved in the design of hardware and software for data communication systems and point-of-sale equipment. @ Glover is the Vice President of ABOL Systems.

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3rd DESIGN CONTEST RESULTS

One method we use at CIRCUIT CELLAR INK to measure our growth and success as a magazine is the ever-increasing response to our annual design contest. Our third year has not disappointed us. Once again, we are impressed with the quality and innovation of the designs submitted, which made our job of choosing winners extremely difficult. Please join us in congratulating all your fellow readers who made the Third Annual Circuit Cellar Design Contest a success. Several of our entrants and winners will be featured in upcoming issues or Volume II of The Circuit Cellar Project File. For those of you who believe you can rise to our challenge, find the on button for your slide-rule and start thinking about next year. But for now, let us salute the winners.

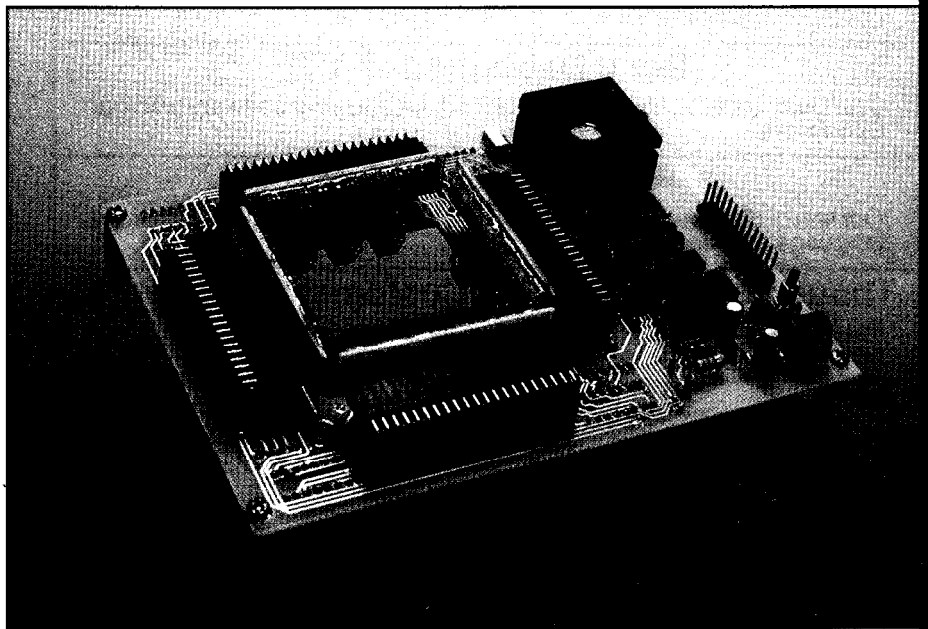
OPEN CATEGORY

First Place: \$500

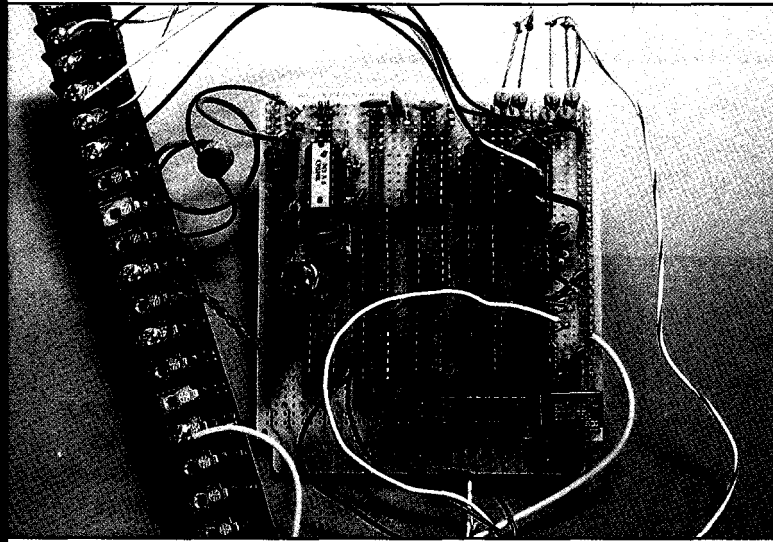
An MC68HC11-based Sensor for Two-Dimensional Position Measurement of Small Objects
by Brian Farmer

Brian's work in robotics led to his winning design of an MC68HC11-based sensor. He had programmed a robot to insert geranium cuttings into peat plugs with preformed holes. Unfortunately, the robot functioned with strictly vertical motions and had no regard for the natural curvature to the plant cuttings. The result was a large amount of damage. So Brian designed a sensor that could be used in a robotic work-cell for measuring the extent of bend in plant material. The device uses LED and phototransistor arrays mounted on opposite sides within a square housing.

Brian's sensor is conditioned and serialized by dedicated circuitry, and it is controlled and monitored by an MC68HC11 microcontroller. The unique functionality of Brian's entry won our hearts and won him first place.



COST-EFFECTIVE CATEGORY



First Place: \$500

The **ScopeMotor**, a Voice Operated Telescope Positioning System by Michael Swartzendruber

Amateur astronomers are presented with a unique working environment: darkness. Adjustments to a telescope must be intuitively made by hand. Voice control would be the most logical answer, and Michael has constructed one such system that is extremely economical. The system has three major areas: a voice signal input and analog signal conditioning circuit, a voice recognition chip (the **VCP-200**) from Voice Control Products Inc., and a stepper motor clock source and high-current

stepper motor drivers. The **VCP-200** module allows true speaker-independent operation of most telescope positioning functions.

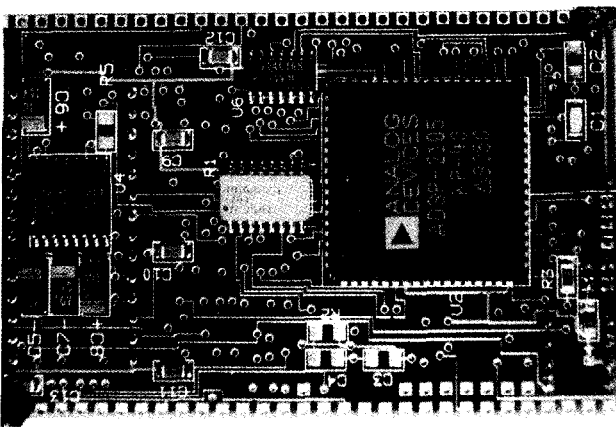
DSP CATEGORY

Our new DSP Category apparently took people by surprise. As a result, we had only one entry that truly fit the category and was good enough to be a winner.

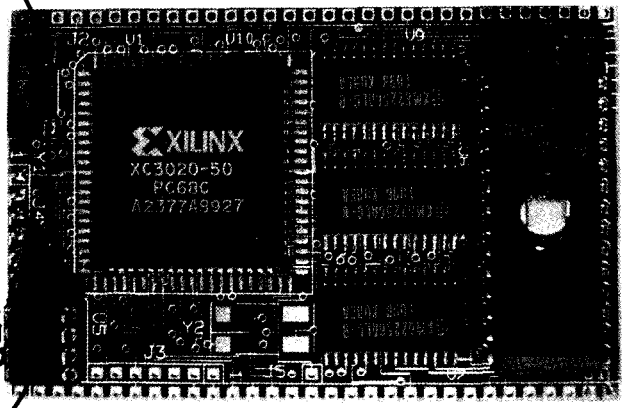
First Place: Analog Devices EZ-LAB Demonstration Board, "Digital Signal Processing Applications," "Digital Signal Processing in VLSI," and \$250

ADSP Module
by T. Bertinetti

Originating from France, this professional-quality, credit-card-size module uses the Analog Devices **ADSP2105** along with a combination of on-board peripherals to make a very small but powerful digital signal processing system. Running at 10 MHz, the **6-layer** surface-mount board includes up to 96K bytes of SRAM, up to 64K of EPROM, 2K bytes of EEPROM, a Xilinx programmable gate array, and an RS232 serial port. While designed for DSP applications, the ADSP Module is also well-suited to general embedded applications.

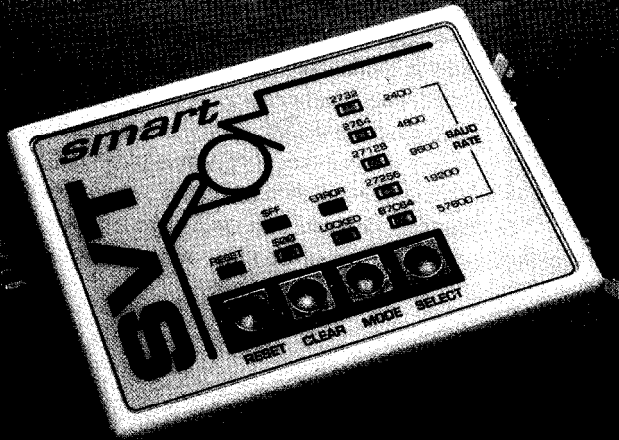


PC NOT SUGGESTED CORRECTLY!



3rd DESIGN CONTEST RESULTS

OPEN CATEGORY



Second Place: \$250

SmartROM
by Sanjaya Vatak

SmartROM, an intelligent EPROM emulator that needs only a standard RS-232 serial port as a host resource, is an exceptionally well-crafted device that uses either an **80C31** or an **80C32** microcontroller with firmware that can convert raw object files into binary EPROMs from 2732 to 27256. It can mimic the **87C64** EPROM with its on-board address latches. Sanjaya has built an emulator that is very fast, capable of downloading at most standard data rates up to 57,600 bps (115,200 bps using an **80C32**) without any handshaking or delays. We were especially impressed with SmartROM's flexibility: a choice of six different data rates, file detection when downloading, status

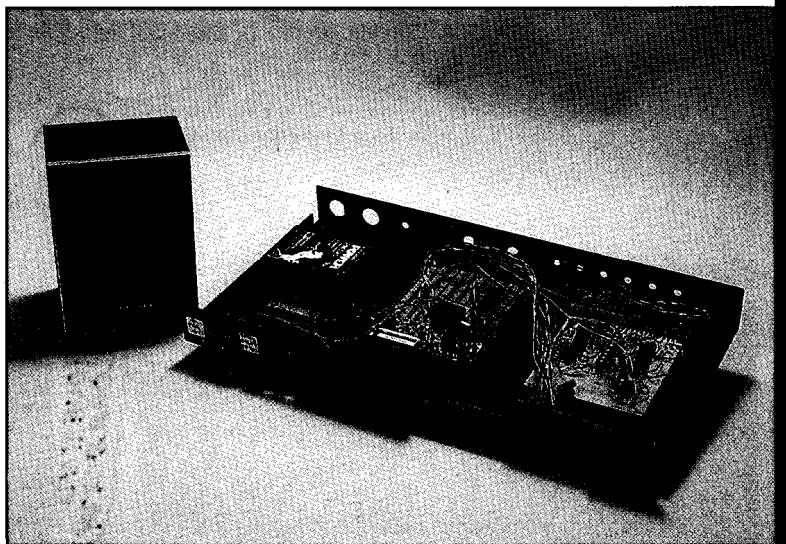
LEDs, and two options for blank state clinched second place for this project. Sanjaya also used ingenuity and creativity to give SmartROM professional-looking packaging using off-the-shelf materials.

COST-EFFECTIVE CATEGORY

Second Place: \$250

An RMS Limiter
by Bob Gardner

Bob developed the RMS Limiter as an alternative to the expensive electronic speaker processors available that monitor signal levels and turn the volume down before the speakers can be damaged. A Motorola **MC68HC11** is at the heart of this project, controlling a programmable attenuator circuit using input from a full-wave rectifier. Bob provides user feedback through a front-panel two-digit display.



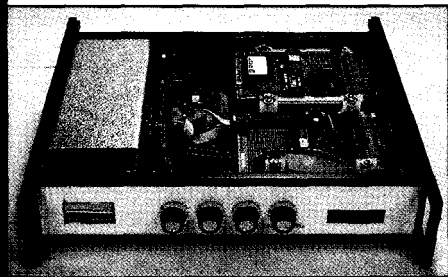
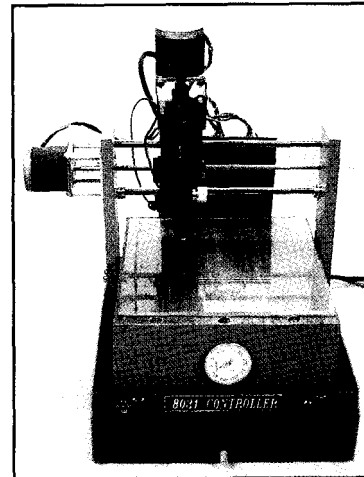
OPEN CATEGORY

As we said earlier, the quality of our entrants was exceptional. The level of excellence led us to no other choice but to award three projects ~~third~~ place.

Third Place: \$100 (three awards listed in no particular order)

The PC-Controlled XYZ Table
by Alan Rauscher

Alan used an IBM PC and an 8031 motor controller to achieve the extreme accuracy and repeatability that he needs when drilling printed circuit boards or panels. He also wrote a TSR in order to use the table to engrave signs, panels, or name tags using a CAD package, such as AutoCAD or FastCAD. The Dremel drill motor can be moved in three directions: X, Y, and Z, with Z as the vertical movement of the drill turret. What intrigued us about the XYZ Table was the degree of accuracy obtained using simple materials readily available. Although the table was constructed of wood, the drill is accurate to five thousandths of an inch and is suitable for a board or panel of 6 x 6 inches.



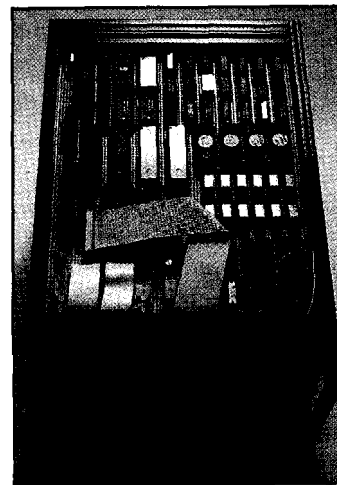
The GPZ8, an Audio Digital Sampling System
by Tom Nickel

The GPZ8, an audio digital sampling system, is a audio effects generator created by Tom to be used with musical instruments, primarily the electric guitar. Tom built the GPZ8 around the Zilog Z80 microprocessor to simplify redesign of functionality, reprogramming of internal EPROM, and revising software. The enclosure is a rack-mountable 19" x 4" x 12" and is powered by 110 VAC. The GPZ8 digitizes a guitar signal, stores it, and then plays it back in either forward or reverse, adding delays or changing the speed to produce an assortment of echoes and sweeping

reverberations. Specific effects can be chosen through two footswitches. Tom also added a 'fail-safe' circuit to protect a musician's performance should there be a malfunction or power difficulties.

PAWSDWC, A Power Arbitrary Waveform Synthesizer with Digital Waveform Capture
by Mark Wheeler

While the name is quite a mouthful (we defy anybody to pronounce it), we won't mumble when trying to describe this project. The list of supported functions would please anyone trying to work with analog signals: the PAWSDWC will capture and play back a waveform, plot the waveform on a printer using a standard Centronics parallel port, upload and download waveforms to and from an RS-232 port, allow hand-drawn waveforms to be digitized using a hand scanner for synthesis by the system, allow user control of input and output gains, and supply up to 40 volts peak-to-peak at 3 amps on its output. Mark intends to continue updating the system with new features in the future.

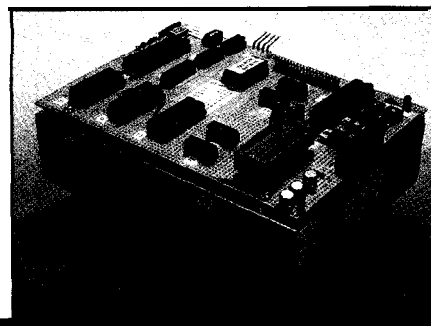


COST-EFFECTIVE CATEGORY

Third Place: \$100

The Control Power of Embedded Forth
by Thomas R. Barnett

Forth is still the language of choice among die-hard embedded-application engineers. Thomas based his Forth Design Center on a version of Zilog's Z8 processor with a built-in Forth interpreter. With the addition of some memory, a serial port, and an EPROM programmer, he put together a flexible system for doing Forth program development.



DEPARTMENTS



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Firmware Furnace



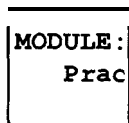
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From the Bench



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Silicon Update



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Domestic Automation



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ConnectTime

Micro-C, LEDs, and a Rotary Encoder

Sturgeon's Rule has it that 90% of science fiction is junk. A similar rule applies to PC software, but I'd say that 90% is a lower bound. Once in a while, though, you find a product that makes up for the rest.

As longtime Furnace readers are well aware, I've been examining 8051 C programming for quite a while. Although I remain entirely underwhelmed by the tonnage of machine code per C instruction, I concede that C helps you produce better programs more quickly. As long as you keep the overall size of the project within reason, C is the way to go.

However, the cost of most 8051 C compilers and assemblers has been prohibitive for people who simply want to find out what all the fuss is about. That situation is now ended; the compiler I used for this project costs \$50 and the companion assembler weighs in at \$25. And best of all, they are excellent-quality tools that you need make no apologies for owning.

The project this time is an all-digital combination lock with an RS-232 output. The topic is certainly not original, but it's a convenient way to illustrate a C program that handles interrupts, updates an LED display, and works in 128 bytes of Internal RAM. In fact, the lock makes an ideal 8751 project because it uses only about 2K of code space (even in C!).

AN HONEST LOCK

A standard combination lock, familiar to you from years of locking your bike to utility poles, has a digital dial. You twist it one way to set the first number, reverse course for the second number, and then back again to the final count. If you start out in the right direction and get all three numbers correct, the lock pops open. Of course, you can also slip a shim down the hasp and flip it open without knowing the combination, but that's another story.

The digital combination lock mimics that user interface, but improves on the display and overall security. Turning the knob updates one character in the display. Once you've got the right value, you pause and the next character lights up. Adjust all four correctly and the lock pops open.

The difference is the digital lock can't be shimmed. The four-character combination is sent over an RS-232 link to a remote location where it is compared (perhaps by the PC controlling the rest of your house?) to the correct combination. If it matches,

FIRMWARE FURNACE

Ed Nisley

the central computer activates the electric lock. Indeed, you can vary the combination by time of day or use it to track which of several authorized people gained access.

Why not have the combination(s) stored in the 8031 so it can activate an output bit that drives the lock? Think about it: all a perpetrator need do is smash the box, rip out the guts, find the wire that obviously goes to the lock (because it has a relay on the CPU end!), and short the wires to the power supply.

Age and treachery will always overcome youth and innocence.

With that in mind, I've packaged the guts in a simple plastic case that is not suited for high-security outdoor use. I'll leave it to you to armor-plate and weatherproof as needed for your application. There is one unused I/O bit, so if you really want to add an unlock function, have at it. Just don't call me afterwards.. .

SENSING ROTATION

A push button is the archetypal digital input device because firmware can make two buttons produce "up" and "down" counting sequences. However, some situations call for a rotary knob. When you're peering

into a 'scope while tweaking an output to perfection, the time-tested user interface is a knob: clockwise for more, counterclockwise for less, a fast twist for a bunch, a slow turn for an itsy, and hold still while you think. You don't have to wonder which button you're pressing and how long to hold it down before it auto-repeats on you....

While you can read a standard analog potentiometer with an analog-to-digital converter, a better solution is an all-digital, panel-mounted rotary encoder with TTL-compatible outputs. The processor interface re-

quires just two bits: one generates an interrupt as the knob turns while the other indicates rotation direction. What could be easier?

The most common type of rotary encoder uses a masked wheel and a pair of photodetectors as shown in Figure 1. As you twist the knob, the wheel turns and the photodetectors report whether they "see" their respective LEDs through the mask or not. The mask shown in the figure produces only two pulses per revolution per detector, but real-world units will give you a hundred to several thousand pulses.

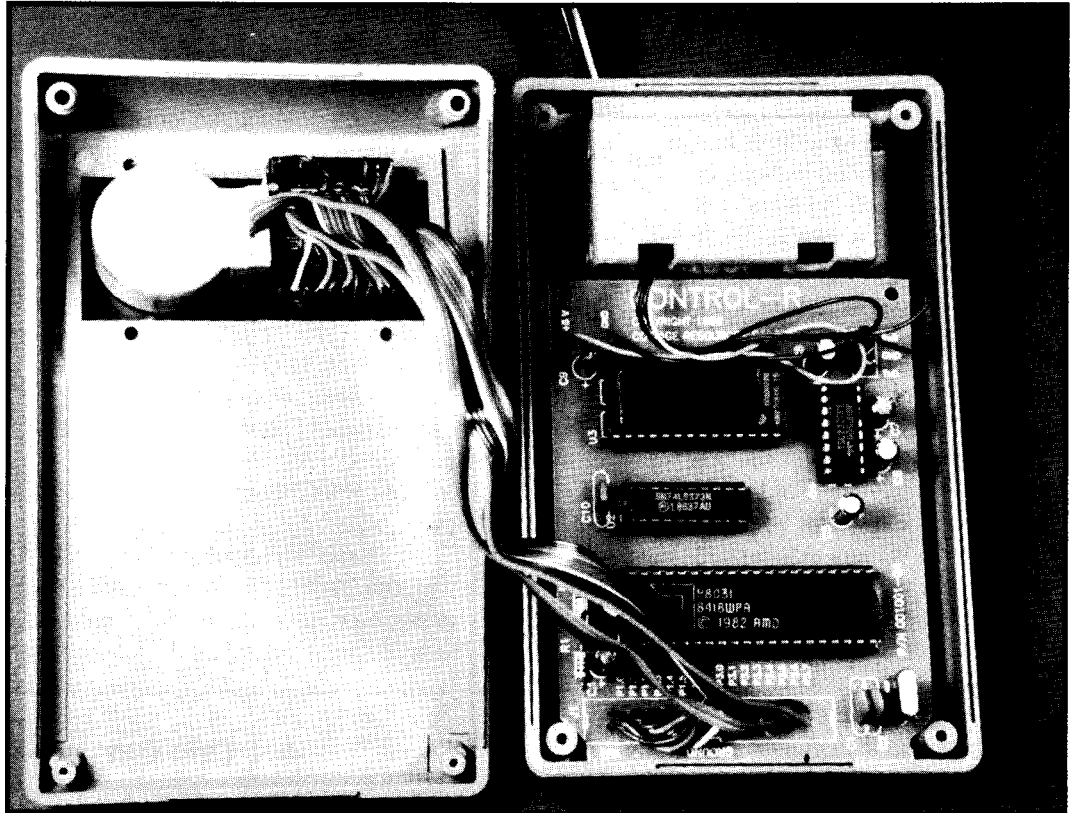


Photo 1—The computer, rotary encoder, and display fit nicely in an off-the-shelf plastic box.

Figure 2 holds the key to using a rotary encoder. The photodetector outputs, commonly called Phase A and Phase B, are in "quadrature," which is a fancy way of saying Phase B has a 90° phase shift relative to Phase A. The sign of the phase shift depends on the rotation direction: -90° for clockwise, +90° for counterclockwise.

However, actually figuring out the direction doesn't involve trigonometry, phase angles, or complex calculations. Simply monitor Phase A for a 1-to-0 logic transition; if Phase B is high immediately after the transition, then the wheel is turning clockwise. If Phase B is low, it's going counterclockwise.

The most practical way to monitor the encoder is to write an interrupt routine triggered by Phase A. When an interrupt occurs you know that Phase A has just gone low, so reading Phase B gives an immediate indication of the direction. Each interrupt represents 1/N-th rotation, where N is the number of pulses produced per full turn. A simple signed variable can hold the number of counts; the interrupt routine increments the variable for each clockwise event and decrements it for each counterclockwise event. A count of +N means the wheel has gone one full turn clockwise, -N means the same but in the other direction.

The connections for a Clarostat Model 600-128 rotary encoder are shown in Figure 3: Phase A goes to the INTO input on pin 12 and Phase B goes to pin 15. The encoder draws about 30 mA from the +5 V supply for its LEDs, photodetectors, and buffers. As you might guess from the model number, the 600-128 produces 128 counts per revolution and gives about 2.8° per count.

Incidentally, the patterns on the encoder wheel can be arranged in two ways. If you shift the Phase B pattern by 90° it will move the output signal by 90° (think about it) and reverse the sense of rotation. The Clarostat encoders use this pattern, so expect

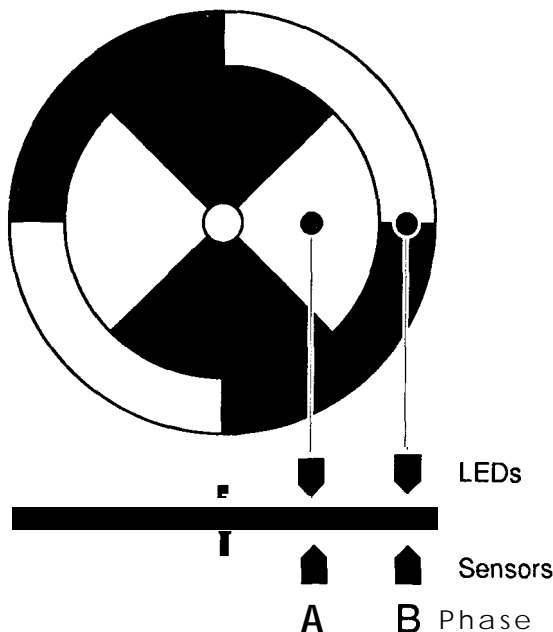


Figure 1—This rotary encoder produces two pulses per revolution per detector.

to flip your code no matter how careful you are.

Listing 1 shows the Micro-C code needed to update a 16-bit variable on each Phase A interrupt. Micro-C does not support the "interrupt" keyword provided by some other C compilers, but the in-line assembler code needed to save and restore the CPU registers is quite simple.

Micro-C can't handle a hardware bit directly, so the TESTBIT macro uses a few assembler instructions to copy the Phase B input bit into a C

variable. TESTBIT ensures the variable will be 0 if the bit is low and 1 if the bit is high; although this verification is not strictly necessary, it makes tests against 1 meaningful.

Apart from those instructions, the code needed to decipher the encoder's state is a single `if` statement. That's simple enough.

Also, you can use encoder interface ICs that handle all the details without interrupting the CPU. These chips would be appropriate for high-performance applications that require extreme precision and rapid rotations. For monitoring a knob on a panel, firmware alone will suffice! Jeff tells

me he's collecting information for the definitive encoder tutorial but won't commit to a date—stay tuned to his "From the Bench" column for more details.

With input in hand, we can look at the output display.

CLASSIC CHARACTERS

Although LCD panels are probably the best overall display for small embedded systems, there are some situations where they are not appro-

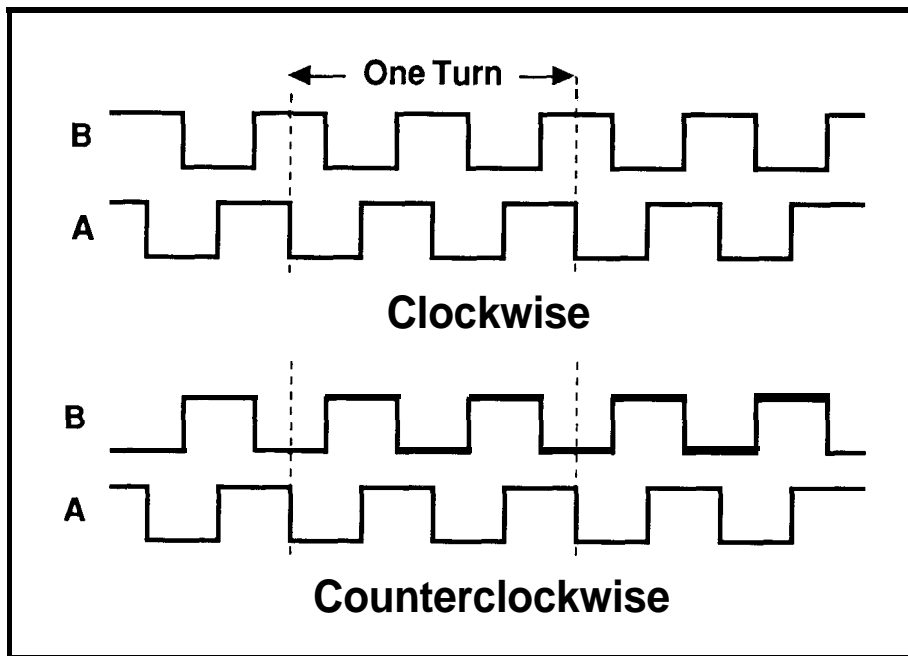


Figure 2—Photodetector outputs have a 90° phase shift that depends on rotation direction.

priate. If you need high contrast, good night visibility, or just a tiny package, LEDs are hard to beat. The only catch is raw LED characters tend to use either lots of cheap components or a few expensive ones.

The display for this project is an oldie that solves the component count and cost problems: the Litronix DL-1416 4-character X-segment alphanumeric display. My data sheet is dated July 1979, which should give you some idea of when these things first came out.

Back when TV sets were small and dollars large, you could get a magnifying lens for that "big screen" effect. The DL-1416 has teeny-tiny LED segments and a big lens bubble over each character. You need to be directly in line with the optical axis to get a good view, but for a lock that's not a disadvantage at all: how many people do you want scrutinizing your combination?

The DL-1416 handles all the LED multiplexing and refreshing without an external clock input. It is not a low-power device: the data sheet specifies 35-100-mA drain from the +5-V supply. The interface is quite simple, with two address bits selecting one of four characters, six data lines for the ASCII character, and a write strobe to load the data. A chip enable simplifies multichip displays and a unique cursor function.

The DL-1416 timings are lethargic by contemporary standards. The address and data setups are 1000 ns and the strobes must be at least 500 ns wide. The simplest 8031 interface uses I/O port bits to drive the control lines, although other CPUs allow wait states to match the bus to the display.

Figure 3 shows the connections required to bring the DL-1416 to life. The -CE (Chip Enable) input is grounded because I only needed one unit, so the device is always enabled. Power goes to pin 18, ground to pin 19, and the remaining pins are not used.

Although the DL-1416 uses the ASCII character set, it includes only codes 20 hex (space) through 5F (underscore). This range includes the common punctuation symbols, nu-

meric digits, and upper-case letters. The chip does not convert lower-case letters and does not include some useful symbols, but on the whole it beats building discrete LEDs.

THE REST OF THE HARDWARE

Apart from the obligatory 8031 CPU, address latch, and EPROM, the only other chip is a MAX232, which converts serial port signals between RS-232 and TTL voltage levels.

As you can see in Photo 1, I used a Cottage Resources Control-R board for this project. While suitable for only the smallest projects because it has a 2764 EPROM and no provision for external RAM, it works well when the job fits. I had to nibble off only two corners to shoehorn it in the enclosure.

The Control-R does have an anomaly that can cause considerable headscratching. I routinely use an EPROM emulator instead of burning EPROMs, so I was surprised when neither of my emulators worked on the Control-R board. EPROM pin 26 turned out to be tied to 8031 pin 26, although it's not shown on their schematic. If the board were to use a 27256, pin 26 would be address bit 13 and the connection would make sense. However, the board uses a 2764, which shows pin 26 labeled as "no connection." The processor's A13 was driving the pin to a state my emulators weren't expecting. Also, EPROM pin 1 is tied high, not low as shown in their schematic.

The catch is both of my EPROM emulators require all unused pins to be either disconnected or pulled up. After I tied pin 13 high, both emulators (and the EPROM!) worked correctly.

Moral of the story: take nothing for granted!

INTRODUCING MICRO-C

With so little hardware, the firmware must obviously provide the majority of the lock's functions. Before diving into the code, I should explain a little about Micro-C so you know what to expect.

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The Micro-C compiler is a front-end translator that produces intermediate code. A CPU-specific code generator translates that code into assembly language statements, which then go through the appropriate cross-assembler to produce a HEX (or for PCs, EXE) file. The compiler and assemblers are available for a bewildering variety of CPUs: 80x86, 8080/Z80, 8051/31, 6811, 6809.. essentially all the popular micros.

The C dialect is "K&R" rather than "ANSI," so much of what you read about C nowadays does not apply: no function prototyping, no argument checking, no single-line comments, and so on. There are some non-standard extensions and quirky idioms ("register" instead of "near"), but the code is at least nominally portable to other compilers. It is entirely usable and a generation of C programmers got along well enough without the new ANSI standard features.

Of course, that same generation is responsible for C's reputation as a write-only language used to create programs full of bizarre tricks and obscure bugs. You get out what you put in: be neat, be discreet, and stay OK; be tricky and get dead.

The 8051 C compiler supports TINY, SMALL, COMPACT, MEDIUM, and LARGE memory models. You can use in-line assembler code for speed when it counts. The start-up code includes a tiny debugging kernel that you can use (I haven't, yet) to get your code working directly on the target hardware.

Dunfield also has an 8051 CPU simulator that shows the current CPU state, disassembles the instructions, and dumps Internal and External RAM. It can connect to a debugging kernel on the 8031 (through the serial port) to report and control the state of I/O ports. The current version works at the assembly language level and does not include symbolic information, but he is considering adding that feature and creating a C source level debugger as well.

The full-up Micro-C package comes with source code for everything: compilers, assemblers, run-time libraries, simulator, utilities, you name it. The 8086 compiler can rebuild itself, as well as the other programs, using the MAKE files included to simplify the process (you get the MAKE program and source, too). There are dozens of sample programs.

To put this compiler in perspective, everything described above will set you back slightly over \$100 including shipping.

Obviously, we are talking obsession here. Dunfield's code is good, tight work that I'd be proud to have written. His style is somewhat idiosyncratic, as you would expect, but he knows what he's doing and can explain (or at least justify) his design decisions without retreating into mysticism. Once again, his products show that the best PC programs come from one person in pursuit of a vision.

And I have yet to hit a compiler bug. Enough said?

MICRO-C AT WORK

As you saw in Listing 1, the Micro-C language requires some help to handle the (admittedly bizarre) 8051 architecture. The LED output routines provide a better look at what's needed to write hardware-specific code with a general-purpose language.

Remember, Micro-C was designed as a portable compiler to produce code for a variety of machines. The compiler is not the place for 8051-specific features and quirks; those be-

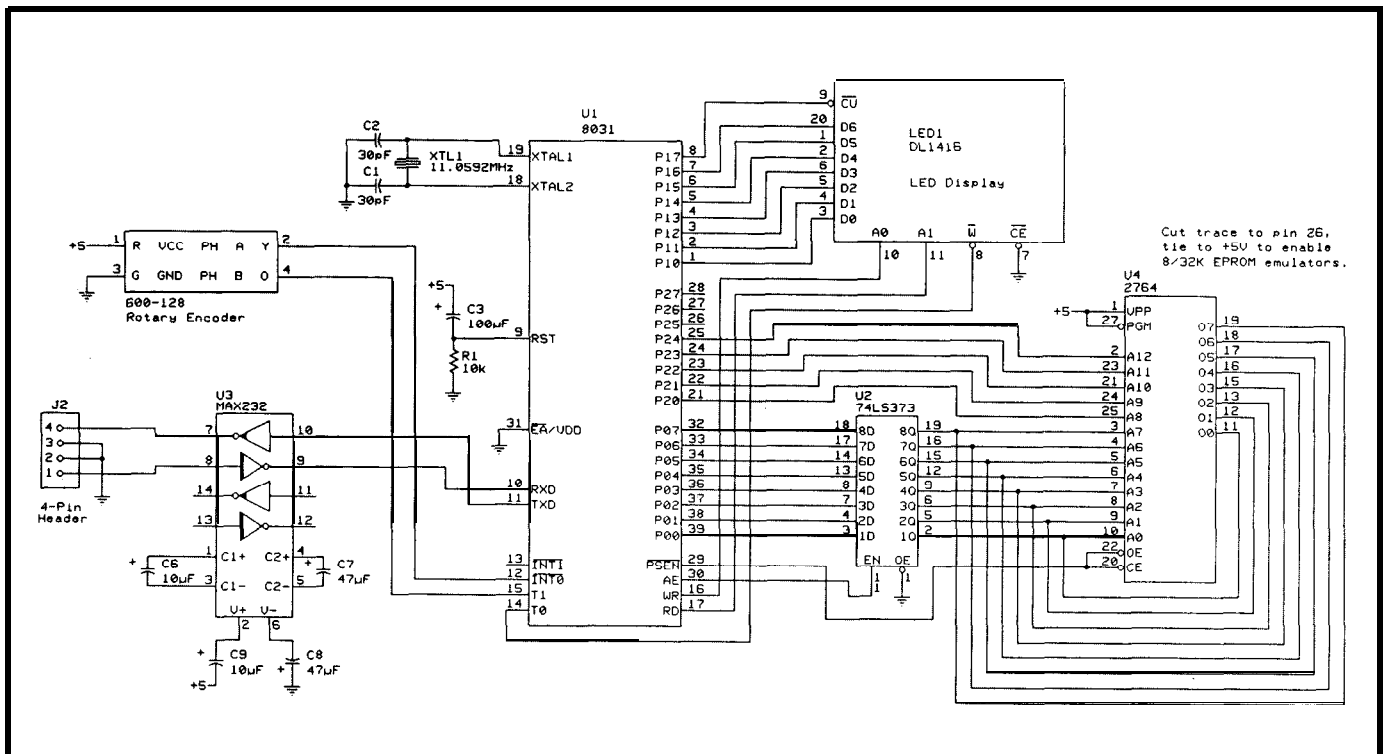


Figure 3—Using a standard 8031 circuit for its core, the electronic combination lock requires little additional circuitry to interface to the rotary encoder and LED display.

long either in the run-time library as callable functions or embedded in the code as in-line assembler sequences. You can buy tailored compilers, but they sacrifice portability for access to the 8051 market.

That's what tradeoffs are all about.

In any event, the code required to adapt Micro-C to the 8051 is not particularly burdensome. The TESTBIT macro in Listing 1 is an example: a few instructions to set up a C variable from an 8051 hardware bit. Yes, It Would Be Nice if Micro-C

would allow hardware bits in conditional tests, but a few instructions is not a big price to pay for generality.

The SETBIT and CLRBIT macros are #defined to insert a single assembler line into the C code: SETBIT translates into SETB and CLRBIT becomes a CLR instruction. Even a tailored language would be hard-pressed to do better than that!

WriteLED () starts with a loop that updates each of the four display characters. The DL-1416 puts character 0 on the right, but it is most natural for C strings to start with charac-

```

/*-----*/
/* Global variables and bit definitions */
#define PHASEB P3.3 /* rotary encoder B phase input bit */
NEAR int EncCounter; /* raw encoder counts */
NEAR BYTE PhB; /* temp variable for bit testing */

/*-----*/
/* Bit test function */
/* MC can't do an 'if' directly on an 8051 bit variable */
#define TESTBIT(byte,bit) \
#asm \
    CLR A \
    MOV C,bit \
    MOV A.0,C \
    MOV byte,A \
#endasm

/*-----*/
/* External Interrupt 0 handler */
/* This is triggered by Phase A of rotary encoder going low */
ExtInt0() {

/*--- save regs */
#asm
VExtInt0 EQU *
    PUSH A
    PUSH PSW
    PUSH B
tendasm

/*--- decide which way we're turning */
    TESTBIT(PhB,PHASEB);
    if (PhB) {
        --EncCounter;
    }
    else {
        ++EncCounter;
    }

/*--- restore regs and return... */
#asm
    POP B
    POP PSW
    POP A
    RETI /* preempt normal return */
tendasm

```

listing 1 -Each encoder Phase A pulse produces an interrupt on the INTO line. This interrupt handler checks the PHASEB input to determine which way the encoder wheel is turning and adjusts the EncCounter variable accordingly.

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ter 0 on the left (you think of LedChars[0] as coming before LedChars[1]). The six lines of assembler invert the Index variable to change the character order and transfer the value to the output bits driving the DL-1416 address pins.

You could use this Micro-C statement to set the DL-1416 address bits within the loop:

```
P3=(P3&0x3F) | (~Index<<6),
```

which might (ideally!) compile to something like:

```
MOV    A,P3
ANL    A,#$3F
MOV    B,A
MOV    A,Index
CPL    A
RR     A
RR     A
ANL    A,#$C0
ORL    A,B
MOV    P3,A
```

But immediately after that C statement executes, the rotary encoder stops working. The reason is the P3 bits picked up on the right side of the statement (by MOV A, P3) include the current encoder output bits. If either of those bits is zero, the value assigned to P3 on the left (by MOV P3, A) sets the corresponding output latch bit to zero.

Now, we all know the input value read from an 8051 CPU port is the logical AND of the output latch and the pin state, right? So there should be no surprise that a zero latch forces the input to look like zero. Hmmm?

Even if you use a tailored language you must know exactly how the hardware works to get the correct result. I'd be slightly embarrassed to admit how often I've flubbed this one, so we shall discuss it no further. However, the error is much, much harder to find when a high-level language makes I/O operations look just like memory operations; after all, if an operation works on variables, remembering it won't work on ports is hard.

The bottom line is that the relatively few things Micro-C can't handle directly can be simulated by C (or

```

/*-----*/
/* Global variables and bit definitions */
#define NUMCHARS 4 /* number of LED characters */
#define LEDWR P3.4 /* LED -WR write strobe */
#define LEDCU P1.7 /* LED -CU cursor enable */
#define LEDA0 P3.6 /* LED address bit 0 */
#define LEDA1 P3.7 /* LED address bit 1 */
#define LEDDATA P1 /* LED character data */

#define BLINKCODE ' ' /* "off" character during blinking */
#define CURSORCODE ' ' /* background when cursor goes away */

/*-----*/
/* Bit set and clears */
#define SETBIT(bit) ; \
asm \
    SETB bit \
endasm

#define CLRBIT(bit) ; \
asm \
    CLR bit \
endasm

/*-----*/
/* Write all digits to the LED display */
/* We invert the order of the characters to make LedChars */
/* readable and easy */
WriteLED() {
    for (Index = 0;
        Index < NUMCHARS;
        ++Index) {
asm
    MOV    A,Index
    CPL    A /* swap left<->right */
    MOV    C,A.0 /* set up address bits */
    MOV    LEDA0,C
    MOV    C,A.1
    MOV    LEDA1,C
endasm

    TempChar = LedChars[Index]; /* pick char from array */

    TESTBIT(TestBits,FlagBlinkEn);
    if (TestBits) {
        TESTBIT(TestBits,FlagBlink);
        if (TestBits) {
            if (Index != CursorIndex) {
                TempChar = BLINKCODE;
            }
        }
    }
    LEDDATA = TempChar;
    SETBIT(LEDCU); /* turn off cursor strobe */

    CLRBIT(LEDWR); /* write the data bits */
    SETBIT(LEDWR);
}

/*--- set up cursor character overlay */
/* the cursor is always written and goes OFF by default */
TempByte = 0; /* assume cursor should go off */
TESTBIT(TestBits,FlagCursorEn);
if (TestBits) {
    if (CursorIndex < NUMCHARS) {
        TESTBIT(TestBits,FlagCursor);
        if (TestBits) {
            TempByte=0x08 >> CursorIndex; /* put cursor on char */
        }
    }
}
LEDDATA = TempByte; /* Cursor Enable bit is 0 = ON */
CLRBIT(LEDWR); /* write the cursor bits */
SETBIT(LEDWR);
}

```

Listing 2—The DL-1416 LED display is controlled entirely through CPU I/O port bits. The firmware must set up the data and toggle the control lines to write characters and position the cursor.

assembler) functions or in-line assembler code (perhaps disguised by a #define to look like a function).

The remainder of the C code for the combination lock looks just like C code you'd find anywhere else. That's the good thing about C; most of the code in any project has nothing to do with the 8051 itself, so using a higher-level language to get the most done with the least effort makes sense. The digital lock's complete source code is available on the Circuit Cellar BBS as usual. [Editor's Note: Software for this article is available from the Circuit Cellar BBS and on Software On Disk #24. See page 105 for downloading and ordering information.]

IS MICRO-C FOR REAL?

Despite my admiration for Dunfield's work, Micro-C is probably not the ideal C for very complex projects. I've gotten used to ANSI C features and the error checking built into current compilers. In addition, high-end compilers support full C source code debugging, which greatly reduces the time required to get a project running. When you're doing this stuff for a living, the return on investment can be compelling.

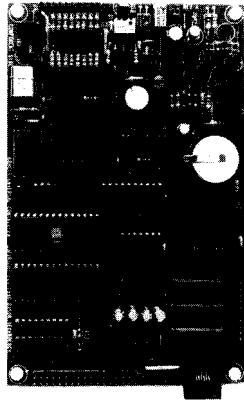
With that in mind, I plan to use Micro-C for many upcoming Firmware Furnace projects. The compiler produces code for Motorola micros as well as the Intel family, but I don't expect to write much portable firmware because the bit blasting doesn't convert nicely. Stay locked in for some interesting stuff...and suggestions for topics are always welcome.

If the price of entry has kept you out of the microcontroller C market, you have no further excuses. Micro-C is as good as it gets!

CREDITS AND SOURCES

David Penrose's "Electronic Combination Lock" entry in the Second Circuit Cellar INK Design Contest inspired the topic. He captured Third Place in the Cost Effective category and followed up with a chapter in *The Circuit Cellar Project File, Volume I*. His lock used a 8748 CPU

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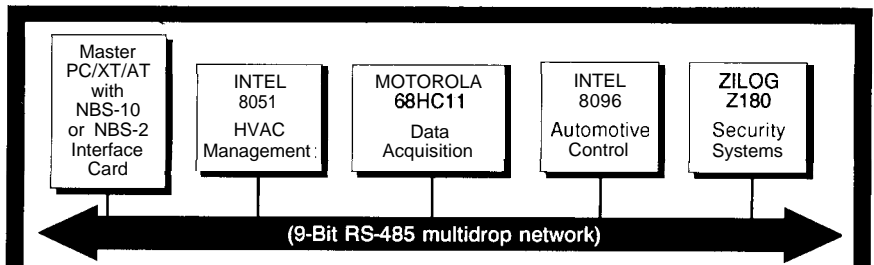
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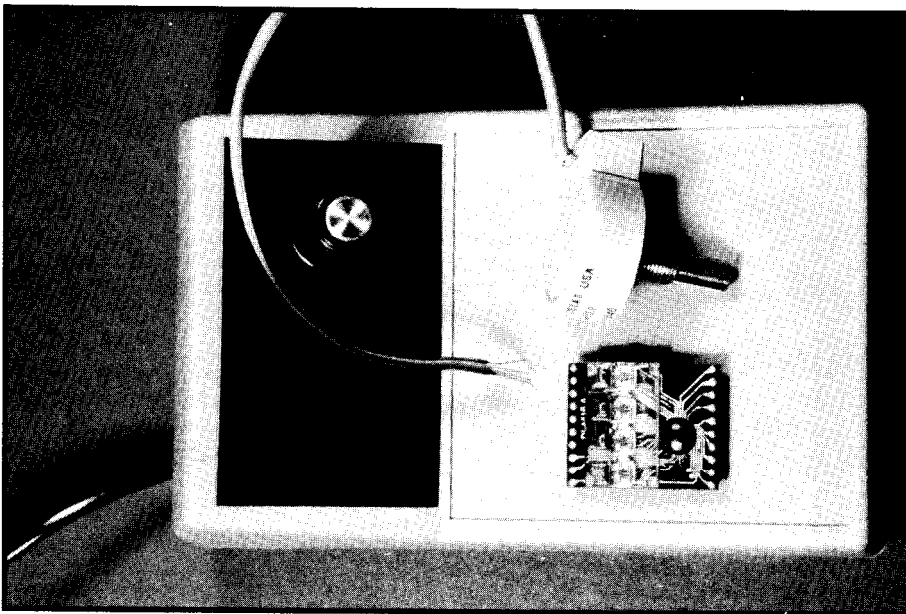
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Reader Service #121



and 7-segment LEDs controlled by a clever assembly language program, so our projects don't have much in common apart from the rotary encoders. Indeed, you might want to compare how our programs solve the same problems in different ways.

A demo version of Dave Dunfield's Micro-C is available on the Circuit Cellar BBS, but it produces

Intel 8086 code for the IBM PC and is not directly useful for 8051 projects. He has bundled the 8051 Micro-C compiler, cross-assembler, simulator, and a bunch of handy utilities into an "8051 Developers Special" for \$99.95 plus \$4/\$6 for surface/air shipping to U.S. or Canadian addresses.

He will send a catalog of his products and prices if you send a stamped

self-addressed envelope. If you can't wait to order, make your check payable to Dave Dunfield at: Dunfield Development Systems, P.O. Box 31044, Nepean, Ontario (Canada), K2B8S8. Tell him I sent you. . .

The Control-R board is made by Cottage Resources; see their ad in the pages of this magazine for details.

The rotary encoders and LED displays are available from your usual electronics distributors. They also appear regularly in mail-order surplus outlet ads, so keep your eyes open for good deals. My DL-1416s came from my junk box, so I haven't actually placed an order for them in a long time. ❖

Ed Nisley is a Registered Professional Engineer and a member of the Circuit Cellar INK engineering staff. He specializes in finding innovative solutions to demanding and unusual technical problems.

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Electronic Identification

Rockville General Hospital, September 20, 2005.

"Congratulations Mr. B, you have a new son. We've just finished implanting a PIN microchip under his thumbnail, and his Personal Identification Number is #USA-CT-9-20-2005-01 36," Doc announced. "You know, ever since the World Council mandated PIN implants at birth, I've felt more like a technician and less like a doctor. It won't be too long before every living being on this planet can be identified and their whereabouts pinpointed in just a matter of seconds," he added proudly. 'Isn't technology wonderful?"

"It certainly has made our lives easier, there's no doubt about it," I acknowledged. 'No need to carry ID or credit cards any more, this little implant does it all."

FACT OR FICTION

Is this view of the future far from the truth? Today we fanatically organize, alphabetize, and enumerate our lives. We have numbers for everything: phone numbers, house numbers, zip codes, even time and date codes. The decimal system is no longer adequate; we have to have binary, hex, octal, hexadecimal, Roman numerals, and so on.

Take your social security number for instance. Nearly every form you fill out or bill you receive has this identification on it, and you can't even open a checking or savings account without one. You and I are just numbers in the massive data bank of the IRS.

HALT, WHO GOES THERE?

What is it that links our social security number to us? Fingerprints? Photographs? Magnetic strips or our signatures? How can these items lead to our identification? They all have a common thread. Differentiating aspects within each item, such as a fingerprint with a whorl versus a loop, a picture of a blond versus a redhead, or your credit card's one versus zero flux orientation, help separate one from the other. The total number of possibilities for an aspect make up a set. A 16-bit binary set like the address

range of an 8031 has 65,536 possible IDs (or addresses). Our social security number has a very large set: 1,000,000,000 possible combinations. Your ATM machine input pad uses the same 10^4 (10,000) set as your telephone, and security is based on the impracticality of **trial-and-error** guessing because of the large number of combinations.

A signature is adequate identification for our everyday transactions. However, signature recognition by computer is still in the Stone Age and not ready for the mass market, so we must still rely on more conventional means of identification. Present forms of identification may include your house key, credit card, safe combination, library card, or a password. Some of these forms are more secure than others. For example, the house key, which identifies the bearer as "one who may enter," can be copied at any hardware store.

A door key also uses a set of possibilities to specify a combination. Your house key's notches must match the pin lengths within your door's lock, or the key can't rotate the tumbler and remove the bolt from the doorjamb. Each notch is more than the binary value of notch/no notch because most keys can have notches of varying depths. A trinary or quadruple value can be associated with each notch. A key with eight notches of binary depth has a set

of possibilities totaling 2^8 (256), and an eight-notched trinary depth key's set is 3^8 (6561). Naturally, the greater the number of combinations, the more secure the set. So using a housekey for security is based on a combination set that is large enough to be impractical to break and because you can prevent it from being copied.

HARDWARE AND SOFTWARE SECURITY

If you have an AT, you probably have a hardware lock on the front of the box. This lock enables and disables keyboard entry. Without the proper key no keyboard entry can be made and the system is safe. You may also have some variation of password protection to prevent

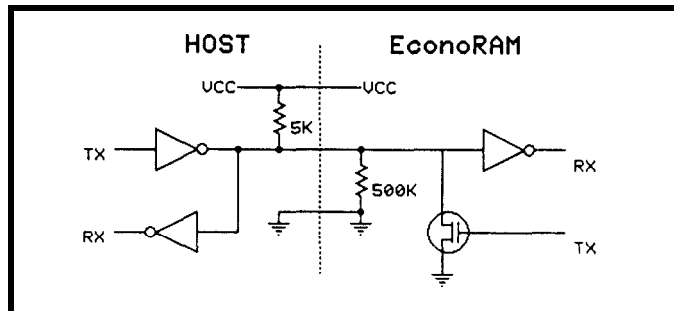


Figure 1 — The host interfaces at its 4.7k pull-up with the 500k pull-down of the EconoRAM.

unwanted access either to your system or to certain file areas. Both hardware and software keys establish identification from their own fixed set of combinations and offer a level of security.

Hardware and software securities are oftentimes intertwined. Take a look at the ever controversial dongle. This piece of hardware sticks to your computer's I/O port and perks up under the right conditions to send back information to the system. The software that started the transaction then reads the data sent by the dongle and executes a conditional jump based on that data. This jump could be a friendly message informing you the dongle is not attached followed by a quick boot out of the program if the data is not as expected, otherwise normal execution is resumed. If the software is really nasty, it could calculate how the dongle would respond and adjust the base address of a jump. Then the data with the added offset would equal the next program line to be executed. Data that does not indicate a dongle would add an incorrect offset to the base address and jump to somewhere inconsistent with the normal program flow. This inconsistency could create anything from minor to major havoc. Code of this type is akin to intentional virus planting and as such would be a likely candidate for legal suit. Let's save the exploration of dongles for another day.

ID IN A TO-92

Dallas Semiconductor released the product EconoRAM a couple of years ago. At the time the press release crossed

my desk I read it and thought, "RAM in a TO-92 package, WOW!" But then I read further and discovered it was only 256 bits, which made the calisthenics needed to communicate hardly worthwhile. So into the file cabinet it went along with all the other orphan ideas looking for good homes.

Every orphan deserves a good home, and I think I've found one for EconoRAM. It can be used in the security of your system. First, a little background. EconoRAM is a low-cost, 256-bit memory device that has reduced its control, address, and data interface to a single pin. Include power and ground, and you have a grand total of three pins. Operating voltage is from 1.2 to 5.5 V at a current of only a few nanoamps. Data retention standby current is typically less than 1 nA.

OK, so how does this 256 x 1 fully static RAM work with only one lead? The host interface consists of a bidirectional bit with an open-drain driver and a pull-up of about 4.7k. EconoRAM has the same interface except it uses a 500k pull-down. This pull-down keeps the data pin low when the device is disconnected, but it allows the pin to be easily pulled high by the host when connected. If the host outputs a logic "1," EconoRAM can pull the data line to a logic "0" state because of this wired-OR connection. Figure 1 shows the interface necessary for communication with EconoRAM.

The host is responsible for initiating a read or write bit stream sequence. Each bit of the sequence is a time slot. The time slot begins on a logic "1" to logic "0" transition and lasts for a minimum of 60 μ s. Three types of time slots are

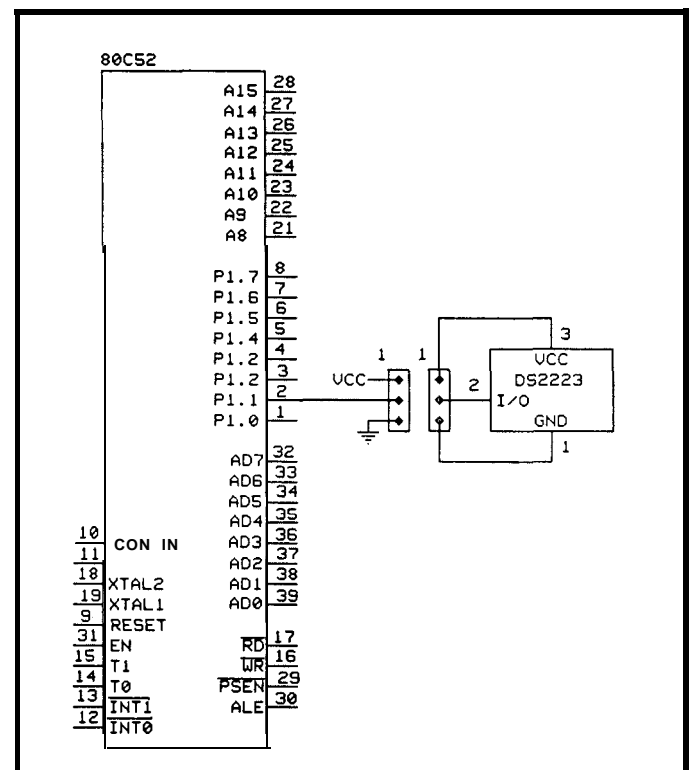


Figure 2—If the power source for the EconoRAM is always from a battery, then the number of connections involved in the 80C52-to-DS2223 interface falls from three to two.

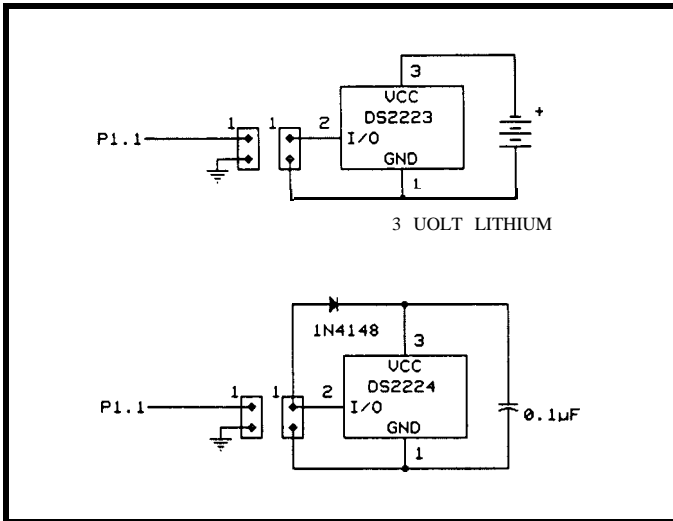


Figure 3—The 80C52-to-DS2223 interface shown with two connections and powered by either a lithium battery or the data line.

possible. A “zero” time slot remains at logic “0” for a minimum of 60 μ s. A “one” time slot returns to a logic “1” after a maximum of 15 μ s at logic “0” and remains at logic “1” for the rest of the 60 μ s. A “read” time slot must return to logic “1” after 1 μ s to allow the EconoRAM to place its data on the line. The EconoRAM’s data is valid for a

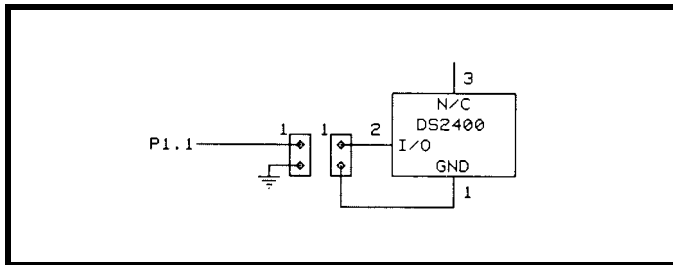


Figure 4-A data line can be used to power the DS2400 because the capacitor retains enough of a charge to power communications.

minimum of 15 μ s and should be read by the host during this time. The data line will remain idle for the rest of the time slot.

Communication is initiated with a sync sequence of 264 “zero” time slots. This sequence increments the internal address pointer of EconoRAM to its maximum count, assuring synchronization to the command sequence that follows. The command sequence is a command word followed by 256 additional time slots. The command word is either F9H for writing 256 bits of data or F1H for reading 256 bits.

The host must issue eight “one”/“zero” time slots for the command word followed by 256 “one”/“zero” time slots to write data or 256 “read” time slots to read data. If the internal address counter is at its maximum count, reception of a command word will reset the counter and institute a new sequence. Therefore, be sure to always finish a complete read or write cycle to return the device to its known sync state and the address counter to maximum count.

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```

10 DBY(3EH)=6DH
20 PRINT
30 PRINT "Hit."
40 PRINT "1 - SYNC"
50 PRINT "2 - READ"
60 PRINT "3 - WRITE"
70 PRINT "4 - PRESENCE"
80 PRINT "5 - END"
90 G=GET
100 G=GET
110 IF (G<31H.OR.G>35H) THEN GOTO 100
120 ON G-31H GOTO 130,150,210,280,510
130 CALL 6000H
140 GOTO 20
150 CALL 6003H
160 FOR X=4DH TO 6CH
170 PHO. DBY(X),
180 NEXT X
190 PRINT
200 GOTO 20
210 FOR X=4DH TO 6CH
220 PRINT "Value #",X-4DH," to be saved into
    register",
230 PHO. X, : INPUT V : IF (V<0.OR.V>255)
    THEN GOTO 220
240 DBY(X)=V
250 NEXT X
260 CALL 6006H
270 GOTO 20

```

```

280 CALL 6009H
290 FOR X=4EH TO 55H
300 PHO. DBY(X),
310 NEXT X
320 PRINT
330 IF DBY(4DH)=0 THEN PRINT "NO PRESENCE
    DETECTED" : GOTO 20
340 IF DBY(4EH)=01H THEN PRINT "FOUND DS2400"
    ELSE PRINT "NO RECOGNITION"
350 PRINT "CALCULATING CRC"
360 C=0
370 FOR B=4EH TO 54H
380 V=DBY(B)
390 FOR Z=0 TO 7
400 W=V.XOR.C
410 F=W.AND.1
420 W=C
430 IF (F=1) THEN W=W.XOR.18H
440 IF (F=1) THEN C=INT(W/2)+128 ELSE
    C=INT(W/2)
450 IF (V.AND.1)=1 THEN V=INT(V/2)+128 ELSE
    V=V/2
460 NEXT Z
470 NEXT B
480 IF C=DBY(55H) THEN PRINT "CRC OK" ELSE
    PRINT "BAD CRC"
490 PRINT
500 GOTO 20
510 END

```

listing 1—BASIC-52 makes a convenient front end for the EconoRAM support routines written in assembly language.

TIME-SLOT SUPPORT ROUTINES

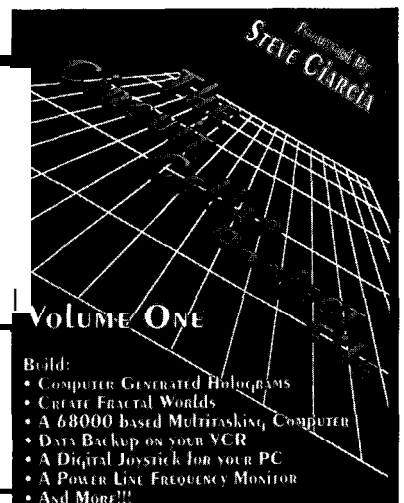
The bidirectional ports of the 8031 make it ideal for interfacing with EconoRAM. I chose the RTC52 board and the 80C52 as a platform because I could quickly write some BASIC code as a shell for the assembly language time slot

routines. The standard 11.0592-MHz crystal has an execution cycle slightly longer than 1 μ s. Although I could have used a timer for accurate timing loops, I chose to use software loops because absolute timing wasn't necessary.

Figure 2 shows the interface used with the DS2223 EconoRAM. It gives 32 bytes (256 bits) of storage, which is

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```

ORG      6000H
JSYNC:   LJMP  SYNC
JREAD:   LJMP  READ
JWRITE:  LJMP  WRITE
JPRES:   LJMP  PRES

;
SYNC:    PUSH  B
         PUSH  DPL
         PUSH  DPH
         MOV   DPTR,#0208H;COUNT TO 264
LOOP1:   ACALL WRZERO      ;ZERO TIMESLOT
         DJNZ  DPL,LOOP1
         DJNZ  DPH,LOOP1
         POP   DPH
         POP   DPL
         POP   B
         RET

;
READ:    PUSH  ACC
         PUSH  B
         PUSH  DPL
         PUSH  DPH
         PUSH  PSW
         PUSH  OOH
         ANL  PSW,#0E7H  ;WORKING BANK 0
         MOV  R0,#4DH    ;STACK SPACE
         MOV  DPL,#08H   ;GONNA SEND 8 BITS
         MOV  A,#01H     ;READ COMMAND
LOOP2:   RRC      A       ;LSB INTO CARRY
         JNC  BRANCH1    ;IF A '0'
         ACALL WROME     ;ONE TIMESLOT
         AJMP BRANCH2
BRANCH1: ACALL WRZERO    ;ZERO TIMESLOT
BRANCH2: DJNZ  DPL,LOOP2 ;DO ALL BITS
         MOV  DPH,#20H   ;GET 32 BYTES
LOOP3:   MOV   DPL,#08H  ;GET 8 BITS
LOOP4:   ACALL RDSOME    ;READ A TIMESLOT
         RRC      A       ;CARRY INTO MSB
         DJNZ  DPL,LOOP4 ;DO ALL BITS
         MOV  @R0,A      ;SAVE IN USER REG
         INC  R0         ;NEXT USER REG
         DJNZ  DPH,LOOP3 ;DO ALL BYTES
EXITRD:  POP   OOH
         POP   PSW
         POP   DPH
         POP   DPL
         POP   B
         POP   ACC
         RET

;
WRITE:   PUSH  ACC
         PUSH  B
         PUSH  DPL
         PUSH  DPH
         PUSH  PSW
         PUSH  OOH
         ANL  PSW,#0E7H  ;WORKING BANK 0
         MOV  R0,#4DH    ;STACK SPACE
         MOV  DPL,#08H   ;SEND 8 BITS
         MOV  A,#0F9H    ;WRITE COMMAND
LOOPS:   RRC      A       ;LS% INTO CARRY
         JNC  BRANCH3    ;IF A '0'
         ACALL WRONE     ;ONE TIMESLOT
         AJMP BRANCH4
BRANCH3: ACALL WRZERO    ;ZERO TIMESLOT
BRANCH4: DJNZ  DPL,LOOP5 ;DO ALL BITS
         MOV  DPH,#20H   ;WRITE 32 BYTES
LOOP6:   MOV   DPL,#08H  ;WRITE 8 BITS
         MOV  A,@R0     ;GET BYTE TO WRITE
LOOP7:   RRC      A       ;LSB INTO CARRY
         JNC  BRANCH5    ;GO DO A WRZERO
         ACALL WRONE     ;ONE TIMESLOT
         AJMP BRANCH6
BRANCH5: ACALL WRZERO    ;ZERO TIMESLOT
BRANCH6: DJNZ  DPL,LOOP7 ;DO ALL BITS
         INC  R0         ;NEXT USER REG
         DJNZ  DPH,LOOP6 ;DO ALL BYTES
EXITWR:  POP   OOH
         POP   PSW
         POP   DPH
         POP   DPL
         POP   B

```

(continued)

listing 2—The main timeslot routines are written in 8031 assembler and are called from BASIC-52.

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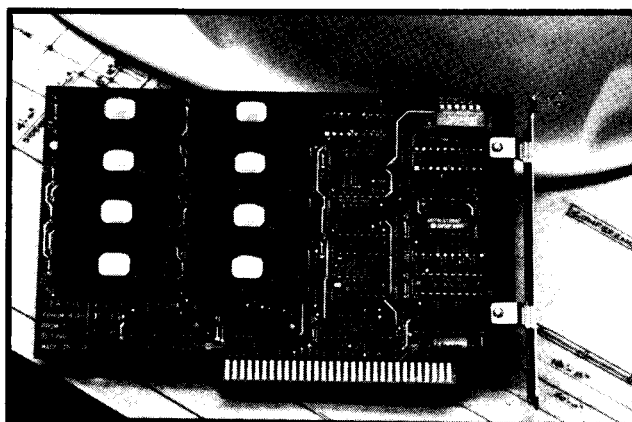


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79

enough room for ten social security numbers (in BCD). A 30-mAH lithium battery will hold those numbers firm for over ten years. If the power source for the EconoRAM is always the battery, then the number of connections necessary falls from three to two. Figure 3 shows this implementation.

Now let's investigate the DS2223's sister part, the DS2224. Same interface, same communication protocol, same number of bits of storage, but the first 32 bits are ROM and not RAM. Not only are they ROM, but they are prewritten with a unique serial number. No two are the same, at least not for the first 4,294,967,295 parts made, and each one has its own signature ID. Even if you never use the RAM, this part is ideal for identification. Figure 4 demonstrates how the data line can be used to provide power for the DS2224. The capacitor retains enough of a charge to power communications without the usual third connection. Of course, it does not retain the data in the remaining 224 bits once the device has been disconnected. However, in this case, we are only interested in the 32 bits of ROM data, which will be safe even without power.

DATA INTEGRITY

Data passing from device to host can be read incorrectly. A checksum of the 32-bit serial number and any other RAM data would provide greater data protection. A calculation and checksum comparison would reveal po-

```

POP      ACC
RET

;
PRES:    PUSH  ACC
         PUSH  B
         PUSH  DPL
         PUSH  DPH
         PUSH  PSW
         PUSH  OOH

;
ANL      PSW,#0E?H ;WORKING BANK 0
MOV      RO,#4DH   ;STACK SPACE
ACALL   PRESDET   ;LOOK FOR PRESENCE
MOV      A,@RO    ;PRESENCE FLAG
CJNE    A,#0FFH,EXITPR ;NO ONE HOME
INC      RO       ;MOVE THE POINTER
MOV     DPL,#08H  ;SEND 8 BITS
MOV     A,#0FH   ;DS2400 COMMAND
LOOP8:   RRC      A ;LSB INTO CARRY
         JNC    BRANCH7 ;IF A '0'
ACALL   WRONE    ;ONE TIMESLOT
AJMP    BRANCH8
BRANCH7: ACALL   WRZERO ;ZERO TIMESLOT
BRANCH8: DJNZ   DPL,LOOP8 ;DO ALL BITS

;
MOV      DPH,#08H ;GET 8 BYTES
LOOP9:   MOV     DPL,#08H ;GET 8 BITS
LOOP10: ACALL   RDSOME  ;READ A TIMESLOT
         RRC      A ;CARRY INTO MSB
         DJNZ   DPL,LOOP10 ;DO ALL BITS
MOV     @RO,A    ;SAVE IN USER REG
INC     RO       ;NEXT USER REG
DJNZ   DPH,LOOP9 ;DO ALL BYTES

EXITPR:  POP     OOH
         POP     PSW
         POP     DPH
         POP     DPL
         POP     B
         POP     ACC
         RET

;
WRONE:   CLR     P1.1 ;OUTPUT A LOW
         SETB   P1.1 ;OUTPUT A HIGH
         MOV    B,#1CH ;28 LOOPS (60 us)
         ACALL  LOOP ;DELAY
         RET

WRZERO:  CLR     P1.1 ;OUTPUT A LOW
         MOV    B,#1CH ;28 LOOPS (60 us)
         ACALL  LOOP ;DELAY
         SETB   P1.1 ;OUTPUT A HIGH
         RET

RDSOME:  CLR     P1.1 ;OUTPUT A LOW
         SETB   P1.1 ;OUTPUT A HIGH
         MOV    B,#01H ;1 LOOP (4 us)
         ACALL  LOOP ;DELAY
         MOV    C,P1.1 ;PUT BIT IN CARRY
         MOV    B,#1AH ;26 LOOPS (56 us)
         ACALL  LOOP ;DELAY
         RET

PRESDET: CLR     P1.1 ;OUTPUT A LOW
         MOV    B,#0E?H ;236 LPS (480 us)
         ACALL  LOOP ;DELAY
         SETB   P1.1 ;OUTPUT A HIGH
         MOV    B,#05H ;5 LOPS (16 us)
         ACALL  LOOP ;DELAY
         MOV    A,#3CH ;60 LOOPS (240 us)
         MOV    @RO,#00H ;NO PRESENCE
LOOP11:  JB     P1.1,BRANCH11 ;J IF NO LOW
         MOV    @RO,#0FFH ;FLAG PRESENCE
BRANCH11:DJNZ   ACC,LOOP11 ;KEEP LOOKING
         RET

LOOP:    DJNZ   B,LOOP ;DELAY LOOP
         RET

END:     END

```

Listing P-continued



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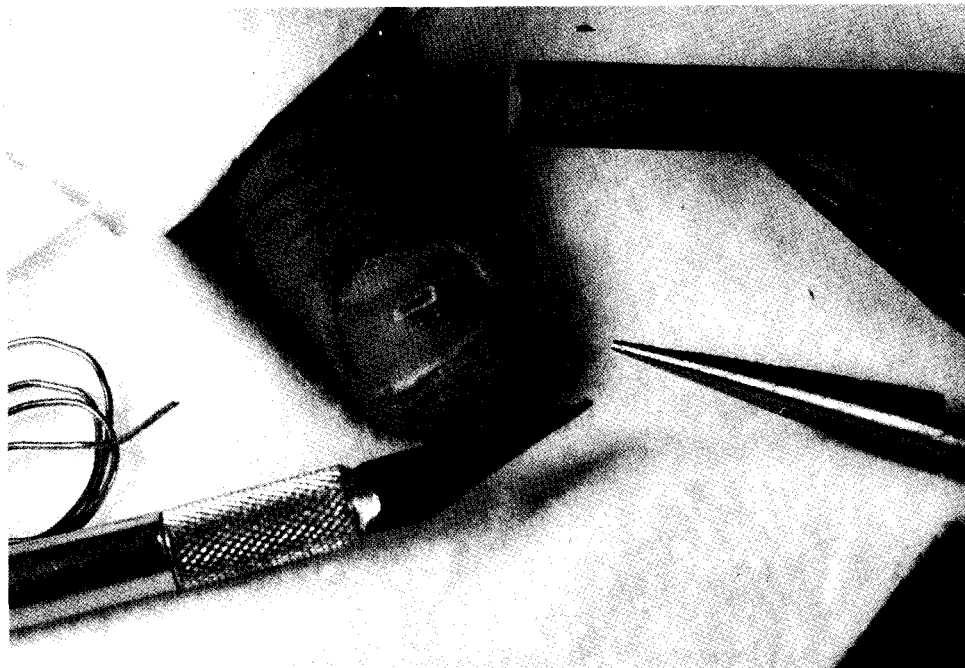
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Photo 1 -Perhaps by the year 2005, we'll have a less painful way to implant the thumbnail PIN than a knife and soldering iron.

tentially garbled data upon the reading of the device. However, in order for a calculated checksum to be stored along with any other data, the RAM bits must be battery backed.

Enter a new device. The DS2400 silicon serial number extends the possible bit combinations from 32 bits to 48 bits of prewritten ROM. An B-bit CRC is appended to the serial number ensuring data integrity. This device is strictly ROM and needs no battery backup. Time slots are used for data communication, as with the DS2223 and DS2224, but the DS2400 has a unique feature.

If the host sends a "zero" time slot of 480- μ s minimum duration, any connected DS2400 will answer with a presence signal. If the host detects the presence of a DS2400 and sends the command byte OFH, the DS2400 will return the type identifier byte 01H, followed by the 48-bit serial number and B-bit CRC. The presence signal and type



identifier set the groundwork for a whole family of devices that are sure to come off the drawing boards of Dallas Semiconductor.

Listing 1 is the BASIC shell I wrote for the RTC52. This program makes calls to the time-slot routines (Listing 2) written in machine language. The first routine writes 264

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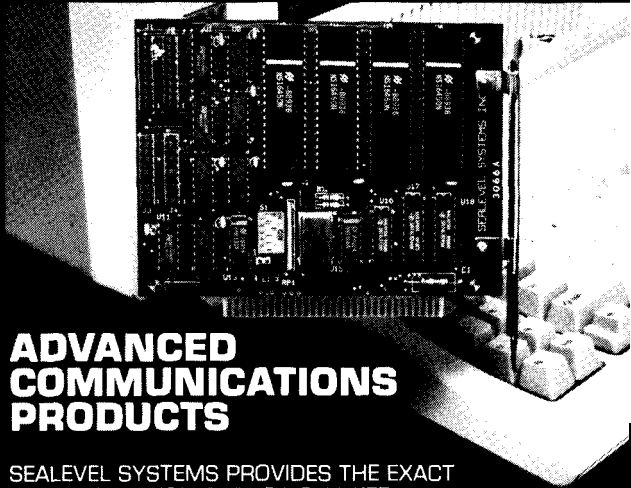
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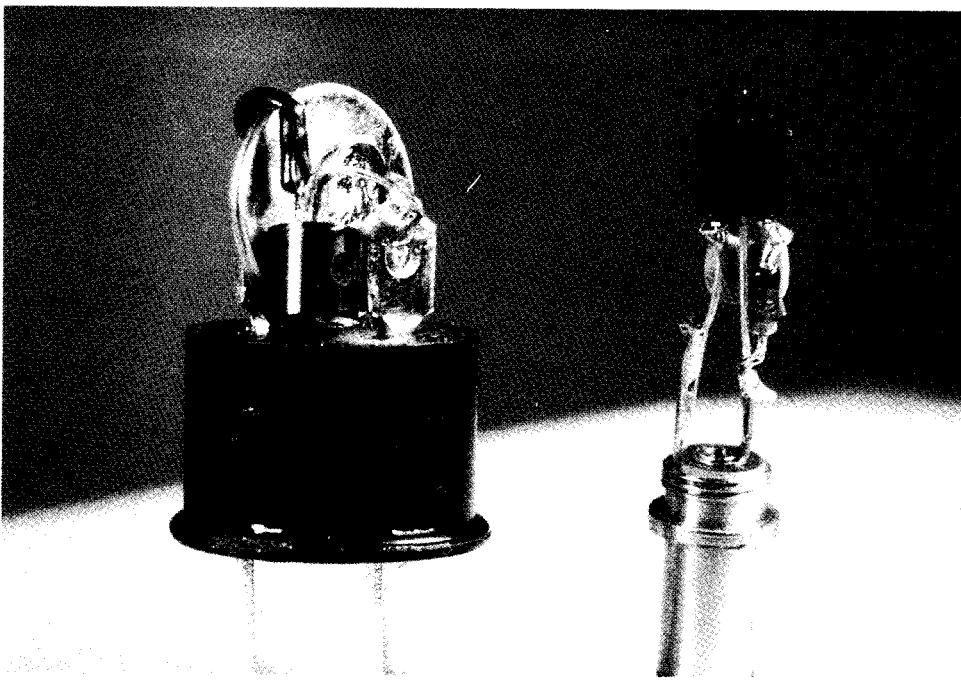


Photo 2—The EconoRAM's small size lets you install it inside a connector housing. On the left, an EconoRAM is installed on an Amphenol connector with its own button cell battery. On the right, a data-line-powered EconoRAM fits on a typical power connector.

I'm sure you can see all that these units make possible. Low cost and interface simplicity allow easy integration of these devices into many applications. Some uses could involve home or auto security, inventory and product identification, bank transactions with running account information, and even an implanted PIN. Just don't expect to get a duplicate made at the local hardware store. ❖

"zero" time slots to sync up the DS2223 or DS2224. The second reads 256 bits from a DS2223 or a DS2224. The third writes 256 bits to a DS2223 or a DS2224. (The data written to the ROM bits are tossed into the bit bucket.) Finally, the fourth routine looks for a DS2400 and reads the 48-bit serial number and B-bit CRC. BASIC then calculates a CRC and compares it with what was read, verifying a good data transmission.

Jeff Bachiochi (pronounced "BAH-key-AH-key") is an electrical engineer on the Circuit Cellar INK engineering staff. His background includes product design and manufacturing.

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- 419 Very Useful
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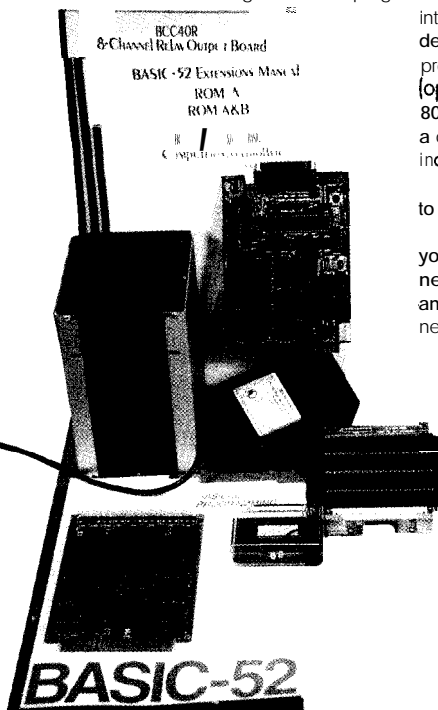
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BASIC-52

Summer Harvest

A Cornucopia Of Chips

**SILICON
UPDATE**
Tom Contrell

There was a time when summer in the not-yet-Silicon Valley was a rather leisurely affair. Not so these days when “Summer Slowdown” refers to the cyclical dip in IC sales, not sitting on the porch with an iced tea watching the fish jump and the cotton get high.

IC sales may slow down while the nation’s purchasing managers drag their kids to Wally World, but the development of new and wondrous ICs doesn’t. Here’s a sampling of Silicon Valley’s summer harvest,

HACKER PARADISE

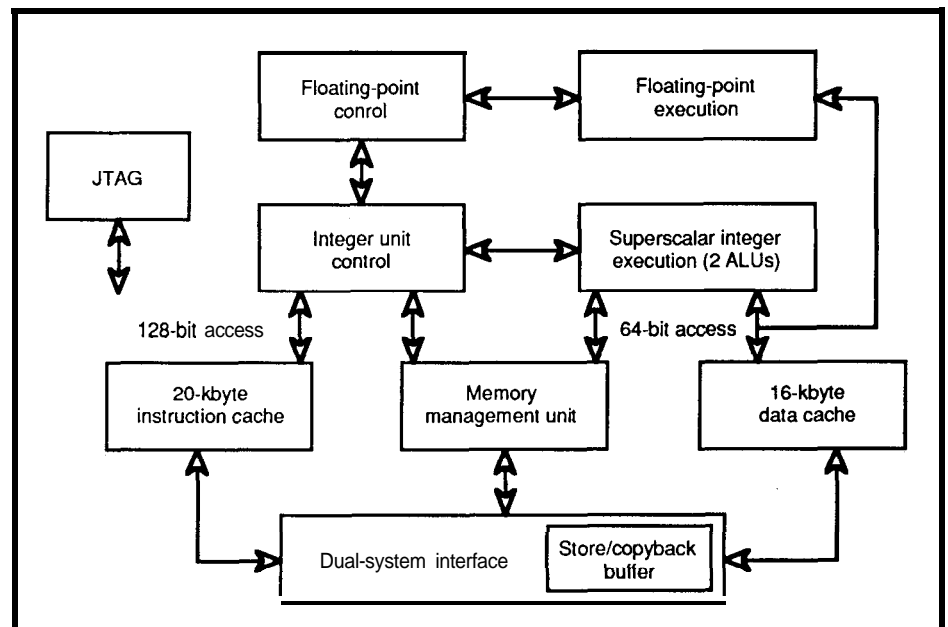
Where’s a die-hard computer guru supposed to go on vacation anyway? Remember, these are people who take their kids to computer camp, not Wally World. In fact, given the propensity of the most obsessed to avoid daylight at all cost, summer is just a good excuse to spend even more hours in the lab. However, the preconception that computer types are antisocial is overblown—they just prefer to hang with their own kind. Thus, a “fun get-away” like the IEEE Hot Chips symposium has no trouble

attracting hundreds of chip-heads, including me, from around the world.

Check out the fun-filled schedule for a day at Hot Chips. All I can say is, watch out Club Med!

- 8:00–10:00 Listen to people talk about chips
- 10:00–10:30 Break-talk about chips over coffee
- 10:30–12:00 Listen to people talk about chips
- 12:00–1:00 Lunch-talk about chips over food
- 1:00–3:00 Listen to people talk about chips
- 2:30–3:00 Break-talk about chips over colas

Figure 1—The upcoming SuperSparc superscalar chip from Sun and TI will have two integer units.



Complexity Considerations in Big-Issue Machines

. Operand bypassing grows as

$$(no_of_src_operands) (results_in_pipeline) i = 2 \text{ (s)} i = 0 \text{ (r)}^2$$

. Data dependence checks grow as

$$(no_of_src_operands) \sum_{n=1}^{i-1} n = 2 \binom{i(i-1)}{2} = O(i^2)$$

. **Plus** priority encoder complexity
– additionally increases logic complexity or logic depth

. Complexity grows faster than issue rate

Figure 2—The feasibility of speculative execution relies heavily on the conventional wisdom that ‘transistors are free.’ However, many note that ‘wires aren’t.’

3:30–5:00 Listen to people talk about chips
5:00–7:00 Reception-talk about chips over wine
7:00–10:00 Listen to people talk loudly (good wine!)
about chips

Despite all the talk, there wasn’t much new. In fact, as I claimed in an earlier article that logic synthesis represents the “End Of Hardware,” it seems we’ve just about reached the “End Of Architecture.”

These days the main controversies concern two questions: What is the best way to exploit instruction-level parallelism, and is there any instruction-level parallelism to exploit?

The interesting point is the questions are being addressed in the above order; that is, people have been beating their brains out over the first question for some time, but only now are they taking a close look at the second question.

Instruction-level parallelism refers to the fact (hope?) that “sequential” instructions can be packed together for simultaneous execution by a suitably equipped machine. For instance, there isn’t any reason

```
A(i)=B(i) ; execute one
A(i+100)=C(i) ; after the other
```

can’t be “parallelized” into

```
A(i)=B(i) : A(i+100)=C(i) ; execute both
; at the same
; time
```

But how about

```
A(i)=B(i)
A(i+j)=C(i)
```

On first glance it looks like they could be combined similarly, but don’t forget the case where $j=0$ which will cause the machine to try to assign two different values to $A(i)$ at once!

Researchers seem to disagree on the answer to the second question (i.e., how much parallelism is present in real-world programs?). Various studies report results ranging from 1.37 to 90! Needless to say, research continues...

Anyway, since it’s greater than one, we’ll be seeing more superscalar chips with two integer units like the presumably soon-to-appear SuperSparc (previously known as “Viking”) from Sun and TI (Figure 1). Supposedly Intel had a similar idea in mind for the ‘586, but has scrapped it (R&D budget shifting to the legal department?). I assume it may resurface in a later ‘x86.

The problem is, superscalar—which attempts to parallelize your program while it is running—leads to horrible circuit complexity. Someone put a transparency up during the “Five Instructions Per Clock: Truth Or Consequences” session (after the wine!) that said “Superscalar-The CISC Empire Strikes Back.”

So what’s next? Well, while speculation may have reigned supreme on Wall Street in the ‘80s, it’s moving to Silicon Valley in the ‘90s: “speculative execution” is the latest hot-button. For instance, if you have two execution units and encounter a conditional branch, don’t wait for the condition to be resolved, but simply continue execution down both paths. After the condition becomes clear, side effects from the incorrect path are removed. The feasibility of speculative execution relies heavily on the conventional wisdom that “transistors are free.” But it has been noted by some, including Michael Smith of Stanford (Figure 2), that “wires aren’t.”

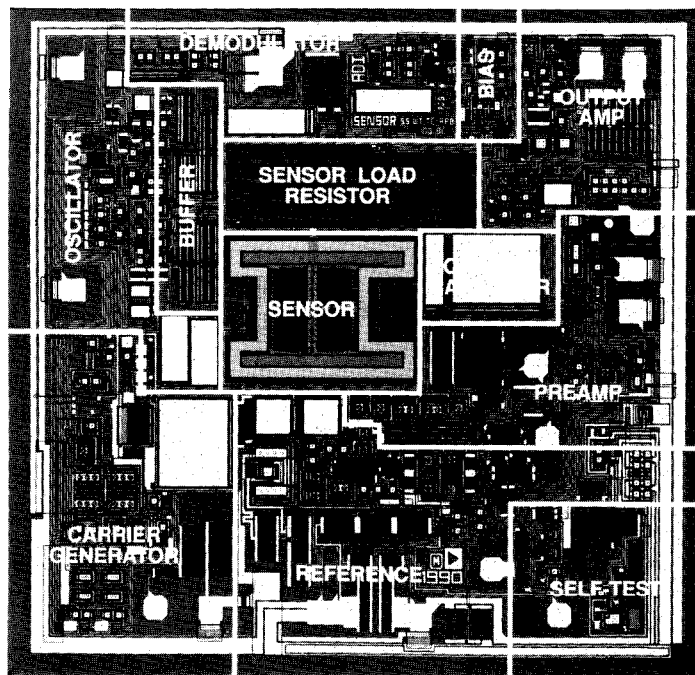


Figure 3—The Analog Devices ADXL-50 accelerometer uses micromachining techniques to measure acceleration in a single plane from 0 to 50 g’s.

Kind of makes you long for the days of BASIC on a 6502, huh? That's how I know we've really reached the "End Of Architecture."

Overheard: Two gurus from secret startup XYZ Corp. comparing their new whizzy to market leader ABC's latest widget:

XYZ Guru #1—"We're way ahead of ABC"

XYZ Guru #2—"Yeah, all we've got to do is get it working.."

MICROMACHINES

In my opinion, the real secret for high performance is "crank the clock," but such a view would certainly be deemed technically incorrect by the supertypes. Nevertheless, it seems the most interesting developments (like 100-MHz CMOS) are in the hands of semiconductor process wizards.

Beyond high speed, the wizards have even more tricks up their sleeves: micromachines. Micromachines result when semiconductor processes are used to make electro-mechanical devices. For instance, researchers have already demonstrated prototypes of tiny chip motors and gears.

On a more practical front, micromachining techniques are already being put to work by Analog Devices in their new ADXL-50 accelerometer (Figure 3). The device measures acceleration in a single plane from 0 to 50 g's with

5% accuracy and is designed especially for automotive airbag systems that currently use multiple mechanical sensors. However, the ADXL50 can certainly be used for other applications, and they will benefit from the competitive pricing—\$5.00 in high volume—dictated by the automotive marketplace.

Figure 4 shows a close-up of the "H"-shaped micromachined sensor located in the middle of the die. The "H"-shaped portion is the mass that is acted upon by acceleration, while interleaved capacitors detect the change. Actually, the device is operated in a Force/Balance mode in which an opposing electrical force is applied to keep the mass stationary. The amount of this charge corresponds to the acceleration, and additional on-chip circuits further condition and amplify the output.

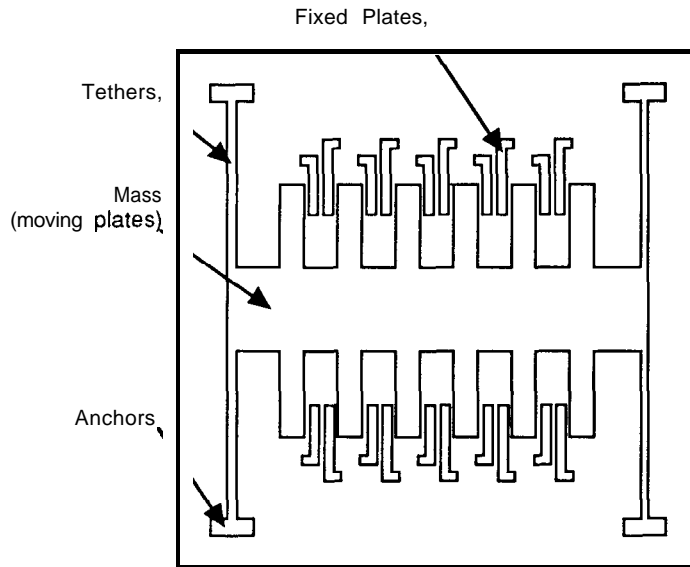
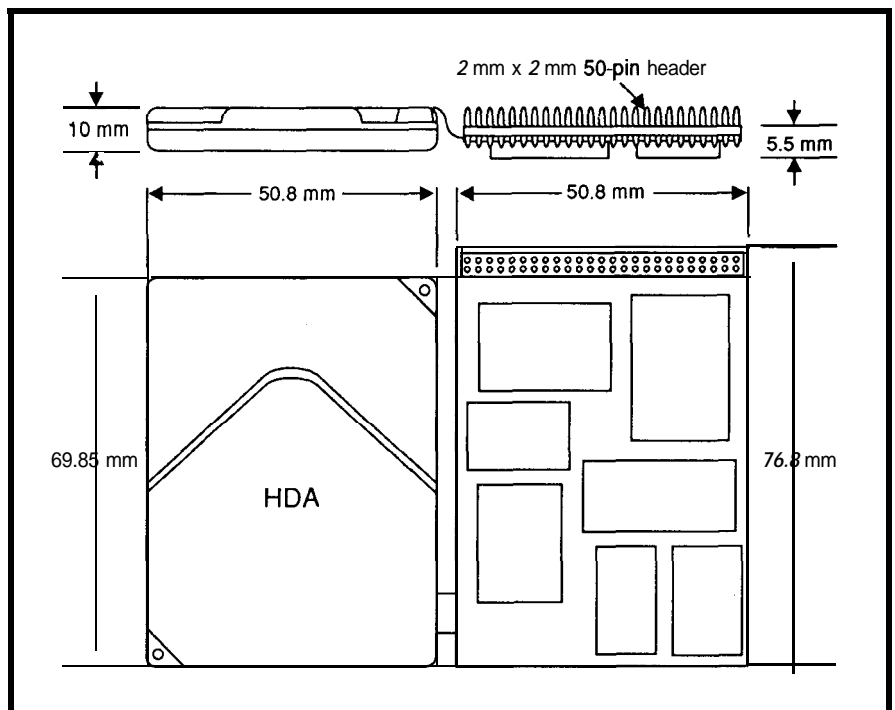


Figure 4—The ADXL-50's "H"-shaped micromachined sensor located in the middle of the die is the mass that is acted upon by acceleration, while interleaved capacitors detect the change.

Figure 5—Most hard disk suppliers are currently working on 2.5" models, but Integral Peripherals Inc. is leapfrogging everyone else and showing a 1.8" drive. Initial offerings include 20-megabyte units, but plans for 40-megabyte units are under way.



The ability to combine electronic and mechanical functions on the same die is further exploited to incorporate a self-test feature that allows the airbag controller to test the sensor by initiating electrostatic deflection of the mass and checking for the appropriate output voltage. Needless to say, this is much better than finding out the hard way whether your 5-10-year-old airbag still works.

Micromachines promise some interesting applications in the future. I personally look forward to the proposed "Roto Rooter" micromachines that, after being injected into the bloodstream, will trundle along chomping up the artery-clogging byproducts of the Silicon Valley lifestyle. Oh, hang on a second, the pizza delivery guy is here...

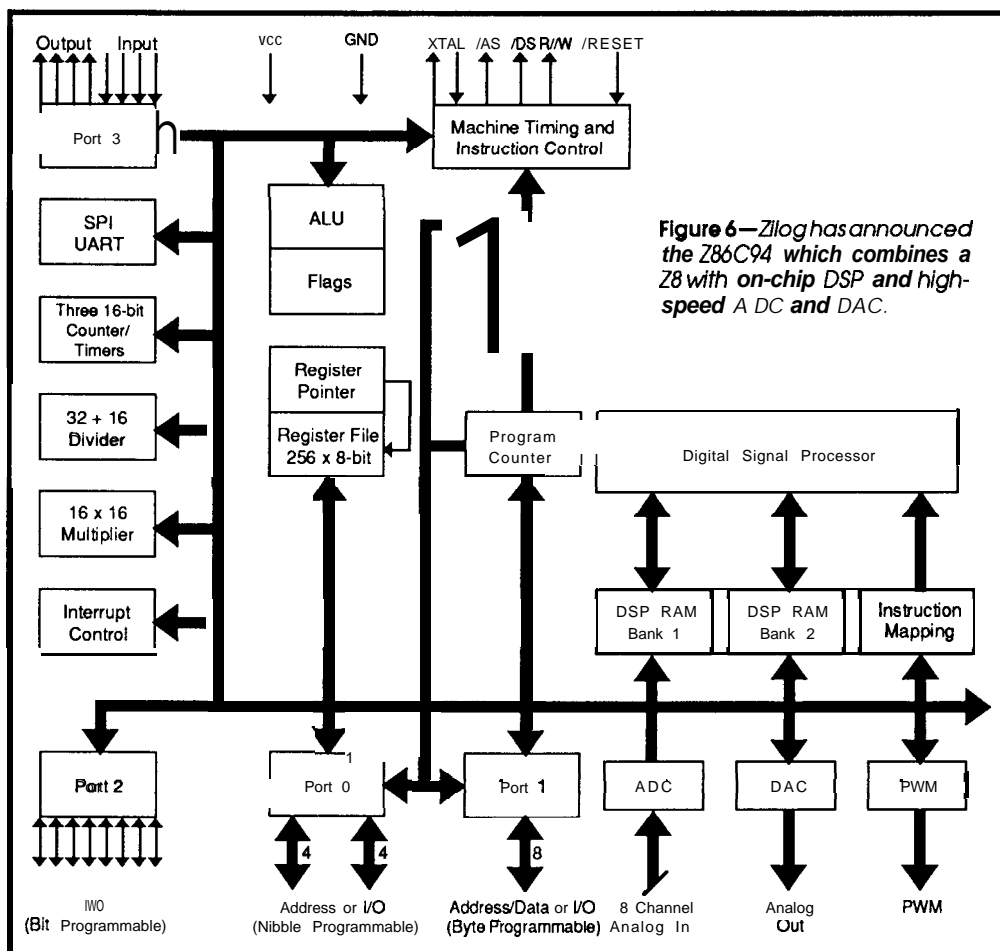
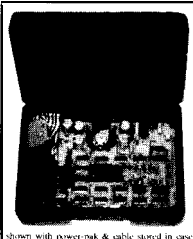


Figure 6—Zilog has announced the Z86C94 which combines a Z8 with on-chip DSP and high-speed A/D and DAC.

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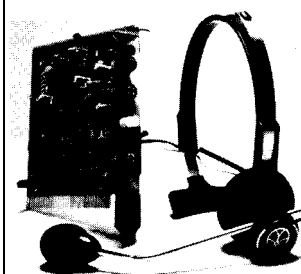
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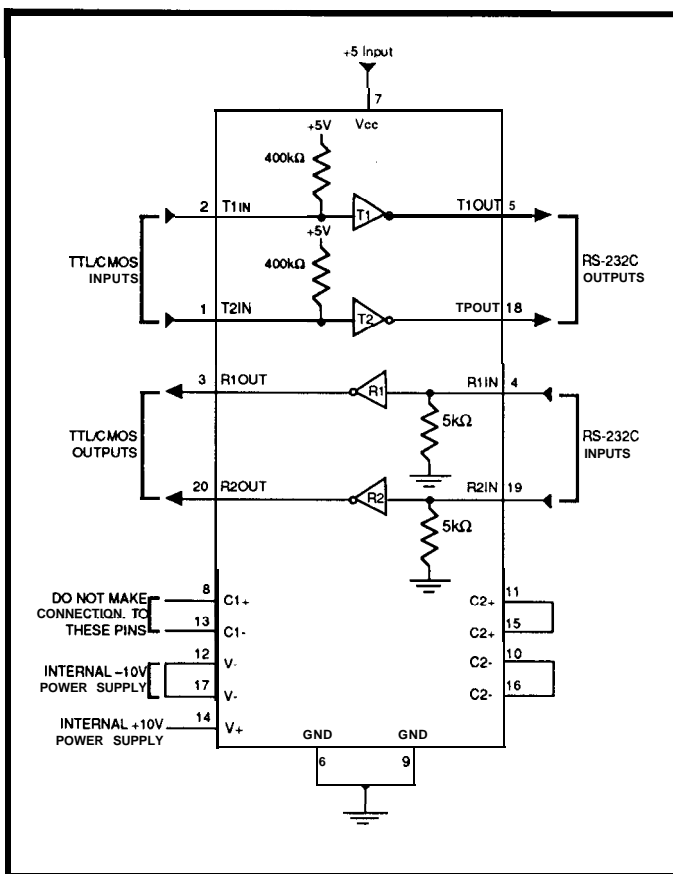


Figure 7—The MAX233 includes the capacitors within the chip to minimize parts count.

MICRODISKS

One of the more interesting developments expected to surface at Comdex are tiny hard disks. Most suppliers are working on 2.5" models, but already one start-up—Integral Peripherals Inc.—is leapfrogging everyone else and showing a 1.8" drive (Figure 5). Initially they're offering a 20-megabyte unit, but plan to introduce 40-megabyte units soon. Incredible, isn't it?

These tiny drives are a natural for the emerging RAID—"Redundant Array of Inexpensive Disks"—concept. Interestingly, one of the pioneers of RAID research is David Patterson of Berkeley RISC fame. I consider the fact a leading CPU architect is switching to disk research more backup for my "End Of Architecture" hypothesis.

Anyway, the RAID concept calls for the use of multiple disk drives to increase performance (i.e., parallel access) and/or increase reliability (via redundancy). Different RAID configurations offer various tradeoffs between cost, performance, and fault tolerance.

Using the new 1.8" disks, I can imagine a "RAIDcard" that would combine multiple disks, controller electronics, and some RAM cache on a single plug-in board.

Beyond that, who knows? Maybe someone will make an even tinier disk that looks/plugs-in just like a RAM chip. Now that's virtual memory.

Note how, for packaging flexibility, the controller card and actual hard disk assembly (HDA) are physically

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separate. Even with a separate controller, tiny disks call for ever more highly integrated control ICs. Integral use a version of National Semiconductor's HPC family with special enhancements (multiply/accumulator) for disk motor (spindle and head) control.

Along similar lines, Zilog has announced the Z86C94 (Figure 6) which combines a Z8 with on-chip DSP and high-speed ADC and DAC. Like the National chip, the added circuits are designed for high-speed digital servo-motor control.

KISS

"Keep It Simple, Stupid" ranks right up there as one of my guiding precepts (along with "Don't Fix It If It Ain't Broke" and "S##t Happens"). Thus, I'm just as excited about plain-jane real-world problem solvers as I am about the latest technowidget.

I discussed one of these in a previous article: the Maxim MAX232 RS-232 driver/receiver chip. Its simple claim to fame was +5V-only operation. Before the MAX232, a triple-output power supply (+5V, ±12V) or kludgy DC-DC converter setup was required.

The **only thing** "broke" with the MAX232 is that it needs five external capacitors. Well, the new MAX233 (Figure 7) is finally the dream RS-232 chip I've been waiting for. Especially handy for tinkerers, where every extra connection potentially leads to late-night hair-pulling sessions (have you ever tried to debug a capacitor?). ❖

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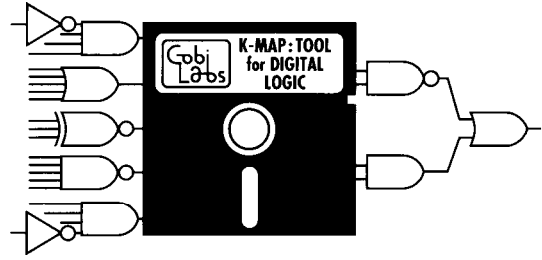
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Tom Cantrell holds a B.S. and an M.B.A. from UCLA. He owns and operates Microfuture, Inc., and has been in Silicon Valley for ten years working on chip, board, and system design and marketing.

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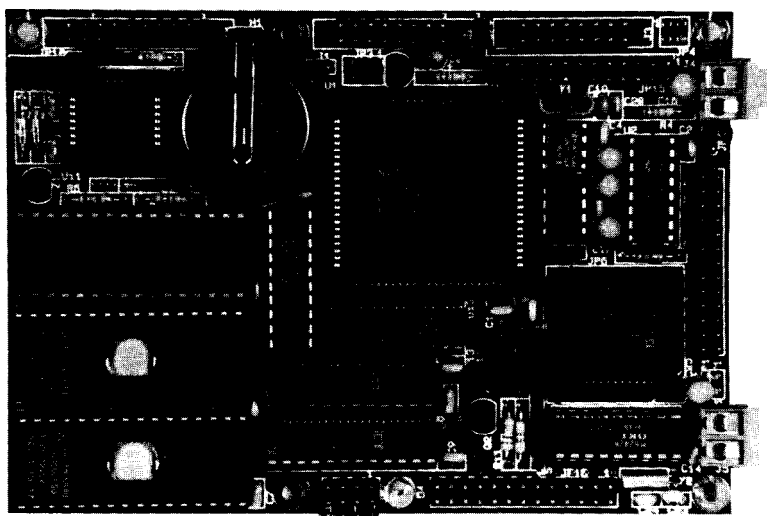
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Parallel Filters

Design and Simulation by Computer

The difficulties many have when trying to work with parallel filters has resulted in much of their capabilities left unexplored, but using them can be much easier if a computer does most of the dirty work.

You can use a computer to design a parallel filter without laboriously setting up and testing every possible arrangement. Simulation of parallel-T filters by computer is particularly simple. The filters can be applied to data in records of indefinite length, or in real time using a previously developed algorithm [1], because they use only low- and high-pass filters. They achieve a range of characteristics you can conveniently explore using a spreadsheet program. I will discuss two such programs and show some of the filter characteristics they can simulate.

The parallel-T filter shown in Figure 1a is noted for its sharp rejection of a single frequency. In fact, the attenuation at the "resonant" frequency can be infinite with

precisely sized components. By deliberately altering component values, you can reduce the severity of the attenuations.

This filter has a rather complex transfer function [2]. But the design of Figure 1a was used by analog-circuit designers before isolation amplifiers were easily available; they had to achieve filter characteristics with the least precise components possible. I will show you how simpler circuits (meaning those more easily simulated by computer) obtain practically the same characteristics. When these simple circuits are used, the parallel-T turns out to be an example of a number of filters having noteworthy properties.

ANALYSIS

The response of a single low-pass filter section (Figure 1b) is described by the Laplacian expression

$$G_L(s) = \frac{1}{(1 + Ts)} \quad (1)$$

For two identical filters in cascade, separated by a unity-gain isolation amplifier [3], the expression is

$$G_L(s) = \frac{1}{(1 + Ts)^2} \quad (2)$$

In these expressions T is the time constant of the filter, which you can conveniently measure for sample data in terms of a number of samples (it equals $P/2\pi$ where P is the period in samples/cycle at the "turnover" point). The

filter described by equation (2) has a flat response for periods greater than T , while for shorter periods the response drops off at 12 dB per octave.

Similarly, a single high-pass section having the same time constant (Figure 1c) is described by

$$G_H(s) = \frac{Ts}{(1 + Ts)} \quad (3)$$

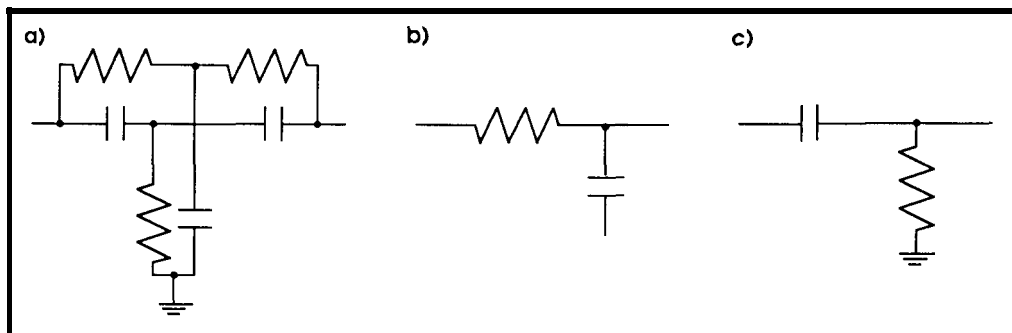


Figure 1 —(a) An example of a parallel filter characterized by its sharp rejection of a single frequency and a complex transfer function. (b) An example of a single low-pass filter. (c) An example of a single high-pass filter.

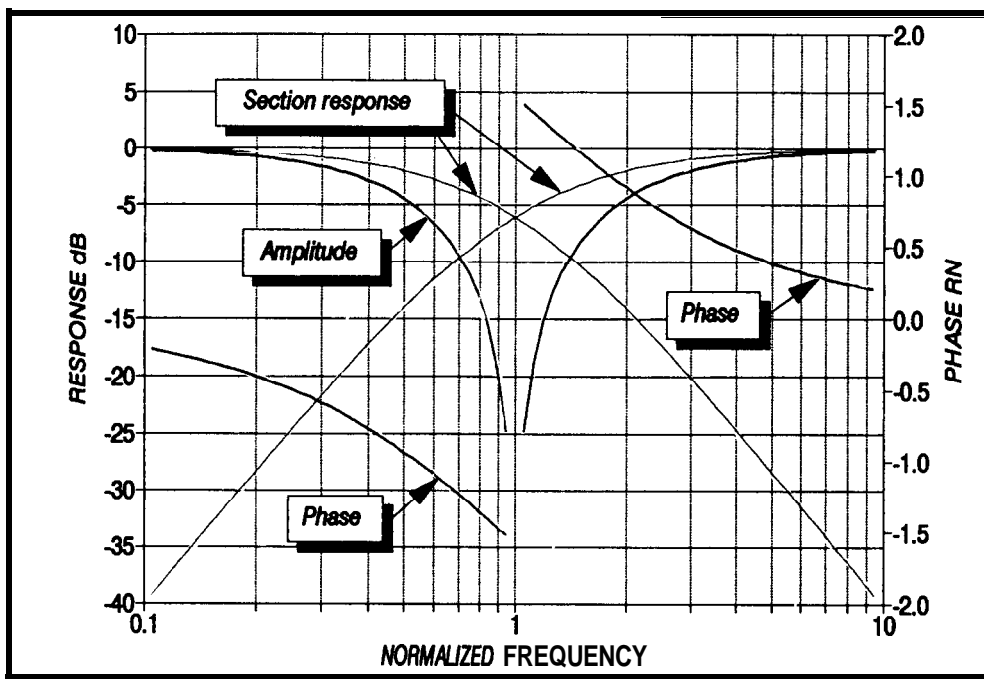


Figure 2—The response of a simulated two-section parallel-T filter.

and two isolated sections in cascade behave as

$$G_H(s) = \frac{(Ts)^2}{(1 + Ts)^2} \quad (4)$$

This filter's response is flat for periods less than T and drops at 12 dB per octave for longer periods [4].

Assume a signal is split into two channels, one going through a two-section high-pass filter and the other through a two-section low-pass filter. After passing through the filters (all of which are assumed to have the same time constant) the two signals are added. The sum of the two signals has the transfer function

$$G(s) = \frac{(1 + T^2s^2)}{(1 + Ts)^2} \quad (5)$$

You can obtain frequency and phase responses by substituting $j\omega$ for s and rationalizing the resulting expressions. "Normalize" equation (5) without any loss of generality by setting $T = 1$. The magnitude of the response is

$$M = \frac{\sqrt{(1 - \omega^4)^2}}{(1 + \omega^2)^2} \quad (6)$$

and the phase is

$$\phi = \tan^{-1} \left(\frac{-2\omega}{1 - \omega^2} \right) \quad (7)$$

However, you may omit many of the cumbersome steps leading to equations (6) and (7) by using a spreadsheet. If the substitution of $j\omega$ for s is carried out separately for the low-pass and high-pass filters, addition of real and imaginary parts leads directly to the magnitude and phase of the entire filter.

At $\omega = 1$ (the frequency where all the corners are located) the numerator in equation (6) is zero and the magnitude of the response vanishes. Where $\omega < 1$ the phase is the arctangent of a negative quantity, while where $\omega > 1$ the arctangent is positive. At $\omega = 1$ the phase appears to go through an abrupt transition from $-\pi/2$

to $+\pi/2$. I've simulated these essential characteristics of a parallel-T filter by a simple arrangement of low- and high-pass filters. Figure 2 is a graph of the response.

Total rejection occurs when the responses of the low-pass and high-pass sections are equal and π radians out of phase at one frequency. Use at least two sections of both types of filter because each one has a phase shift of $\pi/2$ only at a period of 0 or ∞ , depending on the type of filter. However, the number of sections has no upper limit because a shift of $\pi/2$ always occurs within a reasonable distance of the corner for every multisection filter.

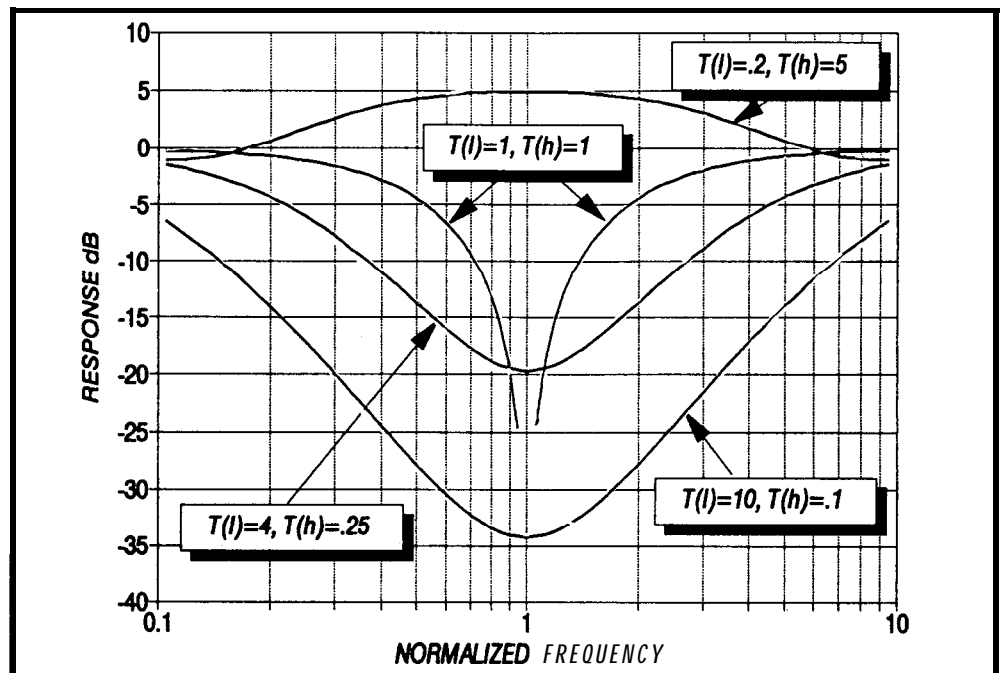


Figure J—The responses of some two-parallel section filters where the time constants of the high-pass sections are the reciprocal of those of the low-pass to maintain the center frequency of 1.0.

Improvement in Sampled-Signal Filter Algorithm

Almost all algorithms for processing sampled signals contain approximations that produce errors in their outputs. An important task in devising an algorithm is to reduce the errors as much as possible.

In determining the time response of a parallel filter at the null frequency to obtain Figure 9, I discovered an easily improved approximation in the algorithm published in my article "Filtering Sampled Signals" in issue #21 of *CIRCUIT CELLAR INK* (6). This determination is a sensitive test for residual errors because the response of such a filter is identically zero at the rejection frequency. The calculated magnitude of this response is consequently a direct indication of the algorithm error.

The error was greatly reduced by a simple expedient that materially increases neither the complexity of the algorithm nor the memory required for its application.

I improved low-pass filtering by using the arithmetic mean of the input samples at times t and $t + 1$ (instead of that at $t + 1$ only) to find the filtered signal at $t + 1$. Thus, the filtered signal at $t + 1$ is $\exp(-1/T)$ that at t (T

being the filter time constant in samples/m) plus $(1 - \exp(-1/T))$ times the mean of the samples at t and $t + 1$.

High-pass filtering requires the added step of subtracting each value of a low-pass filter from the input sample at $t + 1$.

in the time response at the null frequency of a two-section parallel filter with a sinusoidal input signal of unit peak amplitude, the earlier algorithm showed a residual amplitude of 0.0842 peak with 50 samples per cycle. The improved algorithm reduces it to 0.0026.

If the effective "energy" input from one sample to the next is the integral of the waveform between these samples, it is evident that the actual quantity to be used is the integral of the waveform times the sample interval (defined as 1.0). The actual value of this integral cannot be determined because the waveform is unknown. The mean of the two sample magnitudes appears to be a better approximation to this value than either sample alone, at least for sinusoidal waves.

I incorporated this improvement into the spreadsheet TIME-2.WQ1.

SPREADSHEET PROGRAMS

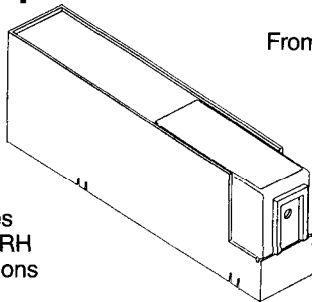
Two-section filters

Filters consisting of two parallel two-section filters will be called "two-section filters" for the rest of the

article. You can set each of the four time constants of such a filter independently using spreadsheet PARAL-2.WQ1. The gain of the long-period sections can also be varied, which in itself covers the complete spectrum of designs; altering the gain of other sections has no point because it

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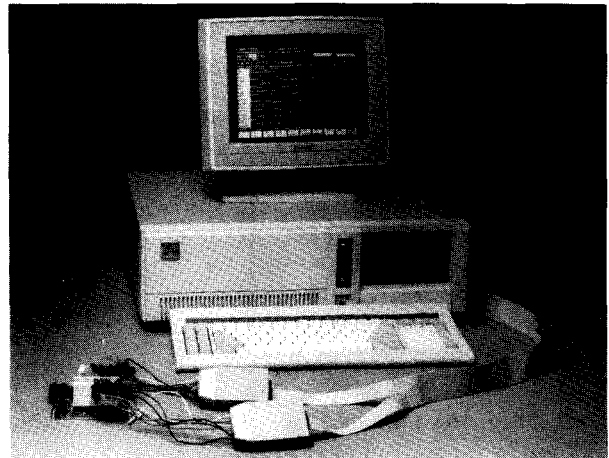
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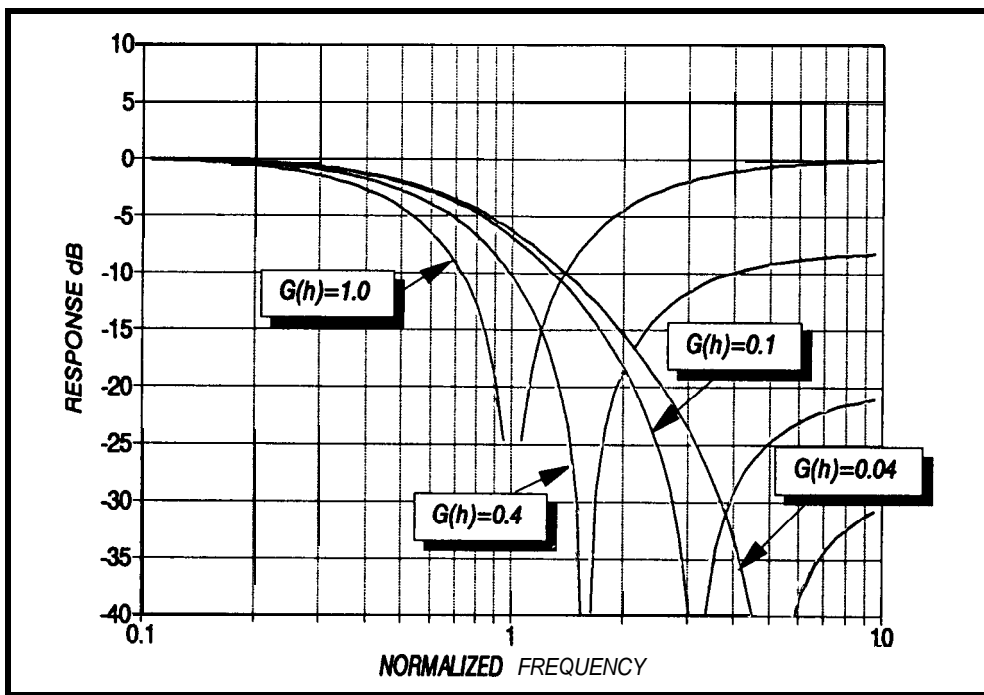


Figure 4—The response of two-section parallel filters with various high-pass gains in which the total rejection of a single frequency apparently still occurs.

can be greater or less than 1 .O. [Editor's Note: Software for this article is available from the Circuit Cellar BBS and on Software On Disk #24. See page 105 for downloading and ordering information.]

If the time constants of the low- and high-pass sections are different, total rejection of one frequency does not occur. The response continues to exhibit a dip as long as the frequency of the low-pass filter is greater than that of the high. The opposite condition produces a broad peak in the response. Figure 3 shows typical curves for cases in which the time constants of the high-pass sections are the reciprocal of those of the low-pass to maintain the center frequency of 1.0. However, if the time constants of all the filters are identical, but the gain of one set differs from that of the other, total rejection of one frequency apparently occurs. The rejected frequency merely moves off from $f = 1.0$ as shown in Figure 4. This parallel-T filter yields a sharper cutoff than an assembly of simple filters, but at the expense of greater gain at a distance.

Also, the spreadsheet can find the response that results from subtracting (instead of adding) the outputs of the low- and high-pass filters. The use of a negative gain for the high-pass filters is necessary. Typical curves are shown in Figure 5.

Three-section filters

The spreadsheet PARAL-3.wq1 is designed similarly for parallel arrays of three low-pass and three high-pass filters. All six time constants can be set independently. You may use the spreadsheet for two-section filters if the time constant of one of the high-pass filters is made very large or one of the low-pass filters very small. Figure 6 shows responses, analogous to those of Figure 2, for a three-section filter in which all sections have a gain of 1.0 and the time constants of the low-pass sections are reciprocal to those of the high-pass sections.

The steeper cutoffs of the three-section filter somewhat sharpen the null in the parallel filter, which can be seen in Figures 2 and 6. The phase shift of three identical cascaded high-pass sections is not $n/2$ at $\omega = 1.0$; the time constants must be $3^{+0.5}$ (and that of the low-pass sections $3^{-0.5}$) to get total rejection at $\omega = 1.0$. When the high-pass part's gain is altered, the response no longer goes through a complete null; in this respect, the three-section filter is not as "well behaved" as the two.

SIMULATION IN TIME

Frequency-domain simulation of parallel filters allows rapid, easy observation of their responses and the

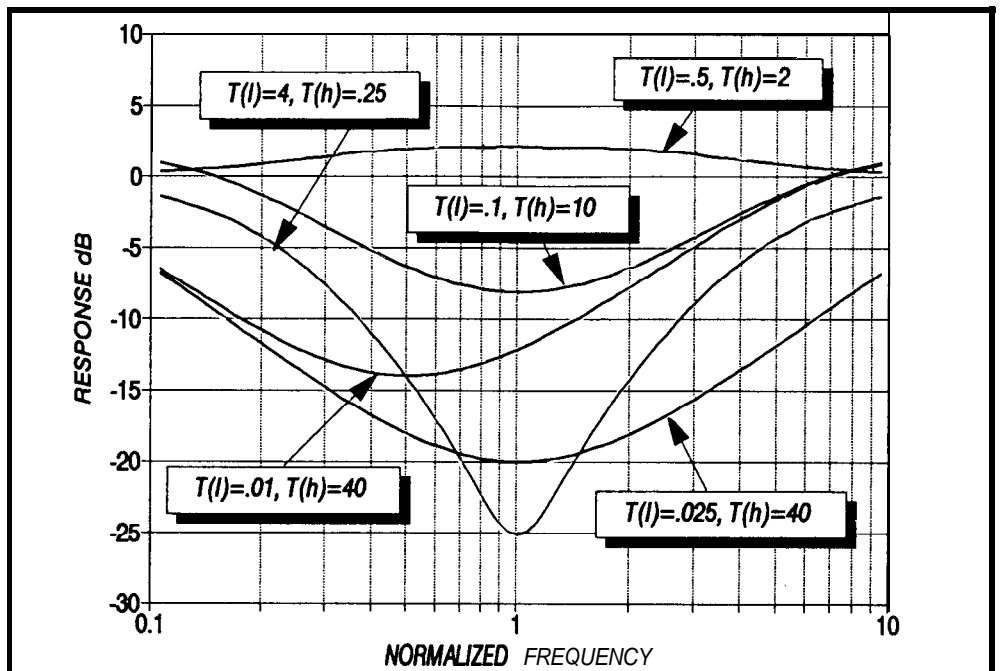


Figure 5—The response that results from subtracting the outputs of low- and high-pass filters.

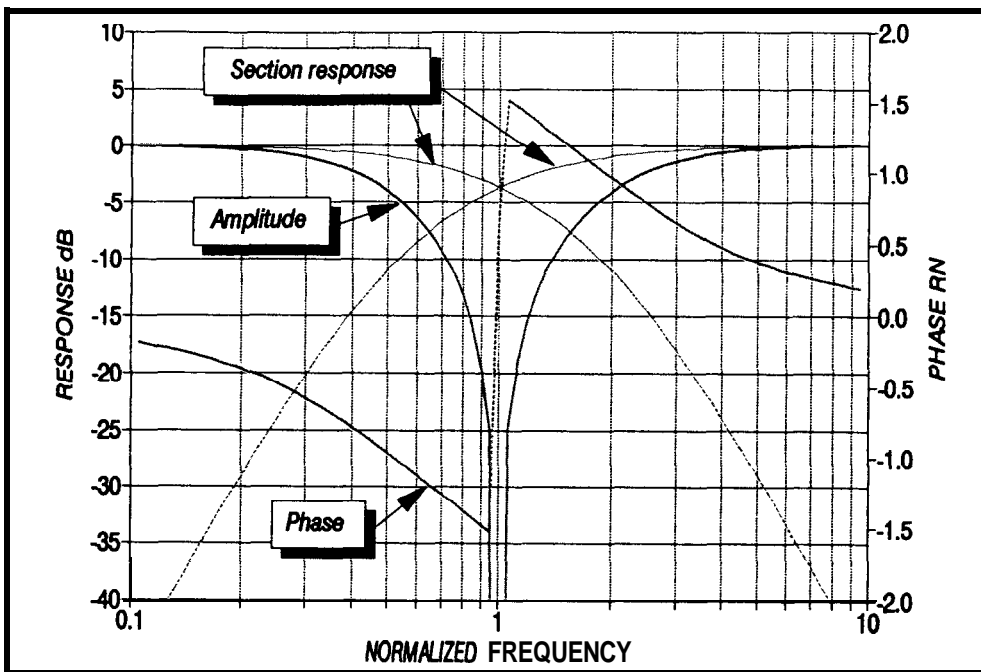


Figure 6—The responses for a three-section filter in which all sections have a gain of 1.0 and the time constants of the low-pass sections are reciprocal to those of the high-pass sections.

effects of manipulating the constants. You can also simulate these filters in the time domain using a spreadsheet if an algorithm is available to perform the necessary filtering. In my article "Filtering Sampled Signals" in issue #21 of *CIRCUIT CELLAR INK*, I showed how to apply low-

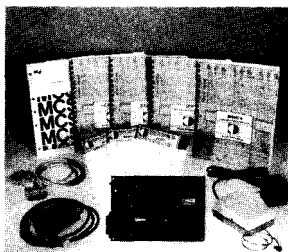
pass and high-pass filters in the time domain to sampled signals, and I developed algorithms that can be readily applied directly to parallel filters [5].

An implicit advantage of this kind of simulation is cumbersome calculations for frequency-domain simulation are unnecessary. However, certain disadvantages exist. The sampling frequency must be high enough compared to the signal being sampled that certain approximations will not unduly degrade the results. Also, you can only examine the parallel filter's performance a frequency at a time.

Figure 7 is a time response drawn with the spreadsheet *TIME-2.WQ1*. I subjected the incoming wave to two successive low-pass and high-pass filterings simultaneously, and then merely added the results sample by sample. The time constants of all the filters in this figure are the same as the radial period of the incoming signal, so the output signal is zero. When

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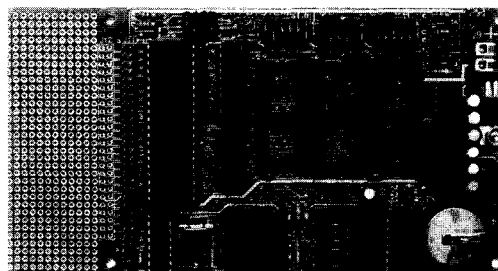


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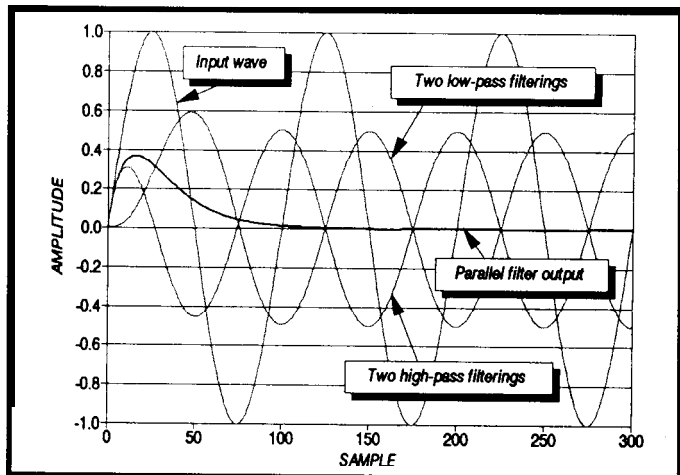


Figure 7—The time behavior of a parallel filter using spreadsheet TIME-2. WQ1 at 100 samples/cycles sampling rate. The incoming wave is simultaneously subjected to two successive low-pass and high-pass filters, and the results are added sample by sample.

the period of the incoming signal is changed, the output is no longer zero, which the frequency-response graphs show.

The starting transient seen in Figure 7 appears in the output record until the response has had time to settle. You can eliminate the response by applying a suitable Hanning time window to the incoming data or just ignoring it until it settles. ❖

REFERENCES

1. Charles P. Boegli, 'Filtering Sampled Signals,' *Circuit CELLAR INK* June/July 1991, pp. 98-101.
2. This filter is extensively discussed in James, Nichols, and Phillips, *Theory of Servomechanisms* (New York, McGraw-Hill Book Company, 1947). p. 117ff. The complexity of the transfer function arises from mutual loading effects.
3. The isolation amplifier prevents the second section from loading the first. The second section is also presumed to be followed by an isolation amplifier to avoid loading.
4. The responses of both low and high-pass sections do not actually show a sharp transition at the 'corner' frequency, but rather change smoothly from one slope to the next. A single-section filter of either type has an attenuation of 3 dB at the 'corner.'
5. Charles P. Boegli, *loc. cit.* Also see the sidebar.
6. Charles P. Boegli, *loc. cit.*

Charles Boegli is president of Randen Corporation in Blanchester, Ohio. Randen is a small company offering services in technical computer programming and analog circuit design.

IRS

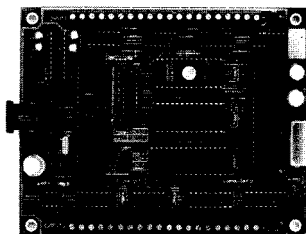
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Home Automation: Read All About It

We often have people new to home automation call us or leave us a message on the Circuit Cellar BBS asking how to find out more.

"Are there any good books on the subject?"

"I'm building a new home and want to prewire it for home automation. What should I do?"

Up to now, I've always had to go into a song and dance about how the industry is still young, there really isn't much out there for the novice, and most systems on the market are specialized enough that it would be difficult to write a general-purpose book about home automation.

I'm happy to report that I can finally stop dancing (I'm awful anyway; just ask my wife) and start recommending some real books. I came across two recently and want to give you my impression of them.

HOW TO AUTOMATE YOUR HOME

Written with the novice in mind, *How to Automate Your Home* does an excellent job of covering a broad range of subjects dealing with all aspects of home automation. Author David Gaddis starts with an overview of the major players in the industry, including X-10, Smarthouse, CEBus, and Echelon. Because the latter three were in a state of flux at the time the book was written (as, for all intents and purposes, they still are), some of the details he presents about them were dated even before the book was published. (Now you know why nobody has been anxious to publish a book before now.) Of the group, X-10 is the only system actually on the market that the individual can obtain, so he uses it as the basis for much of the book.

Gaddis continues with an overview of the various media used in home automation, and spends a chapter talking about wiring homes, both new and retrofits. From there, he spends several chapters discussing home security, appliance and lighting control, audio/video systems, telephones, and environmental control systems. In each case, he presents equipment currently on the market (and does a good job of covering more than just X-10), makes suggestions for how to plan your own automation setup, and presents installation examples that you can use as the basis for your own system.

The information presented is very good, and Gaddis does a wonderful job of covering virtually everything available on the market, but the presentation itself is terrible. The editing is awful, and the book appears to have been prepared using just a word processor (no interesting twists to the layout that can only be provided by page layout software). It also looks like it was printed on a dot matrix (or a bad inkjet) printer. The least he could

*"I'm building a new home
and want to prewire if for
home automation. What
should I do?"*

have done was beg, borrow, or rent a laser printer for the final output. Coupled with cheap paper and poor printing, the bad text makes spending much time reading before eye fatigue sets in difficult.

Most of the figures appear to be bad copies from many different sources. I even recognized some lifted directly from copyrighted material (including the book I'm going to talk about next that I know was on the market first) with no attribution given.

The book also lacks a much-needed index, which might help lessen eye fatigue because you wouldn't have to search as long to find a particular subject.

All in all, *How to Automate Your Home* is an good introduction to the world of home automation if you can get past the poor publishing job. The book runs 128 pages, includes 115 illustrations, and is available for \$29.95.

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AN INSTALLER'S GUIDE TO CEBUS HOME AUTOMATION

Let me start by saying this book is most certainly not for everyone. Written by Michael Maahs in conjunction with Parks Associates, *An Installer's Guide to CEBus Home Automation* is aimed squarely at professional installers (electricians, alarm installers, etc.) who need a practical, down-to-earth description of how wiring should be installed in new (and, in some cases, existing) construction to accommodate present and future home automation needs. While most of the book focuses on CEBus, much of the material applies equally to other systems on the market.

The book begins with an introduction to CEBus and home automation. Then it describes where the outlets (power, telephone, and coax) should be installed in each type of room (living room, kitchen, bedroom, etc.), and why you might want more than what is usually installed in a traditional nonautomated house. It also explains the reasons for some of the nontraditional placement of outlets (e.g., a power outlet up near the top of a window to accommodate remote-controlled power drapes).

After talking about placement, Maahs then discusses how and in what order the various media should be run. Separate chapters discuss wiring a central node panel, the use of "66" blocks, and running power lines, twisted pairs, and coax cables. Later chapters provide guidelines for estimating material amounts and costs, and make specific

recommendations for tools required. Finally, the author makes a brief foray into advanced A/V installations.

The presentation is very nice, with the information organized in a clean, readable format. All illustrations were drawn by Michael Cogbill on a computer specifically for this book and are well done. *An Installer's Guide to CEBus Home Automation* is 90 pages long, includes an index, and is spiral bound so it sits flat on the table without argument. The price on the book (\$149) will probably drive many people away, but if you're building a house and want to prewire so you're ready for the future, I think you'll find it worth the price. Certainly, any current or future professional installers are foolish not to own a copy.

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Ken Davidson is the managing editor and a member of the Circuit Cellar INK engineering staff. He holds a B.S. in computer engineering and an M.S. in computer science from Rensselaer Polytechnic Institute.

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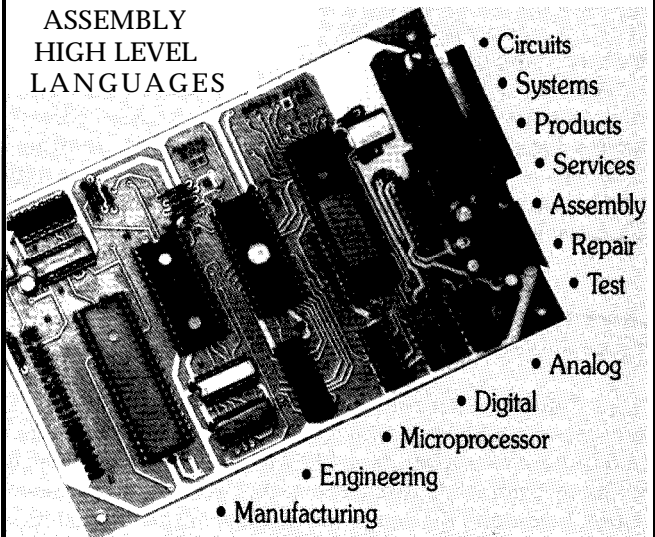
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The text-only environment of a BBS doesn't lend itself to doing graphics, but some adventurous souls often try their hand at "ASCII art." The first thread, dealing with NiCd batteries, has a schematic that I redrew to make easier to read. The second discussion on using RJ-11 connectors for serial connections has some art left intact.

Put a bunch of engineers on a BBS, bring up the topic of rechargeable batteries, and you'll end up with enough good information to write the definitive NiCd book. Read on..

Msg#:46149

From: RICHARD FOLEA To: ALL USERS

Can anyone tell me what I did wrong? I have a Panasonic camcorder (one of the large ones that you rest on your shoulder; I can't remember the model number) that uses a larger rechargeable battery; 12 volt, I think. After about three months of use, the battery wouldn't take a charge anymore. That is, the charger would "charge" the battery, the indicator saying the battery was charging would go off, and I would put the battery in the camera. The battery would only last a few minutes.

Is there something goofy about these batteries that you can't leave them in the charger all the time, or should I occasionally suck all of the current out of it and fully recharge it? Now that I have a battery that acts like this, can I fix it by shorting the terminals with a small resistance? I'd appreciate any suggestions. Also, does anyone know where I can get new batteries? The local mall wants \$50! There has to be a better way.

Msg#:46151

From: RUSS REISS To: RICHARD FOLEA

Yup! Right on both counts. NiCds (which these undoubtedly are) get unhappy both with (SOME) continuous trickle charge, and incomplete cycling. You MIGHT be able to bring them back to life by completely discharging, then recharging a number of times. I wouldn't discharge too quickly, or the internal heating might cause damage, but some resistance that approximates normal usage, I'd guess.

Try calling Periphex Inc. at (800) 634-8132. The fellow there (I forget his name) is very helpful, sells inexpensive packs, and

I'm sure can give you some tips and get you rolling again. Note: "inexpensive" NiCds are never inexpensive though. You can save SOME \$\$ from him, but they won't be CHEAP. I buy my video recorder and ham radio battery packs from him, though, and they are very reliable.

Msg#:46154

From: TIMOTHY TAYLOR To: RICHARD FOLEA

For batteries, try MCM Electronics, (800) 543-4330. I've purchased a number of batteries for my Sony camcorder. One thing to remember is to completely discharge the batteries before the charge cycle begins. That'll somewhat alleviate the "memory" problem. Also, follow manufacturer directions completely when you get new NiCds. You'll really extend the life of 'em.

Msg#:46164

From: PHIL COVINGTON To: RICHARD FOLEA

My Panasonic camcorder uses a 12-V gel lead-acid battery; the number on the battery is PV-BP80. I bought an extra one recently and the instructions that came with it states that you should *NOT* discharge the battery completely and should charge the battery immediately after use. These directions seem to be consistent with the battery type.

Msg#:46175

From: RUSS REISS To: PHIL COVINGTON

You are right! Lead-acids should never be allowed to "drain dry" and should not be stored in a dead state. Gee, I've not seen gel cells in camcorders. I've always liked them better than NiCds in many respects.

Msg#:46207

From: PHIL COVINGTON To: RUSS REISS

I was expecting to find NiCds too, until I opened an old battery from my camcorder and found that it was a lead-acid type-it has six cells with rubber vent caps. The manual for the camcorder also had a warning about breaking the battery and coming in contact with the electrolyte containing sulfuric acid.

Radio Shack's 1992 catalog has a replacement battery that appears to be identical to the battery I have, but the catalog states that it's a NiCd battery pack. Having recently purchased an extra battery pack for my camcorder, I am now wondering if it is a NiCd or lead-acid type. The original Panasonic battery pack has a thin cover that can be pried up and under it you can see the rubber caps for each of the six cells; the new battery (not a Panasonic) appears to be completely sealed. If some of these replacement battery packs are in fact NiCds, I wonder what effect charging these packs with a charger designed for the original lead-acid battery has on the life of the new packs?

Do gel cells suffer from the same problems of incomplete cycling as NiCds? I was wondering if anyone makes a gel cell replacement battery pack for my 2-meter HT.

Msg#:46249

From: STEVE CIARCIA To: PHIL COVINGTON

Generally speaking if your device comes with a modular transformer and not one of those 1-3 hour intelligent outboard chargers, you can make the following assumption: if the charging instructions say plug in the charger overnight, or leave the charger plugged in all the time, but nothing about charging it too long, it is probably NiCd. If the instructions say plug it in overnight but no longer, or something like "Do Not Overcharge," then it is probably lead-acid. NiCds can trickle charge but lead-acids don't like it after they are at a certain level.

You charge a NiCd with a constant-current charger and a lead-acid with a constant-voltage charger. The little modular supplies described above are more like current chargers and therefore only suitable up to a certain point on a lead-acid battery.

Msg#:46250

From: RUSS REISS To: PHIL COVINGTON

Well, Steve pretty much answered it Phil. As for gel cells for HTs, no, I've never seen any. That Periphex number I gave earlier in this thread is run by a ham, mostly for hams. I have thought about making a "battery belt" one could wear that would provide long-term power for HTs for emergency communications, camping, hiking, biking, sailing, and so forth. Never did go far with the idea, though.

Msg#:46186

From: ANDY SARNAT To: RUSS REISS

I couldn't help feeling a little *deja vu* when I read the original question about the failing NiCds: the battery pack in my Toshiba laptop had exactly the same symptoms after about 6 months (i.e., a full "charge" only lasted a few minutes). But I already knew about the NiCd memory problem and I thought I treated that battery pack real nice from the start. I always deep discharged it, I never overcharged it or left the charger plugged in overnight, did everything but take it to dinner and buy it flowers, and this is the thanks I get! So what went wrong?

I even tried to rejuvenate it by fully recharging (until the LED indicated "full"), then discharging to zero by leaving the screen backlight on full intensity until dead, then repeating the cycle six or seven times. No dice.

The local Toshiba dealer says "everybody has to replace their battery pack once a year or so," but of course he SELLS batteries. So I shelled out for a new battery pack, then pried open the old pack to find six NiCd cells all connected in series with metal straps spot-welded to their cases, so I don't see any prospect for replacing the cells myself, even though I've been told that probably just one of the cells is bad.

So I've got three questions for the battery gurus:

- (1) Whuddya do to prevent this?
- (2) Is there a practical way to replace welded-together cells?
- (3) How come my Dustbuster sits on my wall trickle charging continuously for years, hardly ever gets deep discharged, and is still as strong as a Clydesdale?

Msg#:46205

From: BOB ARMSTRONG To: ANDY SARNAT

You can replace those NiCd cells just by soldering in a replacement for the one (or more) that's gone bad. Just rough up the surface some with a file or sandpaper to make it take solder, use some solder wick as a strap, and off you go. I do it all the time. Just don't short the cells... they get *kinda* hot!

Msg#:46217

From: ANDY SARNAT To: BOB ARMSTRONG

Thanks, I'll give it a shot. One more question: can you mix different size NiCd cells in series? Since each cell handles the same current, would the smaller ones suffer damage in series with larger ones under normal load? The reason I ask is that the cells in the battery pack don't seem to be a standard size. They are cylinders about 5/8" diameter and 2.5" long. What would happen if I substituted AA cells for one or more of them?

Msg#:46219

From: JEFF BACHIOCHI To: ANDY SARNAT

You can mix sizes, but current (when the cells are in series) will be limited to the maximum of the smallest cell.

Check Digi-Key. They offer battery packs and individual cells. Sizes are NOT limited to the standard AAA, AA, C, and D, but include 1/2's, 1/3's, 2/3's, and other oddities!

Msg#:46248

From: STEVE CIARCIA To: ANDY SARNAT

Different size NiCd cells have different charge (and trickle charge) ratings. The 100-mA charge on a D-cell will fry an AA cell. Be careful about radically different sizes in series.

Msg#:46252

From: BOB ARMSTRONG To: ANDY SARNAT

They sound like "sub-C" cells. Check your local hobby store for cells used in model cars and airplanes. They range from 1000 to 1800 mA and can be purchased individually or as a 6- to 8-cell pack. Packs average \$25 to \$40 each.

Msg#:46294

From: JAKE MENDELSSOHN To: ANDY SARNAT

Do not ever try to deep discharge a NiCd by just leaving the equipment on and draining it to zero. You can get a situation called voltage reversal where the voltage of the NiCd is actually switched. Once that happens, you will not be able to recharge the NiCd.

Here is what happens to NiCds in series: Assume you have five NiCds in series, each with a full voltage of 1.2 V (carbon-zinc batteries have 1.5 volts per cell; NiCds general have only 1.2 V). The five new NiCds in series give you 6.0 volts. Now after using this NiCd set for a while, one of the cells develops an internal short (see message 46157). This cell is shorted out and is no longer in the circuit. Now when you try to recharge the set as you did before, there are only four cells in the series circuit. Your charging circuit will try to charge them to a total of 6 volts as before. This forces each cell to 1.5 volts per cell. This overcharging damages the other previously OK cells. The end result is you now have one cell damaged with internal shorts and four cells damaged by overcharging. The whole set is destroyed and there is not much you can do, except as the salesman said, "Everyone has to replace their battery pack once a year or so." The 500 recharging cycles claimed in the advertisements is a theoretical limit that I have never even come close to.

If you use a very sharp wire cutter or a Dremel tool you can cut the thin metal connectors that are welded between the different cells. Then try **soldering** your new good cell into the series circuit. The new cell you are adding should have the same level of charge as the other cells in the series or you end up with the same uneven charging problem. I always charge all cells individually to 100% before I solder them together and use them as a team.

There are different configurations of cells with different chemicals, different chemical ratios, and different internal structures. Some cells are meant to use used in situations where they are constantly cycled up and down, others are normally in a fully charged standby mode and supply current only rarely. Some cells are meant to supply heavy current for a short time, others low current for long periods. You really need to match the specific type of cell for the specific use you have in mind.

Gel cells do not seem to suffer from the same "memory" and "internal short" problems that affect NiCds.

The amp-hour rating of these cells is based on a 20-hour discharge rate. Thus, a 10-AH cell will give 0.5 amp for 20 hours ($0.5 \times 20 = 10$). You will not be able to get 10 amps for 1 hour out of the cell. The optimal recharging rate for a cell is 1/10 to 1/20 of the load rating. Thus you should recharge a 10-AH cell at a 1- to 0.5-amp rate.

Msg#:46157

From: JAKE MENDELSSOHN To: RICHARD FOLEA

NiCds have two problems (besides price):

MEMORY—NiCds tend to "remember" how much they were used and then only operate to that level. For example, if a NiCd is discharged to its 80% level and then recharged, and if this

cycle is repeated many times, then the NiCd will "remember" that 20% discharge and will not be able to go beyond it. The 20% becomes the full 100% capacity. The way around this is to "deep discharge" the NiCds every once in a while to clear their memory. I rigged up a small resistor and relay circuit to slowly discharge the NiCds and then stop when the voltage reaches a minimum. You never want to completely discharge a NiCd, because then you may get another problem: "voltage reversal."

INTERNAL SHORTS—A NiCd can also develop an internal short within the cell itself that limits its capacity. The way to clear these shorts is to charge up a large capacitor (>10,000 μ F) to 50 volts and then connect the capacitor to the NiCd. There will be a large spark as the capacitor quickly discharges through the NiCd. This massive current will burn out any of the shorts. You may have to do this a few times to completely clear the NiCd. Charge the capacitor slowly with a resistor in series, but let it discharge directly through the NiCd. Be careful of the large current. It can hurt.

Msg#:46170

From: JOHN S. FETZIK To: JAKE MENDELSSOHN

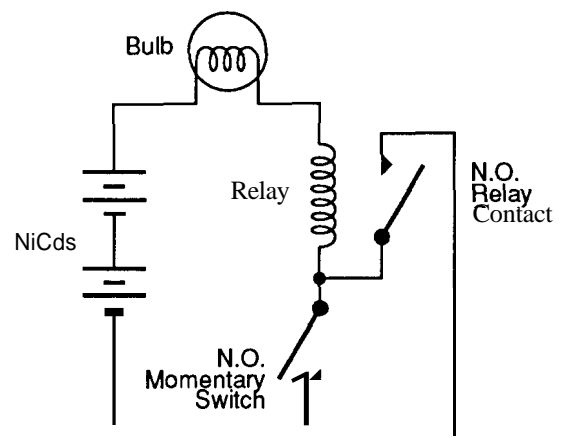
What's your battery discharge circuit look like? What kind of resistor value and what voltage do you have the relay drop out at?

Msg#:46293

From: JAKE MENDELSSOHN To: JOHN S. FETZIK

I am NOT a battery engineer, but after many, many years of spending a small fortune on batteries, talking to many battery engineers, and reading lots of articles, here is what I have gathered:

The circuit I use for deep discharging NiCds looks like this:



Pushing the momentary switch, completes the circuit and activates the relay. The relay contacts touch thus supplying a current path when the momentary switch is released. The current from the NiCd goes through the relay coil and the bulb. When the NiCd is drained low enough that it can no longer keep the relay pulled in, the current stops. The bulb is just a visual indicator that the current is still flowing. I don't think there is any magic value on how low the voltage should be before the

relay is released. For example most 5-VDC relays, once activated, will hold their position with under 2 volts before they release.

Be sure to match the voltage required by the bulb and relay in series to the voltage of the NiCds. This supplies a slow, steady deep discharge with no possibility of completely draining the NiCd. After this deep discharge, slowly recharge the NiCds back to 100%.

Msg#:46379

From: DAVE EWEN To: JAKE MENDELSSOHN

That relay discharger is a very good idea. If you make it a DPDT relay you could make a **cycler**. I think you ought to send this schematic into a couple of the R/C magazines...maybe win something for the "best idea of the month" column.

Msg#:46473

From: PELLERVO KASKINEN To: JAKE MENDELSSOHN

Congratulations! You have come up with EXACTLY the same method of reviving NiCd cells as I use. The only thing that has not appeared to be quite clear on anybody's message so far is: When discharging, you better discharge each cell individually, not as a package of series-connected elements. The series connection is exactly the reason why many packages get damaged in the first place, even though they are "deep discharged." When one cell is low in charge and the whole package is loaded down, the good cells eventually force a reverse charge on the poor chap in the middle with a low or no charge.

Also, when zapping, I always do it for a single cell, even though that may not be quite as necessary as during the proper discharging.

Oh, I was going to say that the vacuum cleaners and hand tools that seem to mistreat their NiCds really bad, all have just a couple of cells in series, so the reversal is much less likely to happen: people just can not run the tool anymore once one of the two cells is empty. Therefore, no more reverse charging from several good cells into one empty cell. Or the potential available for the reverse charging, if attempted, is only that of a single cell, not several times higher.

Msg#:46199

From: MARC CROTEAU To: JAKE MENDELSSOHN

I have a quicker way to "ZAP" the batteries. I basically perform the same task but with something everyone has, a car! Instead of using a BIG capacitor (you might not have one handy!), I use alligator clips on my car battery and I zap the NiCd by just touching it VERY briefly.

I do this 2 or 3 times, then discharge the batteries completely and use my battery charger to fully charge the batteries.

Make sure the polarities are right (parallel) and that you don't keep the two batteries together for too long as overheating might occur and damage both batteries.

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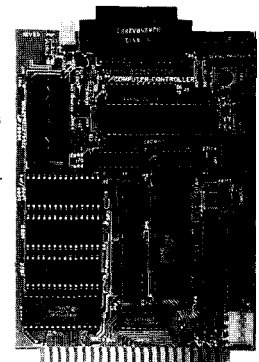
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Reader Service #169

December '91/January '92

103

Msg#:46266

From: PHIL HACKETT To: RICHARD FOLEA

Most NiCds sold for competitive RC hobbyists are at least 1800 mAH. I have seen sub-Cs as high as 2300, but they are VERY expensive and are "freaks" as far as batteries are concerned. The source for these is an importer who buys them by the truckload and then sorts through them with special test equipment.

The truly competitive RC people will NOT use the same battery pack twice during the same event. The batteries will not charge as high without a 24-hour cool-down. Even a 5% loss in power is enough to make you slow.

I know this was off the subject but is something I do deal with in the hobby industry. Strange, isn't it, that "toys" are actually pushing the technological edge of these power sources.. .

What could be more standard than RS-232? Especially when it comes to using RJ-11 connectors? Here, users present some good ideas for making up cables.

Msg#:31074

From: SANJAYA VATUK To: ALL USERS

Is there any kind of standard for wiring an RJ-11(6-wire) telco jack/plug for use with RS232, or does everybody do what they feel like doing? And how do you count RJ-11 pins, anyway? Inquiring minds want to know.

Msg#:31453

From: ROB KELLY To: SANJAYA VATUK

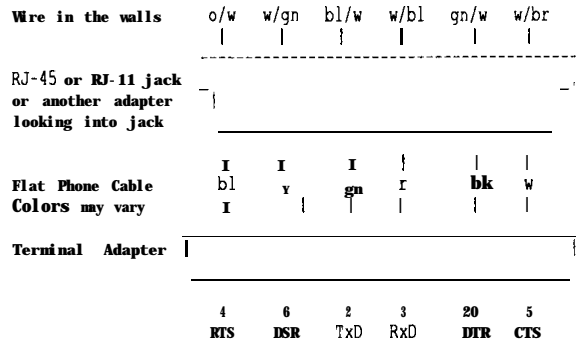
The beauty of standards is that there are so many of them...

Using the RJ-11s for RS-232 is even less standardized than RS-232 itself! Now I'll muddy the waters some more. AT&T uses RJ-45 (8-position) jacks for some of their data communication products and RJ-11 for others. They usually don't use all of the pins, though. I think there are basically two ways to go:

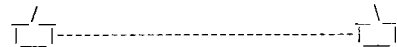
1. Wire the modular to DB-25 adapter such that flipping the flat cable to the device will provide a null modem cable. This means you wire symmetrically (i.e., TxD and RxD are the outside of the plug, RTS and CTS are on the next two pins, etc.). The advantage of this method is that all adapters are wired the same. If you need to null, you crimp the plugs with the flat cable flipped.

2. Wire such that you use a straight-through cable and wire the adapters as DTE and DCE (flip TxD and RxD, etc. in the modular to DB-25 adapter).

I am assuming that you will use flat phone cable from the wall jack to the device or betweendevice. Also if you are coming from a wall jack that also has a phone line, you can't use the center pair. If you don't have to conform to a vendor's standard wiring plan, make your own standard! This plan uses the first method:



You wire the flat cable like this:



This flips the cable and performs the null. As you can probably tell I have spent a LOT of time messing with this. I hope this info helps.

Msg#:31490

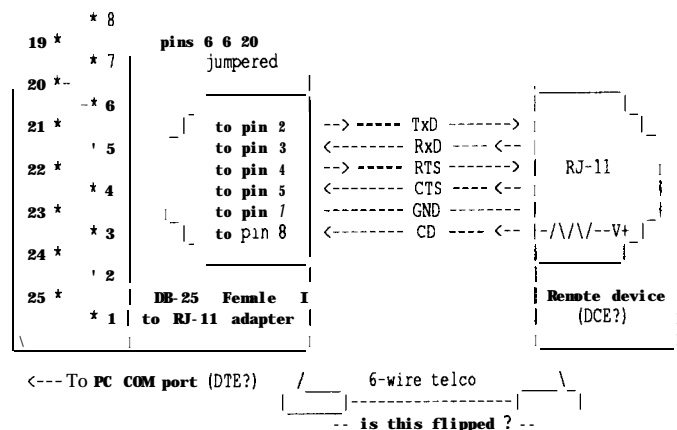
From: SANJAYA VATUK To: ROB KELLY

Thanks! What I have done up until now is just wire the pins I need in basically numerical order as they are numbered on a DB-25. I was using flipped cable because I hadn't planned on making my own, so my female adapters were opposite the male. I think I'll get back to you when I figure out what I did versus what you suggest.

Msg#:31608

From: SANJAYA VATUK To: ROB KELLY

All I can say is this had better come out formatted the way I drew it on my machine! It only took an hour. :) Here's how I wired my setup:



Hope this makes sense.

What is CD? And do I need it for my PC com port to work properly? If not, it seems I could connect DSR straight through

instead (pin 6). I don't need DTR in the remote device. Thanks for your help!

Msg#:31752

From: ROB KELLY To: SANJAYA VATUK

Yes, that cable flips. Hold both plugs side by side, the wire colors should be in the same order. I left off one detail on my diagram: ground! You would have two ground pins to keep things symmetrical. Sorry about the error.

Msg#:31787

From: SANJAYA VATUK To: ROB KELLY

Thanks! I do have one ground. I ended up deleting DCD and adding DTR, or whatever pin 6 is on a DB-25.

Msg#:31636

From: KEN DAVIDSON To: SANJAYA VATUK

Very nice. Do you give lessons in ASCII graphics? As you've found, if you leave at least one space at the beginning of each line, the system won't try to reformat the message when it displays it.

CD (or often DCD) stands for Carrier Detect (or Data Carrier Detect). Your PC shouldn't need it in order to talk to the device.

Msg#:31661

From: SANJAYA VATUK To: KEN DAVIDSON

Thanks! I was going to try using box characters, but I doubt it would work. I'll try rewiring my gizmos without CD and see if it works.

Msg#:31708

From: KEN MUNKHOLM To: SANJAYA VATUK

Check the back page of the latest CCINK. GTEK has a line of RS-232 boards that have RJ-11 connections. You might want to call

them for some information regarding pinout standards. That way you don't lock yourself out of some options for hardware down the road.

Msg#:31528

From: ED NISLEY To: KEN DAVIDSON

Ken, if you don't print this in **ConnectTime**, I want to hear the excuse. Don't tell me the message went to the wrong person, I know you read all of 'em anyway.

The Circuit Cellar BBS runs on a 10-MHz Micromint OEM-286 IBM PC/AT-compatible computer using the multiline version of The Bread Board System (TBBS 2.1M) and currently has four modems connected. We invite you to call and exchange ideas with other Circuit Cellar readers. It is available 24 hours a day and can be reached at (203) 871-1988. Set your modem for 8 data bits, 2 stop bit, and either 300, 2200, or 2400 bps. For those callers with USRobotics Courier HST 9600-bps modems, call (203) 871-0549. Please note this line is not compatible with V.32 modems at 9600 bps.

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The Circuit Cellar BBS is more than a place for readers to exchange technical information. Frequently it has become a place where consultants and business entrepreneurs discuss basic business techniques and ethics.

Recently, one of the consultants on the BBS had a potential customer who wanted to evaluate a design but would only entertain buying the product after it was designed. Part of the deal also included building a prototype for evaluation. Because he didn't trust them, however, he was asking our advice on protecting his design. Was it acceptable to sand off the numbers on ICs? Should he pot both the prototype and the finished units so that they wouldn't steal his design?

Much to my amazement, messages poured in describing the best ways to remove IC nomenclature, complete with discussions on the particular merits of using special solvents instead of abrasives.

Often, the BBSers are so quick to answer a question or offer advice that they don't look at the whole picture. I think everybody completely missed the boat. In my opinion, the first rule of business (consulting or otherwise) is that if you don't trust the customer, you shouldn't even be there. If the design is truly customized for a particular application, albeit inexpensively reproduced, you have invested your time and money already. It's called risk.

Whether or not the customer buys it depends upon their need and willingness to have you as the sole supplier. If distrust is at the level where a "rip-off" is feared, presenting disguised designs only fuels unethical behavior. The customer's perception will be that your solution is so inexpensive (even if you bargain price the finished unit) that they will certainly entertain an in-house design at that point. And, because all engineers share similar training, their solution might end up being very similar. Legally this may not be a "rip-off."

I am not advocating that consultants should not do designs on faith or risk their efforts in designing custom products. Instead, I am advocating speculation when it is strengthened by a trusting relationship with a customer. You should have an agreement in writing up front that acknowledges your efforts toward a product design and that should the company market said device or any part thereof that you are due proper consideration. I'm not telling you how to write a contract, just that in lieu of an ongoing relationship that has already defined these parameters in detail, no reasonable company should refuse putting this agreement in writing.

My experience has been that reasonable-sized businesses cannot deal with black-box purchased products unless complete warranty responsibility is in the hands of the supplier. A one-man shop will have difficulty doing warranty equipment swaps in Saudi Arabia and keeping production rolling at the same time.

Often companies can't invest in new designs as often as they like because the process is too cumbersome or political. Just writing a specification can often take six months. However, "showing them a product" can create double jeopardy. What they may not have been able to specify adequately before will now be much clearer in their minds. The clock starts ticking then toward the ultimate release of that product whether it comes from you or them. Unfortunately, if you don't have adequate resources to produce the product or warranty as required, you will be on the outside again. This is not being ripped off. It's called learning free enterprise the hard way.

Except for being wary when you find yourself using words like "steal" or "protect," you should not avoid taking risk and investing design time for reputable customers. First of all, while you may have graduated well up in your class, there are always smarter people. Count on the fact that a bunch of them work for the customer. Anything you design, they can do too. Your best move is openness. The engineers evaluating your design are employees, not owners. Holding back information only makes their job harder. The more information you provide and document, in fact, the harder it will be for them to substantiate claims of an independent design arriving at the same conclusion.

Finally, unless you have the manufacturing resources to meet the cost, delivery, and warranty requirements of the company, don't even try. Don't give them a prototype that triggers their "designcycle clock" without a plan to benefit from it. Don't think sole ownership. Instead, offer to license or sell the complete design on a one-time fee or royalty basis.

It's a hard lesson to realize that our professional contribution might be quite small when considered in the grand scheme of things. Every design can't be the next hoola hoop any more than every lottery ticket can be a winner. Consulting is a combination of sense and substance. The truly successful consultant is the one who understands how to look at business through the eyes of his customer.

