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July 2001
Vol. 22 No.7

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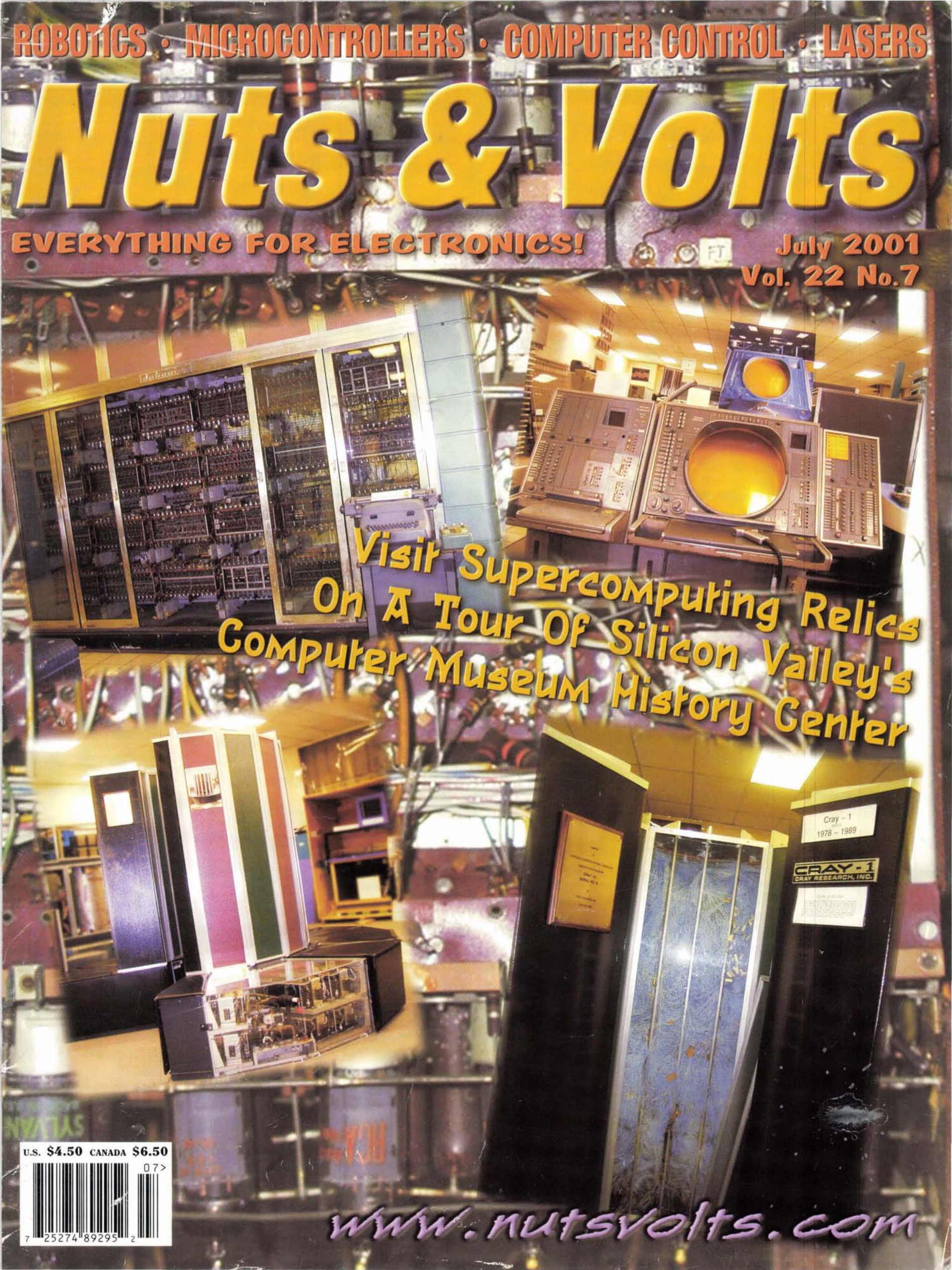

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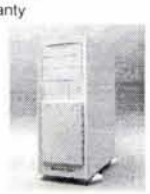

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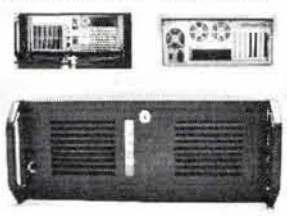

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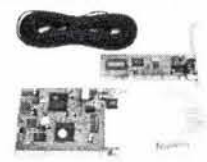

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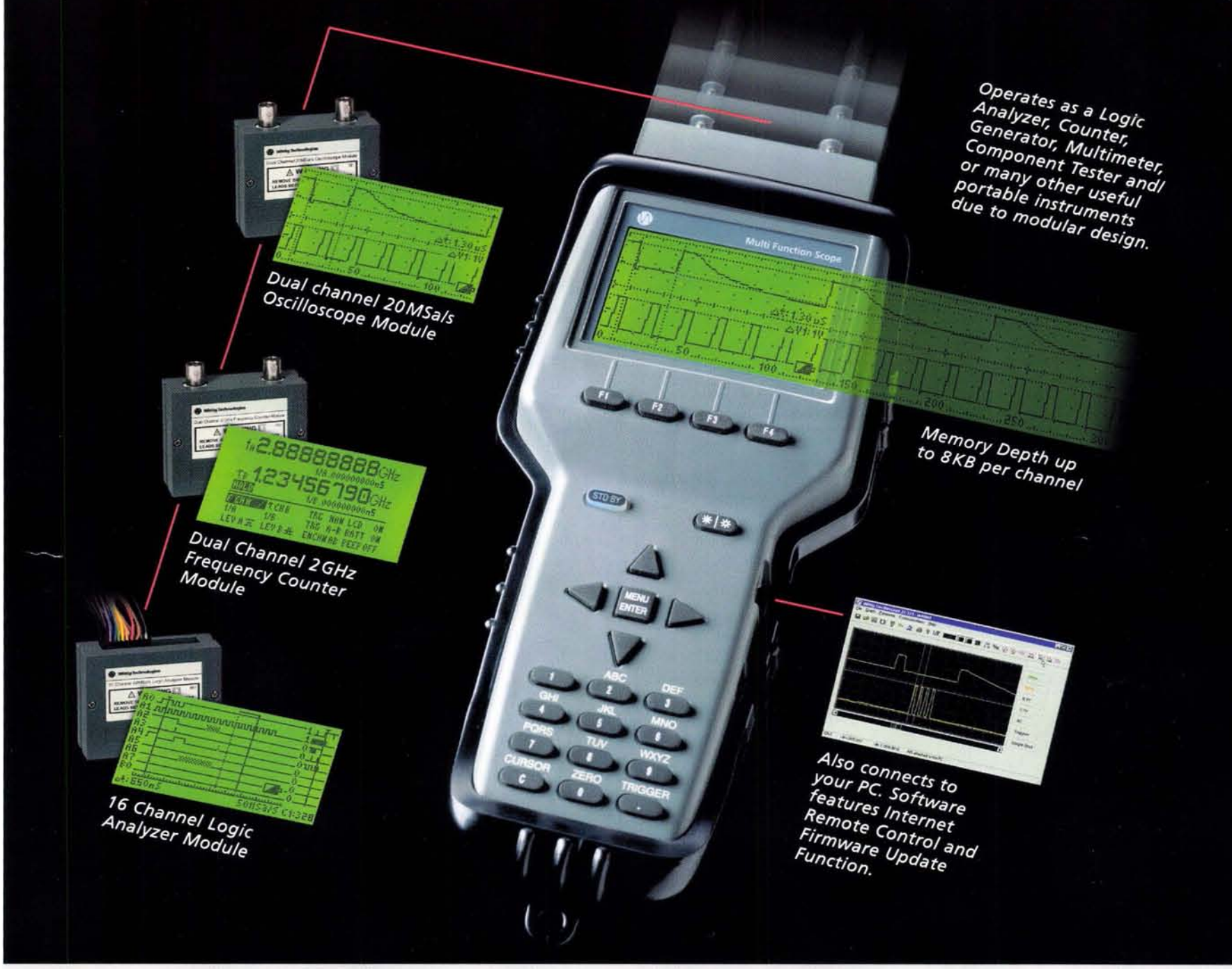

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TechKnowledgey 2001

Events, Advances, and News From the Electronics World

by Jeff Eckert

Advanced Technologies

Old Compound Becomes New Superconductor

Early this year, Japanese researchers at Tokyo's Aoyama-Bakuin University accidentally discovered that a common compound — magnesium diboride (MgB2) — acts as a superconductor at temperatures below 39 K (-389°F). The discovery has generated considerable excitement in the world of physics and, in fact, a March 2001 meeting of the American Physical Society (APS) attracted speakers from Japan, Korea, Switzerland, Italy, Britain, China, France, the Netherlands, Germany, and the USA, all of whom were on hand to discuss the results of experiments they had conducted on the substance. A total of 79 papers were presented.

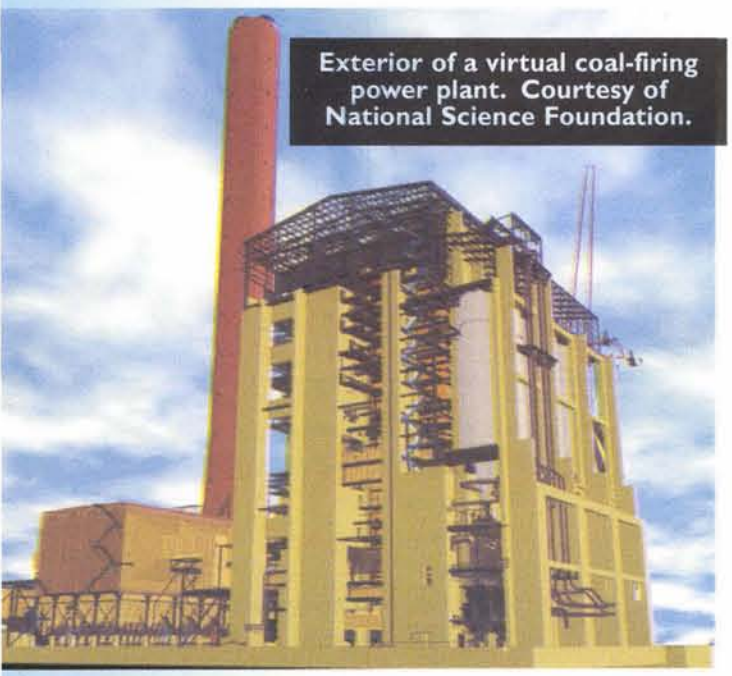
Professor Jun Akimitsu and other researchers were attempting to make a chemical analog of calcium hexaboride (CaB6) by replacing calcium with magnesium when they discovered the heretofore overlooked qualities of MgB2. The compound has been commonly available since 1953, but no one ever bothered to cool it down and test its superconducting properties. At the time, researchers incorrectly believed that a substance must have 3.8 electrons per atom to be a good superconductor. Among the interesting discoveries:

Its superconducting transition temperature is much higher than that of niobium tin, which becomes a superconductor at 20 K. This is the highest transition temperature previously known for a metallic substance. Unlike standard ceramic superconductor materials, MgB2 can be formed into superconducting wires and cooled by electric refrigerators rather than by the use of liquid helium, making it more useful for commercial applications ranging from magnetic resonance imaging (MRI) to power generation. Immediately above the transition temperature, MgB2 has a resistivity that is about equal to that of copper. Other standard materials have resistivities as much as 20 times as high. The material can carry approximately 2 x 10^5 A/cm of current.

Magnesium diboride is readily available, relatively cheap, and can even be ordered online from companies such as Alfa Aesar (**www.alfa.com**), where it is simply listed as magnesium boride. Additional information is available from the APS web site, **www.aps.org**. You can even watch a digital slide show at **www.aps.org/meet/MAR01/mgb2/index.html**.

Computers and Networking

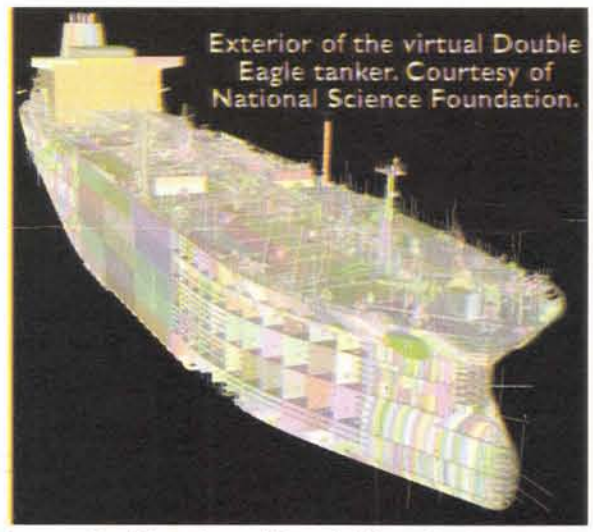
Computer Simulation Leads to Better Structures



Exterior of a virtual coal-firing power plant. Courtesy of National Science Foundation.

The Walkthru Project, created by two University of North Carolina professors and funded by the National Science Foundation, is an advanced simulation concept that uses computer aided design/computer aided manufacturing (CAD/CAM) information to create 3D virtual reality. The goal is to allow architects and engineers to "walk through" complex virtual structures before the actual ones are built. In this way, designers can locate and eliminate potential structural problems with buildings and other large structures before construction begins.

An example is the tanker shown in the computer-generated graphic of the Double Eagle tanker. It is derived from 82 million separate CAD/CAM elements. The entire ship can be traveled from bow to stern, inside and out. The program has also been used to simulate a 13 million element electric power station. The Walkthru Project models were developed on powerful graphic workstations built by Silicon Graphics, but they will run on high-end PCs. The images can also be viewed in "virtual reality caverns" that let the user experience the simulations on a life-size scale. The project, which has been in development since the 1980s, is primarily the work of Professors Fred Brooks and Dinesh Manocha. Last year, Prof. Brooks received the Turing award (the highest honor in the computer science field) from the Association for Computing Machinery. For more details, visit www.cs.unc.edu/~walk. Several 3D animations can be viewed at www.cs.unc.edu/~geom/rendering/videos.shtml.



Exterior of the virtual Double Eagle tanker. Courtesy of National Science Foundation.

Itanium™-Based Systems Introduced

By the time you read this column, several computer manufacturers will have introduced initial Intel® Itanium-based servers and workstations, according to Intel. The company expects approximately 25 computer manufacturers to offer more than 35 models this year. Targeted at enterprise and high-performance computing applications, the Itanium processor is the first in a family of 64-bit products from Intel. Four operating systems will support Itanium-based systems, including the Microsoft Windows platform, Hewlett Packard's HP-UX 11i v1.5, IBM's AIX-5L, and Linux. Caldera International, Red Hat, SuSE Linux, and Turbolinux plan to provide 64-bit versions of the Linux operating system.

Itanium-based systems feature a large cache memory, 64-bit addressability, and the ability to execute more operations simultaneously to speed data queries and transactions for up to 16 terabytes of data. The Itanium processor's floating point engine enables complex computations such as those required by data-mining, scientific, and technical computing applications. Itanium processors feature 2 and 4 MB of L3 cache and 800 and 733 MHz frequency speeds at prices ranging from $1,177.00 to $4,227.00.

Circuits and Devices

Digital IC Measures Time to 125 Picoseconds

Ken Condreva, a researcher at Sandia National Laboratories, has designed and patented a device that provides extremely accurate time measurement down to trillionths of a second. The Falcon IC was originally developed to accurately record critical timing signals in test flights of weapon systems, but it uses standard CMOS technology, is cheap to manufacture, and could have much wider potential. The circuitry employes a "pulse stretching" technique that lengthens the duration of the output signal so it becomes 64 to 200 times as long as the input signal, thus allowing detailed analysis later. The concept is analogous to recording a sporting event with a high-speed movie camera and replaying it slowly to get a more detailed view of what happened. Suggested applications include distance measurement

The Falcon IC is a small CMOS device that provides high-resolution time measurements. Photo courtesy of Sandia National Labs.

(as in surveying land), liquid level measurements in chemical plants, collision avoidance systems in vehicles, and various test procedures. The device is not currently in production, but Sandia is actively seeking partners to mass produce and commercialize it. If your company is interested, contact Scott Vaupen (**sbvaupe@sandia.gov**) for more information.

Electric Bicycles Offer Zero Pollution, Energy Recycling

Yes, you thought of it years ago. We all did. But now many companies (a dozen or so in the US and as many as 200 in China and elsewhere) are actually selling electric motor-assisted bicycles. One of the newest and most interesting is the touring bike from EPS (Energy and Propulsion Systems) Inc., a Canadian company that is just getting into the market. Whereas most of the electric bikes are based on the usual concept of charging the batteries from the AC power line, the EPS vehicle can also recharge itself mechanically when you are braking, coasting downhill, or pedaling against the motor in a generative mode. Via a handlebar-mounted control console, you can choose output levels of 25, 50, 100, or 200 percent of your own mechanical input. The power source is a brushless DC motor that provides 180W continuous and 450W for short intervals. Three battery options are available: conventional lead-acid, nickel-cadmium, and nickel-metal hydride. The price ranges from $1,000.00 to $1,300.00, depending on the battery configuration. EPS also offers a conversion kit for your present bicycle at a cost of about $700.00. More information is available at www.eps-propulsion.com.

The power-assisted touring bike from EPS, Inc., provides a range of 25 to 50 km (15 to 30 mi) on a charge. Photo courtesy of EPS, Inc.

Currie's E-Tryke moves along at about 12 mph and appeals to the older generation. Photo courtesy of Currie Technologies.

Other US companies involved in this emerging market (many of which import at least some components from a relatively few Asian manufacturers) include Ford Motor Company subsidiary TH!NK Mobility (**www.thinkmobility.com**), Zapworld (**www.zapworld.com**), Denali Cycles (**www.denalicycles.com**), Lee Iacocca's EV Global Motors Co. (**www.ebike.com**), and Currie Technologies, Inc. (**currietech.com**). Even Mercedes is expected to introduce one of its own soon.

At last, you can ride through the countryside easily and quietly, gratified by the knowledge that you are emitting zero air pollution. The peace and serenity will be disturbed only by the sound of teenagers on mo-peds, honking their horns as they pass you.

Industry and the Profession

Semiconductor Industry Slump Deepens

Based on the first two quarters of the year, semiconductor industry soothsayers are now predicting that 2001 may surpass 1985 as the worst year in history. Overall, revenues could be down by as much as 20 percent as compared to 2000. In 1985, problems in the DRAM industry helped to create a record-breaking 16 percent decline. Contributing factors seem to be (1) overpurchasing in 2000, which created an oversupply in parts warehouses, (2) the rapid disappearance of much of the dot-com world, (3) a worldwide glut of silicon production capacity, and (4) the growing energy supply problems, which are expected to push production costs upward and profits in the other direction.

The energy crunch, of course, is particularly severe in California, so we might expect industry to suffer disproportionately there. However, there is little manufacturing left in the state, which many semiconductor manufacturers view as increasingly hostile and expensive (the median family income in Santa Clara County is $530,000.00). Perhaps the most colorful comment came from TJ Rodgers, CEO of Cypress Semiconductor Corp., who observed, "I can buy power in Texas and Minnesota for one-third of what I pay in California, and I don't have to kiss anybody's ass to get it."

Apple Computer Initiates Line of Retail Stores

For years, Apple Computer has been plagued by retail store personnel who are not Macintosh knowledgeable and therefore steer customers to Intel/Windows-based PCs instead. Office Depot and other office supply outlets dropped Mac products from their stores, as did Best Buy stores in 1998, and other third-party marketing agreements just have not worked out. To overcome its weakness in storefront operations, the company will open a chain of retail stores that sell Apple products exclusively.

In May, the first two stores opened in Glendale, CA, and McLean, VA, and customer reaction has been widely reported as exceeding the company's expectations. Making it look more like a rock concert than a store opening, more than 500 customers were waiting in line when the McLean store opened at 10:00 am, some of whom had been at the door since 4:00 am. In the first weekend of operations, more than 7,700 people visited the two stores and bought $599,000.00 worth of merchandise.

The stores are almost museum-like, with graphics-adorned white walls, hardwood floors, and uncluttered displays. Relatively few cables are visible, because the 35 demonstration machines are connected via an AirPort wireless network. Customers can try out movie production, burn CDs, experiment with digital cameras, and so on, or watch demonstrations on a 10-foot diagonal screen. Each store also includes a "genius bar" where customers can get technical answers from a knowledgeable factory representative. More than 300 software titles are also available for both home and professional applications. As one visitor remarked, "I'm so glad that Apple has discovered marketing." Plans call for a total of 25 Apple stores to be open by the end of 2001. **NV**

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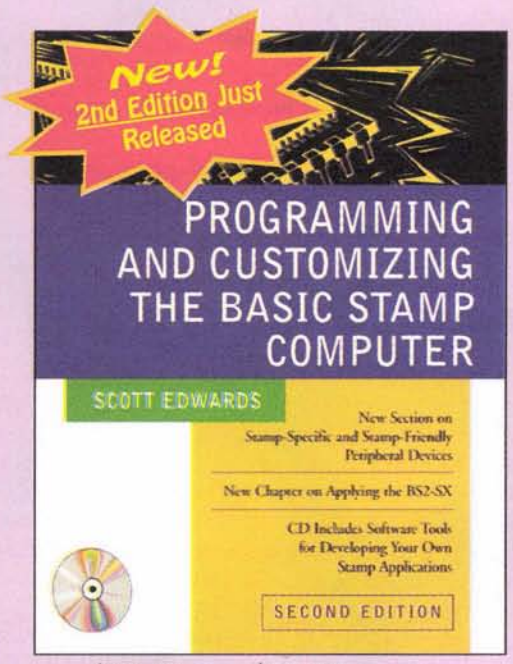

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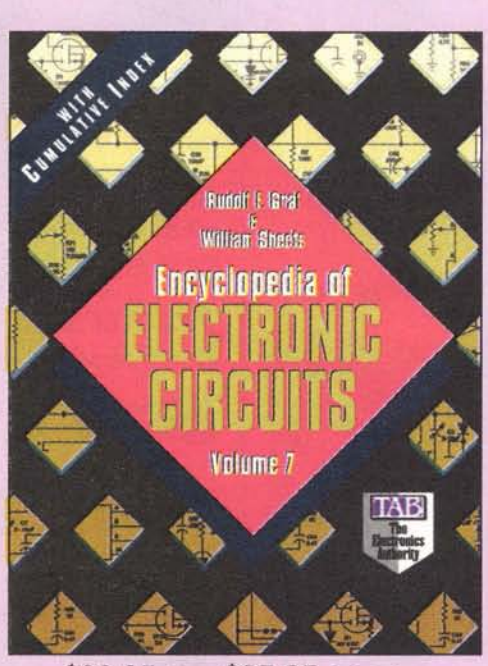

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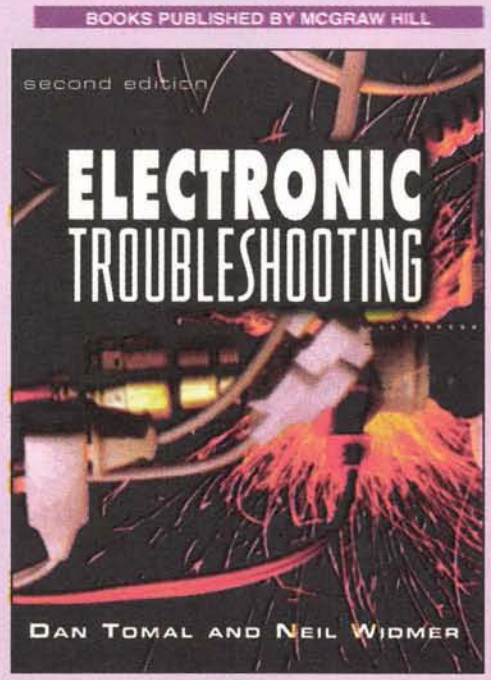

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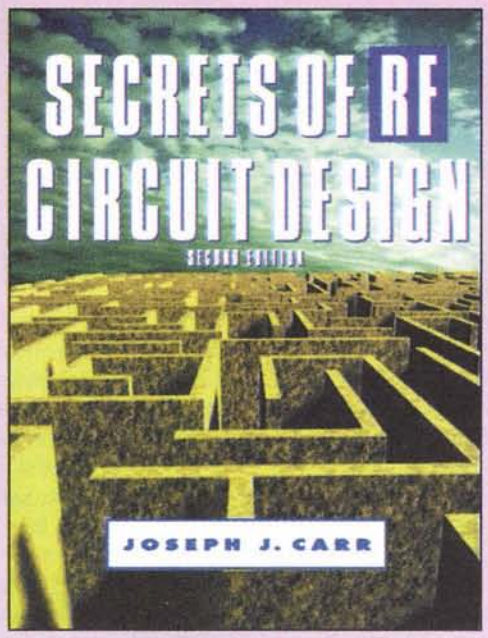

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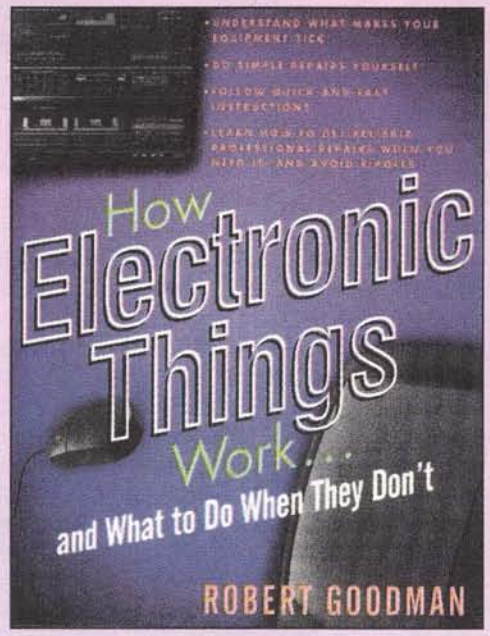

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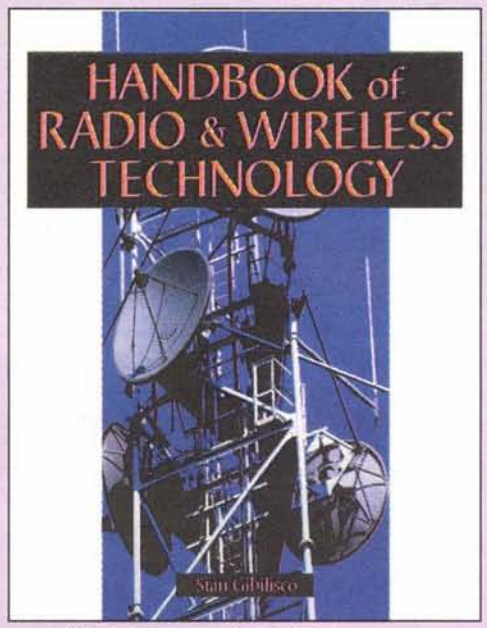

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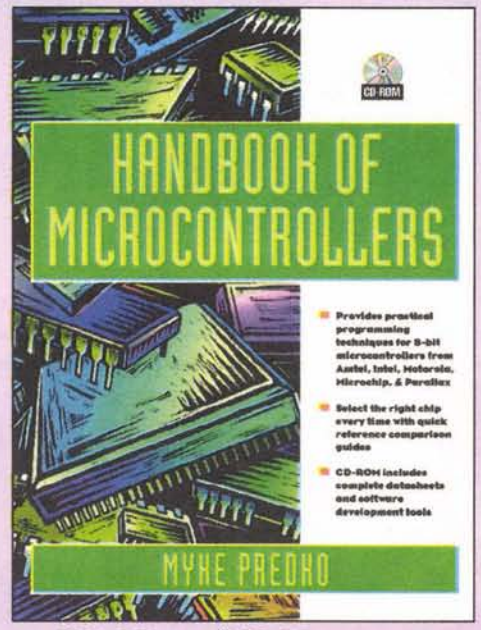

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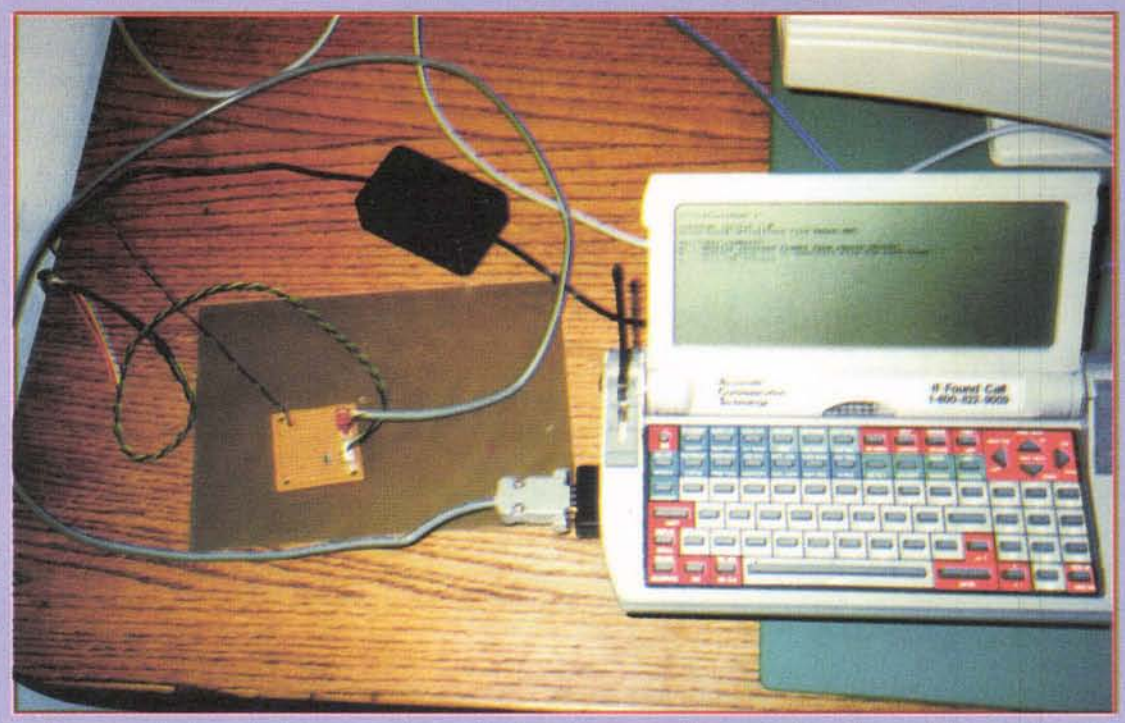
by Karl Lunt

ADD SENSORS TO YOUR HOME ROBOT



The brain of my home robot. This is a hacked Itronix T5000 portable PC connected to a homebrew RF receiver board (small, square perfboard to the left of PC) through a serial cable.

Last month, I described my RF sensor block — a PIC-based circuit that can transmit digital and analog sensor data over an RF link back to the home robot's host computer. That article also covered the transmission protocol, used to insure a reliable data flow from the sensor block. Thus, the first two articles in this series have covered the robot's actuators, built around common X10 control modules, and the sensor data used by the robot to make decisions. All that is left is the software running on the host computer itself.

robohome

I call the current version of my home robotic software robohome. I wrote robohome in Borland C version 4.52, and it runs on a 80386 (or better) DOS box. In my present system, the DOS box is a hacked Itronix T5000 ruggedized PC that — in a previous life — was a telephone test instrument. Unfortunately, T5000s are tough to come by these days, as Resources Unlimited — the vendor I bought mine from — has long since run out. But, if you are lucky enough to stumble across one, I give a full set of instructions for hacking the T5000 on my website at: www.seanet.com/~karllunt.

But the actual DOS box you use isn't important, and nothing in the code presumes anything about the host PC. You could use just about anything with a COM port and a PC BIOS, including a laptop or junker PC.

In fact, the truly ambitious hackers out there could port my original C code to non-PC platforms, such as the Macintosh or a large single-board computer. Companies like New Micros (www.newmicros.com) sell excellent computer boards complete with lots of RAM and ROM space, using a variety of microcontrollers. A full port would be quite a task, as the PC platform has a lot of built-in support for displays and keyboards, but you would end up with a heckuva dedicated home robot brain.

You execute robohome from the command prompt; simply enter a command of the form:

robohome port

where port is required and is either 1 for COM1 or 2 for COM2. When robohome starts up, it will check the selected COM port to verify that it is present; you get an error exit if robohome can't find the port. You must have the RF receiver module connected to this port; robohome will use this port to collect data packets from the RF sensor blocks within range. (See the previous article for details on building and connecting the RF receiver module.)

Next, robohome tries to open the house definitions file, used to relate specific X10 device addresses to common names such as "PorchLights" or "DenHeater." This house definitions file is assumed to be named house.def, and is the same format used by the x10dos program described in my first home robotics article. Rather than repeat that information, I'll refer you to the first article; remember that you can get the full C source code and a working executable of x10dos from my website.

Note that you can run robohome without a house definitions file; if it is missing, the program will warn you, but will otherwise continue.

robohome then initializes several variables and flags used to track the state of communications with the various RF sensor blocks and with the X10 devices. When initialization finishes, robohome prints a menu giving a short list of available commands. Finally, robohome starts an endless loop of scanning for keyboard characters, scanning for incoming data from the RF sensor blocks, and updating the various timers.

Commands

I've added support for a small number of interactive commands, available from the PC's keyboard. You enter a command simply by pressing the proper key; there is no need to press Enter afterwards. Commands are case-insensitive; 'q' and 'Q' are the same.

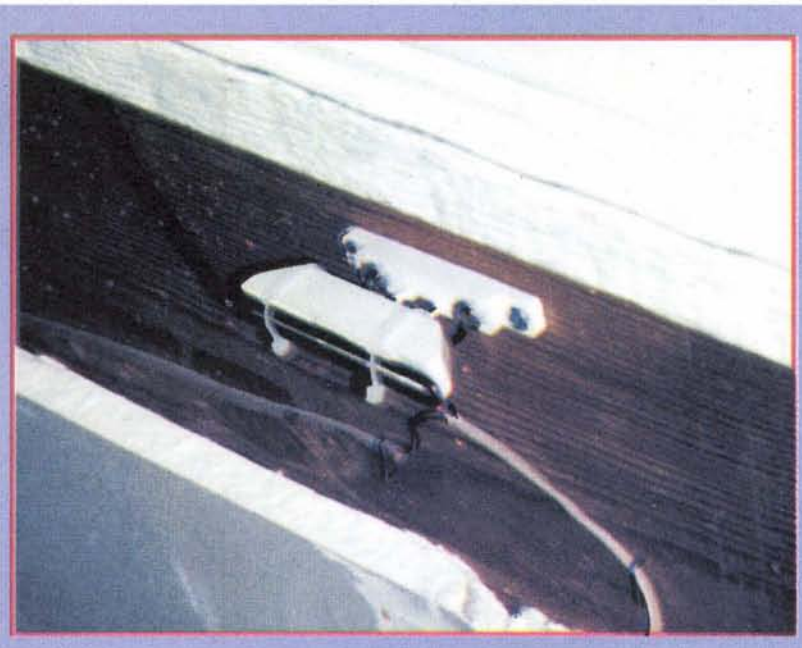
robohome currently recognizes three different commands. Hitting 'Q' immediately quits the robohome program; control returns to the DOS command prompt. Pressing 'M' toggles a data packet monitor on and off. Finally, you can use the 'W' command to toggle a watch mode on and off.

Turning on the data packet monitor lets you see a detailed, real-time report of each packet received by robohome. Not only does robohome display each byte of data as it arrives, it analyzes the packet and shows you if the packet was valid or not. A monitor display of a typical data packet would look something like this:

```
PR1 PR2 LEN=9 ADDR=7
RECN=ed DATA=4b 23 23
21 25 CHKSUM=d4 OK
```

This example shows all fields reported by the monitor. The PR1 and PR2 fields mark the two preamble characters in the data packet. The LEN field shows the packet is nine bytes long, and the ADDR field gives the address of the transmitting unit. The RECN field holds the record number of this packet; record numbers start at 0 and increment to 255 (hex $ff), then roll back to 0. The DATA field shows the value of the sticky byte holding the states of the four digital inputs, followed by the values of analog inputs 0 through 3. Finally, the CHKSUM field contains the checksum byte transmitted in the data packet. If the checksum matches with robohome's calculation, the monitor ends the line with "OK;" otherwise, the monitor displays "BAD."

The monitor provides an excellent way to verify that a sensor block



I built a garage door switch from a RadioShack door alarm sensor, a heavy coat hanger, and some nylon wire ties.

is active. You can also use the monitor to do low-level debugging of an installed sensor block. For example, you might have a sensor block wired to a thermistor for measuring temperature, and you want to know what analog value is being reported. Just activate the monitor, then scan the data packet of the proper sensor block.

The watch command provides a quick means of checking for valid versus invalid packets, and for verifying that the data streams are actually active. If you turn on watch mode, you will see a single plus-sign ('+') each time a valid packet is received, and a minus-sign each time an invalid packet arrives. The monitor can scroll data past so quickly that you could miss a bad packet in the data flood; the watch utility lets you see a snapshot of hundreds of data packets on a single screen.

These commands are only the beginning of what is possible with robohome. Play with the program a while, dig through the source, and feel free to add commands of your own. If your PC screen supports color and cursor positioning (using ansi.sys), you might want to design a real-time data display, showing good and bad packet information for each of the available sensor block addresses. If you want to get really fancy, you could add a way to view analog channels on a given sensor block as a graph or chart. This would let you view historical data and perhaps guide you in making changes to your home.

The clocks[] array

Much of robohome's processing requires tracking event timeouts. Often, robohome must make decisions based on one event happening or not happening within a fixed amount of time after a previous event. I chose to implement a large number of these event timers using an array called clocks[].

Each element in the clocks[] array is a structure containing a .time field of type time_t, and a .tripped field of type char. The .time field holds the number of seconds that must elapse before the corresponding .tripped field is set TRUE. Once each second, the .time field in all elements in the clocks[] array is tested; if it is not zero, it is decremented. If decrementing a .time field causes that field to reach zero, the corresponding .tripped field is set TRUE.

This mechanism lets you customize timeouts for various actions. Your code should pick an element in the clocks[] array, clear the .tripped field to FALSE, and write a timeout value to the .time field when the first part of an action occurs. Other code can monitor the state of the .tripped field and take action when the timeout happens.

Note that I used the ANSI standard time() function for my timing code. This function returns the number of seconds elapsed since midnight GMT, 1 Jan 1970. Thus, the clocks[] array timers only have resolution of one second. This hasn't proven to be a handicap so far, but if you choose to port robohome to another platform, you might have to write your own time() function or even write a new timing method.

The ProcessRcvdChar() function

This function handles each character as it arrives from the RF receiver hooked to the PC's COM port. I implemented this function as a large state machine, using variable rcvstate to hold the current state. rcvstate starts out in the WAIT_FOR_PREAMBLE1 state, waiting for the appearance of the first preamble character at the serial port. Anytime an error occurs in subsequent processing of a data packet, rcvstate is set back to this state to restart the scan for the first preamble character.

If a first preamble character arrives while rcvstate is in the WAIT_FOR_PREAMBLE1 state, the character is discarded and rcvstate advances to the WAIT_FOR_PREAMBLE2 state. If the next character received is the second preamble character, rcvstate is advanced to the WAIT_FOR_LEN state. If it is not the second preamble character, an error condition is detected and rcvstate reverts to the WAIT_FOR_PREAMBLE1 state.

This sequence of testing the received character and advancing rcvstate on success continues until all characters of the packet have been processed. Relevant characters in the packet are stored in a dedicated array named sensors[]. This array holds the most recent data packet received from each RF sensor block address. At the final state, the packet is tested for validity and flags within the appropriate sensors[] element are updated accordingly.

Recall that all RF sensor blocks are only capable of transmitting; they cannot receive commands or prompts from the host PC. The combination of the protocol design and the state machine inside ProcessRcvdChar() reduces the chance of bad transmissions and also allows for collisions between transmissions of different sensor blocks.

If one sensor block tries to transmit while another is already sending, the incoming packet will very likely be corrupted and fail one of the tests in the state machine. The damaged packet will be discarded and the next incoming packet will be collected.

The Evaluate() function

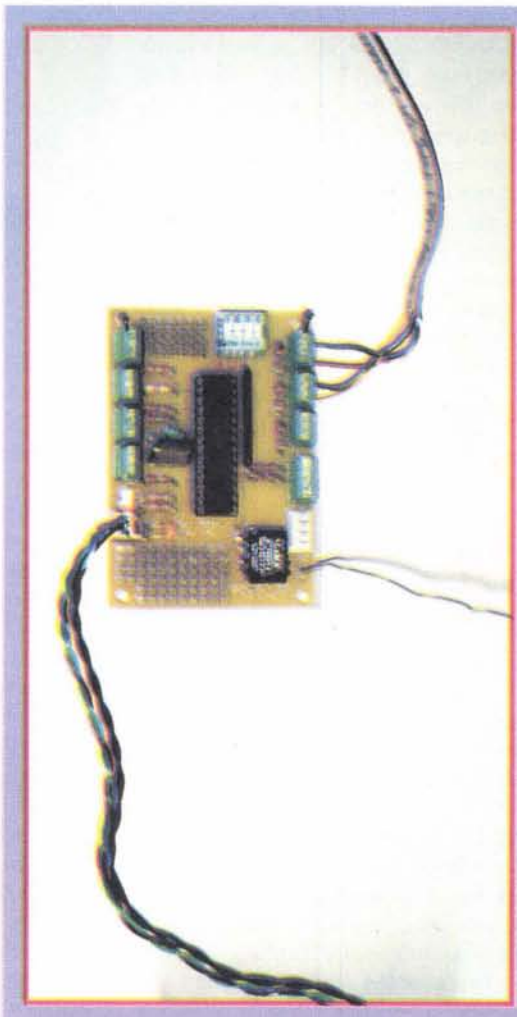
It all comes down to the Evaluate() function. Everything I've done so far; the RF sensor blocks, the X10 transmission code, the Firecracker module ... all of it exists solely for the use of this function. Here is where your code evaluates information received from the sensor blocks, tests the various timers in the clocks[] array, decides what actions to take, and initiates any X10 transmissions.

I've included a sample Evaluate() function from my current version of robohome; see Figure 1. You should use this code as a starting point for developing your own Evaluate() function. I'll walk you through the essential parts; although this is a simple piece of code for a single task, it shows most of the necessary operations your code will need to perform.

This version of Evaluate() examines data from a sensor block hanging on the wall in my garage. The sensor block is wired to two RadioShack door switches — normally used in burglar alarms — that I have mounted over the two garage doors. I have wired the switch on the side of the garage I customarily use to binary input 0 (BI0), and the switch on the side that my wife, Linda, normally uses to BI1. In the program shown here, I've used #define statements to equate the states of these two inputs to literal strings that make more sense than BI0 or BI1. For example, the literal that indicates the switch on my side of the garage is open is GARAGE_DOOR_OPEN_KARL.

The first step in evaluating the sensor data is knowing when the data have just been updated. The Evaluate() function tests the .status field of the sensor[] element dedicated to the garage sensor block. If the .status field was just updated (in other words, if a new data packet just arrived from the garage sensor block), the function processes that data with the following actions.

First, it resets the .status field to ACTIVE. It is important to take this step immediately. While it is unlikely that processing will take more than



Here is my garage RF sensor block, fastened to the garage wall above my workbench. Clockwise from upper right are the leads to the garage door switches, the antenna, and a wire to the 5 VDC supply.

two seconds, it is good practice to clear the flag first. If the flag isn't reset to ACTIVE until the end of the function, it is possible that a second data packet would arrive first, and clearing the flag would hide that event, possibly causing the program to lose the data.

Next, the code gets a copy of the .data[0] element, which holds the binary sticky byte, and uses an AND mask to isolate the two sticky bits that track the state of the input reserved for my garage door state.

If the bits show the door is open, the code tests an element of the clocks[] array reserved for timing my garage door events. If that timer is already at 0, the code sends an X10 command to turn the garage light on. Whether the timer is already at 0 or not, the code then sets the timer for a fixed delay, to keep the light on a minimum amount of time.

The code repeats the above tests and timer setup, based on the state of Linda's garage door. Note that the timer used is the same in both cases; sensible, since there is only one garage light and its operation is the same, regardless of which door is open.

The last block of code in this example function tests the state of the .tripped field for the garage timer. If that field is TRUE, the garage timer has elapsed. In that case, the code sets the .tripped field to FALSE, then issues an X10 command to turn the garage light off.

This simple function, taking only a few lines of code, provides reliable control of the garage light based on the state of the garage door switches. In actual use, I've come to rely on this portion of the home robot. When I open the garage door at night, the light comes on within a second or two after the door is open. The timer for turning off the light doesn't start until both door switches are closed. This means I get five minutes after I shut my garage door before the lights go out, which is plenty of time.

I realize that most automatic garage door openers provide a similar function, and you don't even have to get out of your car to open the door, but that misses the point. My home robot is using my electronics and my software to control my garage lights the way I want them. And note that this version of Evaluate() is only the beginning.

By adding a bit of code and a surplus passive IR (PIR) object detector to one of the binary inputs, you could have the garage lights come on and stay on for so long as a person was moving in the garage. Similarly, you could wire in a third door switch, this time hooked to the utility room door, that would allow the home robot to tell when that door opened. You could even add the appropriate IR LED and object detector to the sensor block's fourth binary input, then position this detector near the utility room door. This would tell the home robot when the utility door opened, and whether there was an object immediately in front of the door before or after it opened.

One other element of the robohome program design deserves discussion. Refer to the two invocations of the DoCommand() function shown here. These invocations use literal arguments such as CMD_GARAGE_LT, CMD_ON, and CMD_OFF. These literals have been #defined in an earlier section of the program to be literal strings such as "GarageLt," "on," and "off." The DoCommand() function uses its arguments to broadcast an X10 command to change a selected device to a selected state. Thus, the statement:

```
DoCommand(CMD_GARAGE_LT, CMD_ON);
```

is the same as the statement:

```
DoCommand("GarageLt", "on");
```

The DoCommand() function searches through a house definitions file, opened at the beginning of the program, and translates a string such as "GarageLt" into an X10 device ID such as B7. Using strings to represent devices and states means that I don't have to change my robohome program when I change IDs for my X10 device controllers. I simply edit the house definitions file and the robohome program stays untouched.

```
void Evaluate()
{
        unsigned int            t;

        if (sensors[RFBLK_GARAGE].status == UPDATED) {
                sensors[RFBLK_GARAGE].status = ACTIVE;
                t = sensors[RFBLK_GARAGE].data[0];                      // get binary data
                                                                        // byte
                t = t & (GARAGE_DOOR_OPEN_KARL | GARAGE_DOOR_CLOSED_KARL);
                if (t == GARAGE_DOOR_OPEN_KARL) {
                        if (clocks[CLOCK_GARAGE].time == 0) {           // if delay
                                                                        // already elapsed...
                                DoCommand(CMD_GARAGE_LT, CMD_ON);       // turn light on
                        }
                        clocks[CLOCK_GARAGE].time = DELAY_GARAGE_ON; // arm the clock
                        clocks[CLOCK_GARAGE].tripped = FALSE;           // just in case
                }

                t = sensors[RFBLK_GARAGE].data[0];              /       / get binary data
                                                                        // byte
                t = t & (GARAGE_DOOR_OPEN_LINDA | GARAGE_DOOR_CLOSED_LINDA);
                if (t == GARAGE_DOOR_OPEN_LINDA) {
                        if (clocks[CLOCK_GARAGE].time == 0) {           // if delay
                                                                        // already
                                                                        // elapsed...
                                DoCommand(CMD_GARAGE_LT, CMD_ON);       // turn light on
                        }
                        clocks[CLOCK_GARAGE].time = DELAY_GARAGE_ON; // arm the clock
                        clocks[CLOCK_GARAGE].tripped = FALSE;           // just in case
                }
        }

        if (clocks[CLOCK_GARAGE].tripped) {                     // if timer expired...
                clocks[CLOCK_GARAGE].tripped = FALSE;           // reset for next time
                DoCommand(CMD_GARAGE_LT, CMD_OFF);              // turn off light
        }
}
```

Figure 1. Listing of Evaluate() function

That's a wrap ...

This version of Evaluate() will get you started on your own home robot. But this article only scratches the surface of what can be done with home robotics. In my next article, I'll discuss a wider array of sensors that you can hook to your RF sensor blocks, and describe the code necessary to add support for more features.

In the meantime, you can grab a copy of the current version of robohome from my website. Feel free to change the Evaluate() function, and to add more command keys. After all, this is a large and interesting experiment; have fun! **NV**

reader FeedBack

Dear Nuts & Volts:

I sent away for my first copy of your magazine, and while reading the Reader Feedback, I saw a letter from an analog systems engineer from Yahoo in Dallas. The fellow was offended by ML Shannon's defense of hackers. By this, I suppose that he is making reference to the so-called white hackers who break in, look around, and leave without being nasty about it. The fellow compares this with a lock pick who sees if he can pick the lock on a house just so he can rummage through the personal effects of the house's owner.

I can see how a hacker can offend a systems engineer. I imagine that each time Yahoo is successfully hacked, there is an embarrassing meeting about how it was done and how to plug the hole. This results in better security for the system.

Anyone who thinks that these hackers are not doing a service to the systems that they hack is out of their mind.

A better analogy would be a lock pick who is trying to pick the locks in an apartment building, and when he finally does break in, he sprays paint on the apartment manager's door that says, "Ha Ha, I was here, and your locks suck!"

I would much rather have my personal information — which I have entrusted to companies like Yahoo — hacked by the guy with the spray paint than by Saddam Hussein's technical staff.

Brian Campbell
Sterling Heights, MI

Dear Nuts & Volts:

The article "Small Logic Gates Spawn Big Dreams" in the May '01 issue was excellent. However, there is a typo in the Boolean equations.

The relation is: x + y = /(/x•/y). Also, /(x+y) = /x•/y.

I believe this is called DeMorgan's Theorem.

Russell Kincaid
Milford, NH

Dear Nuts & Volts:

TJ Byers' article — "Small Logic Gates Spawn Big Dreams Part 2," June '01 — gave us an excellent overview of binary math and the logic circuits that make it happen. I did notice one oversight, however.

The chart labeled "Binary 2's Complement" is incorrect. The chart should look like the following:

Decimal	Binary	2's Complement
0	0000	0000
1	0001	1111
2	0010	1110
3	0011	1101
4	0100	1100
5	0101	1011
6	0110	1010

One of the convenient features of a 2's complement number is that the most significant bit is 0 for a positive number, and 1 for a negative number. This makes it a simple matter to check a number's sign.

Gary Kline
Salinas, CA
garyklinecc@netscape.net

News Bytes

LINUX INSTALLED ON YOUR COMPUTER FREE

In an effort to bring Linux to the business and personal desktop, Linux Centers USA will be installing Linux free on user's computers.

Linux/unix internet servers have long been the first choice of ISPs on the web. Network Administrators are installing stable Linux Samba servers which look like Microsoft NT servers to the users. Led by IBM, major vendors including Intel, Hitachi, NEC, Oracle Sharp, and many others are investing billions in the future of Linux. Still, few ordinary users have it installed on their desktop or laptop computers.

It is not entirely a surprise that Linux is not familiar to the single user. The power of the Linux operating system is especially valuable to system utilities and enterprise applications. The savings in time and money are, of course, greatest in these higher end products — not that the cost of desktop Windows is cheap.

It is also not likely that Linux will make much of a dent in the desktop market in the near future. Good or bad, there are just too many people who feel "at home" with their Windows desktop. They may complain about its speed, limitations, and crashes — but that doesn't mean that they want to learn a new system.

Linux Centers USA believes that the general public would like to see what Linux is and what it can do. The Linux graphical interfaces are looking more and more like Microsoft Windows with every new product released. Linux Centers USA believes that the inherent stability, easy networking, low cost, and security are features that the ordinary user would like to take a look at.

According to Frank Michaels, director of the New York Linux/UNIX program "We expect be able to install Linux on 95% of the computers that people bring to us. For the few that have components not supported by Linux, we will be able to tell the users how to upgrade with hardware supported by Linux."

Computers will be set up to run a graphical interface, an internet connection and browser, an email system, and a suite of office applications. To make an appointment for a free Linux installation, call 800-876-3896, or email info@linuxcentersusa.com.

FREE FORENSIC TOOL FOR DETECTION OPEN TCP/IP AND UPD PORTS!

SmartLine, Inc., has released a free powerful tool that shows all

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News Bytes

open TCP/IP and UDP ports on Windows NT/2000/XP computers and maps them to the owning application.

With SmartLine's Active Ports, Administrators are able to detect trojans and other malicious programs. Active Ports reports which process has opened which port and displays the local and remote IP address for each established connection.

Active Ports even allows Administrators to close any open port. System requirements: Active Ports requires Windows NT 4.0, Windows 2000, or Windows XP, 16MB RAM, and a hard drive with 200 KB of hard disk space.

Active Ports is freeware. It is available for download from SmartLine's website, http://www.ntutility.com.

BOSS EVERYWARE — NON-INTRUSIVE COMPUTER CONTROL

Alexander Jmerik has released Boss Everyware v. 2.3, a powerful Windows security program that secretly records data about how your computer is being used.

Boss Everyware keeps a log of which programs each user has run, and how much time they've spent on them. In addition, it records all of the user's keystrokes, allowing the computer owner or network administrator to answer questions about what correspondence is being created. Boss Everyware makes it easy to answer questions about what new software has been installed, and what specific web sites are being visited.

Acting as a deterrent to inappropriate computer usage, Boss Everyware can display a warning message that tells users that it is running. Or the program can be totally hidden from view, and secretly log usage information. The program can be password protected, and accessible only to the network administrator.

Boss Everyware's data logs can be written in dBASE or a space-saving encrypted format, and exported to popular database and spreadsheet programs. The program's powerful internal reporting system lets you select data by user or by application, create filters for including or excluding information, and arrange the data in a variety of useful ways. You can control how to group the data, whether to show full URLs or just domains, whether to display the non-character keystrokes, and other functions that determine the usefulness and appearance of the reports.

New features in version 2.3 include the ability to log inactivity if the user hasn't made any clicks or keystrokes for some time, a silent deployment package to easily install pre-configured loggers onto multiple computers without visiting each one, refined keystroke reporting, and Report Manager improvements that give the user more control when creating and dealing with reports.

Boss Everyware is easy to install and easy to use, with online help files and a complete tutorial. Whether it's running on a standalone computer or a network, the program uses minimal system resources to create its data logs.

Boss Everyware v. 2.3 runs under Windows NT4/2000/95/98/Me, and all American and European keyboards are supported. Boss Everyware prices begin at $49.00, and the program may be purchased securely online at http://boss.dids.com/.

NEWS BYTES Continued on Page 73

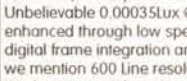
ANOTHER SUPER EXPERIMENTERS SPECIAL, RAYTHEON, LON TALK TERMINAL, Communicates over the AC Line. Using the Industry std. "LONWORKS" System.

Our latest hackers bonanza out does itself. Listen up, this is what we know so far: They were originally intended to activate various climate control (HVAC) functions. They allowed a hotel to optimize energy usage based on electric utility rates as well. The terminals communicated with a "central" PC directly through the AC power cord using the Lon Talk system through an Echelon, PLT-20 power line transceiver. Similar in principle to X-10 devices but far more advanced. This is current technology. See the ECHELON WEB SITE, WWW.ECHELON.COM. The front panel includes: Six momentary "softkeys" whose function changes dependent on the menu items displayed on the LCD. There are four standard cursor keys for menu navigation and one red LED we think is a transmission indicator. The hardware comprises the following: The MCU is a Motorola, MC14315 Lon Talk "NEURON" processor. Memory compliment includes: one socketed AMD-27C128 EPROM. (12.75V). Two 256K, (32K x 8) SRAM, One 64K SRAM, One Xicor-X28VC256J-70, (32K x 8) High speed EEPROM 98.5V Byte alterable). One SED-1330F LCD display driver from Seiko/Epson for the included G191C00K, FSTN, 192 X 128 graphic display module. Display has an on board Hitachi 61104A driver. The display viewing area is 78mm x 54mm. The application software is in memory and the units power up and pass self test. Echelon sells a PC compatible card that plugs right in and allows communication with LON Talk transceivers. The unit is enclosed in a rugged ABS moulded, wall mountable housing. Size: 6.6"W x 6.8"H x 2"T. The system is AC powered via an attached line cord. Weighs about two pounds. This is a truly fantastic device with unlimited possibilities. We have a limited quantity. Order now and see what you can do. **LONTALK-1.....$69ea. or 2 for $129**

NEW! HIGH VOLTAGE, VACUUM RELAY, Rated for 50KV @ 30Amps! KILOVAC type H-25,

A beautiful thing to see with it's gleaming glass enclosure. The key specs. are as follows: S.P.D.T., form C contacts, Tested to 60KV peak dc or 60Hz AC, Coil 500v HIPOT, Contact res. 0.015 Ohms, Switching time 60mS Max., Operating temp. -55 to +125 deg. C., Weight including custom base 9 Lbs., Coil Voltage 26.5Vdc, Pick-up 16Vdc Max., Drop-out, 1-10VDC, Coil resistance, 1200Ohms. Relay is pre mounted on a 1/2" thick, 9"W x 12" L, G-10 base and is enclosed in a LEXAN protective shield on all sides. A 40KV output lead is attached. Truly a rare find. Very limited quantity. **KILOVAC-25.....$749ea.**

NEW! HV REED RELAY, Rated for 5000V peak.



Magnecraft P/N W102VX-51. S.P.S.T. contacts, 24Vdc coil, Coil res. 1000 Ohms. Encapsulated construction suitable for PC mounting. Size: 4.5"L x 0.75"H x 0.9"W Ltd. Qty. **MAGNECRAFT-1.....$29ea.**

NEW! THOMPSON LINEAR BEARING, SUPER PILLOW BLOCK, type SPB-8,

New in the box. Edmund Optical P/N 32536. A very nice, BK7 prism in a size large enough for display of demonstration purposes. Angle accuracy ± 5 Arc min., Reg price, $135ea. Limited Quantity. **PRISM-32536....$45**

TECH SPEC" R/A PRISM.

New in the box. Edmund Optical P/N 32536. A very nice, BK7 prism in a size large enough for display of demonstration purposes. Angle accuracy ± 5 Arc min., Reg price, $135ea. Limited Quantity. **PRISM-32536....$45**

NEW! WATERPROOF TUBE CAMERA mini B&W, Industrial strength, solid machined housing.

Sleek black anodized,O-Ring sealed, BRASS, housing Adjustabe mount included. Specs: 1/3" CCD, 400 Lines resolution, 0.05 Lux sensitivity, AGC, Auto Shutter. Operates on 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25" diam. X 2" long. With 60 ft. cable. Great for general outdoor use. **NEW, GM300K-N.....$99**

STEPPER DRIVERS, SUPERIOR ELECTRIC, SLO-SYN Type, 3180-PT125,

Drivers are removed from equipment. USER MANUAL SUPPLIED. They are designed for use with an external indexer. They are a compact 7"x5"x4". We always sell out of these don't delay. Ltd. qty. **STEPDRV-3180-1....$99ea. or 2 for $189**

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 23sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" panel and 1.5X a 5.6"

WOW! We wish you could see the color saturation and resolution of this superior LCD display, it is fantastic. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect as a portable, general purpose color monitor for standard NTSC color or B&W video systems. Fully compatible with all our cameras as well as Camcorders, VCR's, DVD's etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution, 1152H x 234V, 270K Pixels! Viewing angle, Top 10°, Down 30°, Left 45°, Right 45° . Brightness, 300 nit, Size: W x H x D (mm/in), 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1", Weight (gm./oz.) 280 gm, 10oz. Supplied with 30" input cable. Video input via BNC jack , 12VDC input via a standard barrel connector. Regulated 12VDC @700mA power adapter included. **BRAND NEW, FIRST QUALITY. GMTFT68.....$169ea.**

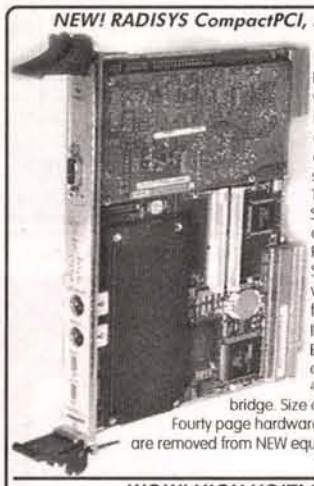
NEW, 470 LINE "DSP COLOR Micro CAM" The HIGHEST PERFORMANCE you can get in a MICRO SIZE.

Yes 470 lines with a 60db S/N ratio to back it up! That's 16X better than a typical 46dB standard camera! The GM-4500, 1/4" CCD camera with its' DSP technology provides high speed white balance with no color rolling. Auto shutter speed of 1/60 to 1/120,000 second. Truly state of the art. Sleek cast aluminum housing protects the 18mm x 26mm pc board inside. Removable mtg. bracket & a 18" cable with BNC video and DC pwr. jack for, no sweat hook up. requires only 12VDC@ 65mA. Optional mirror function available. Why fool around with an open P.C. board? This camera has it all. •1/4" CCD• 470 Lines•1 Lux•AGC•Auto Shutter•Pwr.12V @65mA•270k pixels•Std. 3.7 mm, 68° FOV lens•Focus:10mm to infinity • 3<ounce! • Size (mm): 33W x 29H x 30D **GM-4500-STD, SPECIAL...$99ea.**

STEPPER DRIVEN LINEAR SLIDE is STURDY and COMPACT,

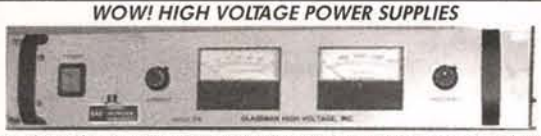
Techno-Isel based, heavy duty 1.5" wide, aluminum and steel, dual rail. Drive is via a toothed belt, powered by a SLO-SYN M061-LF-504, 1.25V @3.8A stepper motor with 200 steps per rev and 60 oz. in. hold. The slides incorporates superior quality, recirculating ball bearings. Size of slider is 3" x 3" x 1/2" thick with mounting plate. Limited quantity. Unit is mounted on a 1/4" thick, black anodized alum. plate. All have been carefully removed for precision optical equipment. Travel: 11.5", Rail Length: 16", Weight: 7lbs., Overall Size: 16"L x 4"W x 6.5"H . Very Ltd. Qty. **ISELMTR-SHORT.....$149ea.**

NEW! RADISYS CompactPCI, MOBILE PENTIUM II, 233MHz, Industrial Computer includes, 64 Megs. of SO-DIM Memory!



For those of you knoweldgeable in the cPCI world and using a Compact PCI chassis this is a golden opportunity. We were fortunate to obtain these unused units. Each board is capable of driving seven cPCI expansion slots. Front panel I/O and indicators include: Two USB ports, Keyboard port, mouse port & SVGA port. Panel ports are standard PC style connectors. Six LED's show system status. Front panel reset switch. A RadiSys, PMC SVGA II. 2 Meg. mezzanine card provides video up to 1280 x 1024 x 256. Floppy header for debug. Dual 16550C RS-232 ports, one IEEE-1284 bidirectional parallel port, primary EIDE interface and a 10/100Mbs Ethernet LAN all via the J5 backplane connector. Intel 443BX / PIIX4E chipset. Digital 21150 PCI-PCI bridge. Size only 0.8" Wide. Requires one 6U system slot. Fourty page hardware spec. included. Don't miss this one. Units are removed from NEW equipment. Ltd. Qty. Regular price > $1650 **RADISYS-PII....$399**

WOW! HIGH VOLTAGE POWER SUPPLIES



Above photo, Glassman, EH series, EH02N50-0XS3, -2KVDC@50mA power supply. Voltage and current limit are adjustable via the front panel multi turn controls with counting dials. Voltage and current is displayed on two front panel meters. Standard rack mount package, 3 1/2" high. 120VAC operation. Excellent condition. **GLASS-02N50.....$349**

Not shown, Glassman, ER series, ER040N05, -40KVDC@5mA power supply. Blank front panel model for remote control applications. Voltage and current limit are adjustable via the rear panel connector by application of a control voltage. (0-10VDC) Voltage and current is read back as a proportional signal at the rear panel as well. Standard rack mount package, 3 1/2" high. 120VAC operation. With HV output cable and manual. **BRAND NEW, GLASS-040N05.....$1295**

350MHz, TEKTRONIX 2467, MICRO CHANNEL PLATE CRT! 4 Channels, 500ps per div. in normal room light.

Displays intermittent variations as they happen. Captures the slowest one shot events with 4ns per division a 100 fold increase in the visual writing rate over conventional CRT. Features: 1 ns rise time, 500ps/Div time base, 2mV/Div. vertical sensitivity at 350MHz, 20ps time interval resolution, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vertical & horizontal scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, pouch, and manual. EX. cond. 90 day warranty. **New..$12K Now TEK2467....$2995.**

NEW! 0.00035 Lux, Black & White, NIGHT VISION CAMERA! Near "Starlight" PERFORMANCE and 600 Lines Resolution. State of the Art Video, Our GMV-6K, Takes the Prize.

For covert, military & scientific applications, this is it. Unbelievable 0.00035Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Did we mention 600 Line resolution? Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64 These provide frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/off BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec., Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768(H) X 494(V), with 380K pixels, 470 Lines, 12VDC ±1V@200mA, Std. video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power adapter included. All functions can be externally controlled. Use std. c-mount lens not included. **GMV-6K...$449ea. Superior, auto iris lens, 12mm, f1.2...$199ea.**

SPECIAL, PRICE BUSTER, PANASONIC, M-A100-PJ, COLOR, CCD CAMERA, ALL ACCESSORIES SUPPLIED!

Originally destined as the video camera, in a major brand conferencing system. Now available for a fraction of its' original price. Great looking styling. Camera has a very stable, manually adjustable pan and tilit base. Front panel LED power indicator. Excellent video performance packaged in a sturdy 2.9"W x 2.9"H x 4.8"L, 11 oz. package. Simply connect camera to any "Video Input." with the RCA cable supplied. Camera has 5.6mm lens with fixed focus from 18" to infnity. No adjustment required! Power is 12VDC from power adapter also included. 1/3" CCD, 330Lines resolution 37% better than standard VHS! Auto white balance. Externally adjustable sensitivity. Perfect for any general purpose video application. Brand new, in original sealed boxes. Don't miss out. **NEW COLOR CAMERA, 100PJ-CCD.....$59ea. 3 for $149**

MASSIVE and PRECISE, IKO LINEAR SLIDE with Roller Bearing, Screw Drive.

The 11 pound, black anodized base of this superb unit is 13.75"L x 6"W x 2.4"H, The interesting thing is that it machined from a solid Aluminum block which must have weighed in at close to 20lbs. before being hollowed out for the precision IKO recirculating ball slide with hardened steel rail. The carriage is motivated up to 11" by an 8mm diam., 10TPI, lead screw drive coupled to a roller bearing nut on the solid 1" thick alum. carriage. Oh and the lead screw is supported at each end by a ball bearing. On one end of the lead screw is a 15mm diam. toothed belt drive pulley and a 6" matching belt. Optical end of travel sensors on both end complete the package. A stepper motor mounted off the slide drives the belt. We give you the stepper too! This is a rare find. It was destined to be part of a wafer handling machine but now it's yours. Ltd.qty. **WAFERSLIDE-1.....$89ea.**

LINEAR SLIDE, for compact motion. Very high quality, Techno-Isel, series one, German made.

This is the slide you have been looking for! Overall length: 19.5" with an effective travel of 18". Very sturdy, based on a heavy duty 1.5" wide, extruded aluminum and 1/2 diam. steel, dual rail. The slide carriage incorporates superior quality, recirculating ball bearings. Size of carriage is 3" x 3" with a solid 1/2" thick aluminum mounting plate. The rails have been carefully removed from precision optical equipment. The slider carriages are all brand new & unused. Each rail includes one slide carriage. A few extras are available. **ISEL-19.....$99ea. EXCAR-1, addtl. carriage only,.....$69ea.**

LCD, 128X64, GRAPHIC DISPLAYS from Varitronix

Type MGLS12864T-G-HT-HV, 128 x 64 pixel module. Standard Toshiba T6963 driver with 8 bit parallel interface. Module size: 78mmW x 70mmH x 10mmD, Viewing area: 62mmW x 44mm H. Dot size: 0.39mm x 0.55mm, Dot pitch: 0.44mm x 0.60mm. with data. An excellent display. Removed from new equipment. Ltd. Qty. **LCD-MGLS128..$24ea. or 3/69**

NEW & IMPROVED, 0.003Lux,UNDERWATER B&W CAMERA, 16X MORE SENSITIVE. Now with 12 INTERNAL, INFRA-RED LEDs!

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF down to 60feet. Adjustabe mount included. Specs: 1/3" CCD, 400 Lines res.,super 0.003 Lux sensitivity, AGC, Auto Shutter. 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area, pipe or ductwork inspection camera. Excellent for general outdoor use as well. **GM-300KX-12..$179**

NEW and IMPROVED, COLOR (down to 60 ft.) UNDERWATER. now with 12, Built-in WHITE LIGHT LED'S,

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustabe mount incl. Specs: 1/4" CCD, 350 Lines res., 0.5 Lux sensitivity, AGC, Auto Shutter. 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area inspection camera. TWELVE, super white LED'S! **GM-400K-12LED.....$229ea.**

DAYLIGHT/LOW LIGHT MINI CAM & A/I LENS,

For dawn 'till dusk applications. Rugged alum. housing, dual mtg. sockets. 1/3" CCD, 420 lines res., 0.1 Lux sens., AGC, 12VDC @120mA. Take full advantage of camera sensitivity with super, 4mm, f1.4, 78° FOV Auto Iris lens included. BNC video out. 50mm sq. X 65mmL. With pwr. adapt. **GM-510A/I...$179 or 2/$349**

B&W QUAD PROCESOR,

The GM4-BQ is an unbeatable value. Four camera inputs with loop through. Full screen image, REAL TIME display, high resolution: 960 x480, brightness adj. for each chan. Alarm time (1-20 sec.) 4 alarm inputs. Auto Sequencing mode with adj. dwell:1-4 sec. Quality video processing. Specs: •4 video inputs. •1 monitor out and VCR in/out, •4 alarm inputs •Buzzer •2 Alarm Out •Dim: 239 x166 x55 mm. **GM4-BQ QUAD.....$179**

ULTRA RESOLUTION & HIGH SENSITIVITY, SCIENTIFIC QUALITY for demanding applications.

Type GM-6000, offers 410K pixels, 570 Lines resolution, < 0.1 LUX sensitivity, >45db s/N with AGC off. Access all operating parameters, outside the camera! C or CS mount. Adjustable shutter speed from 1/60 to 1/ 100,000sec, BLC on/off, AGC on/off, gain auto/off., Auto iris selectable, DC/Video with level control, external/ internal sync. 24VAC powered, adapter included. Video out on BNC. Industrial quality metal housing.Just the thing for scientific or low light. **SPECIAL, GM6000.....$199ea.**

Circle #57 on the Reader Service Card.

OP-AMP COOKBOOK

by Ray Marston

Part 1
Op-Amp Basics

Ray Marston presents the opening episode of a new four-part survey of op-amp principles and applications. This first episode concentrates on basic principles and configurations.

A conventional op-amp (operational amplifier) can be simply described as a high-gain direct-coupled amplifier 'block' that has a single output terminal, but has both inverting and non-inverting input terminals, thus enabling the device to function as either an inverting, non-inverting, or differential amplifier. Op-amps are very versatile devices. When coupled to suitable feedback networks, they can be used to make precision AC and DC amplifiers and filters, oscillators, level switches, and comparators, etc.

Three basic types of operational amplifiers are readily available. The most important of these is the conventional 'voltage-in, voltage-out' op-amp (typified by the popular 741 and CA3140 ICs), and this four-part mini-series takes an in-depth look at the operating principles and practical applications of this type of device. The other two basic types of op-amp are the current-differencing or Norton op-amp (typified by the LM3900), and the operational transconductance amplifier or OTA (typified by the CA3080 and LM13700); these two devices will be described in some future editions of this magazine.

OP-AMP BASICS

In its simplest form, a conventional op-amp consists of a differential amplifier (bipolar or FET) followed by offset compensation and output stages, as shown in Figure 1. All of these elements are integrated on a single chip and housed in an IC package. The differential amplifier has inverting and non-inverting input terminals, and has a high-impedance (constant-current) tail to give a high input impedance and good common-mode signal rejection. It also has a high-impedance collector (or drain) load, to give a large amount of signal-voltage gain (typically about 100dB).

The output of the differential amplifier is fed to the circuit's output stage via an offset compensation network which — when the op-amp is suitably powered — causes the op-amp output to center on zero volts when both input terminals are tied to zero volts. The output stage takes the form of a complementary emitter follower, and gives a low-impedance output.

Conventional op-amps are represented by the standard symbol shown in Figure 2(a). They are normally powered from split supplies, as shown in Figure 2(b), providing positive, negative, and common (zero volt) supply rails, enabling the op-amp output to swing either side of the zero volts value and to be set to zero when the differential input voltage is zero. They can, however, also be powered from single-ended supplies, if required.

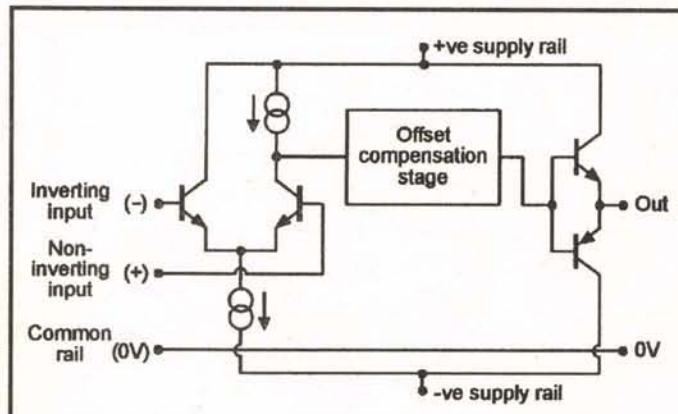


Figure 1. Simplified op-amp equivalent circuit.

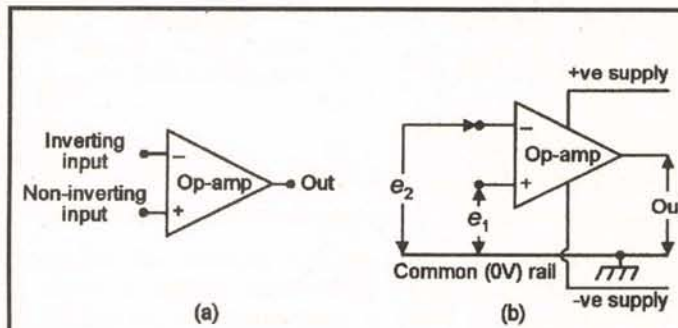


Figure 2. Basic symbol (a) and supply connections (b) of an op-amp.

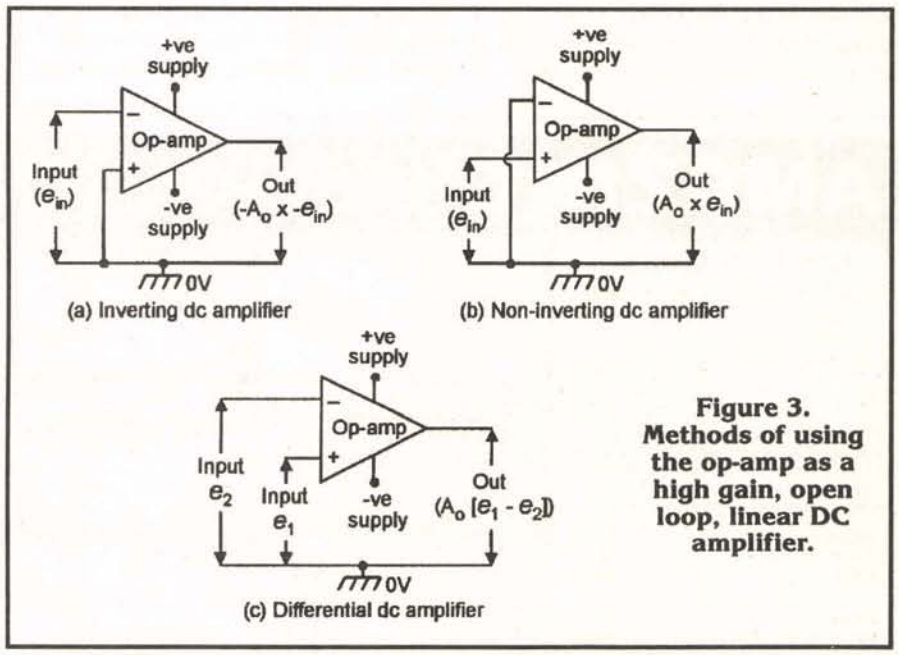


Figure 3. Methods of using the op-amp as a high gain, open loop, linear DC amplifier.

BASIC CONFIGURATIONS

The output signal of an op-amp is proportional to the differential signal voltage between its two input terminals and, at low audio frequencies, is given by:

$$e_{out} = A_o(e_1 - e_2)$$

where A_o is the low frequency open-loop voltage gain of the op-amp (typically 100dB, or x100,000, e_1 is the signal voltage at the non-inverting input terminal, and e_2 is the signal voltage at the inverting input terminal).

Thus, an op-amp can be used as a high-gain inverting DC amplifier by grounding its non-inverting terminal and feeding the input signal to the inverting terminal, as shown in Figure 3(a). Alternatively, it can be used as a non-inverting DC amplifier by reversing the two input connections, as shown in Figure 3(b), or as a differential DC amplifier by feeding the two input signals to the op-amp as shown in Figure 3(c). Note in the latter case that if identical signals are fed to both input terminals, the op-amp should — ideally — give zero signal output.

The voltage gains of the Figure 3 circuits depend on the individual op-amp open-loop voltage gains, and these are subject to wide variations between individual devices. One special application of the 'open-loop' op-amp is as a differential voltage comparator, one version

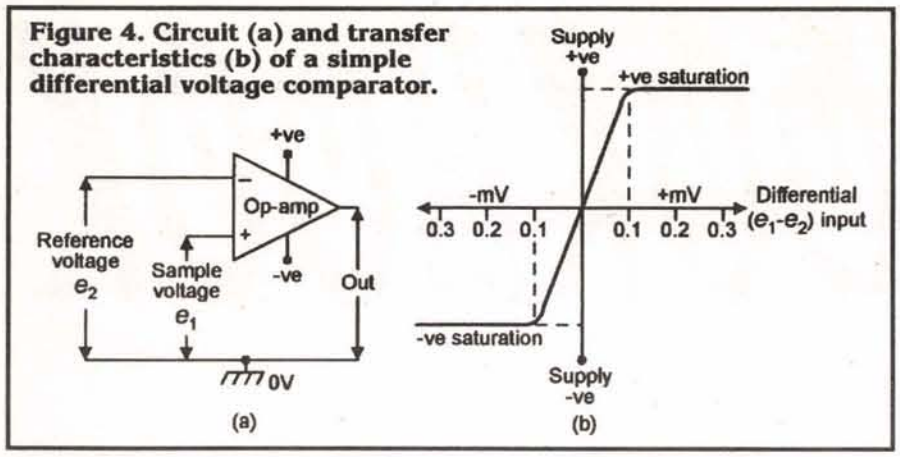


Figure 4. Circuit (a) and transfer characteristics (b) of a simple differential voltage comparator.

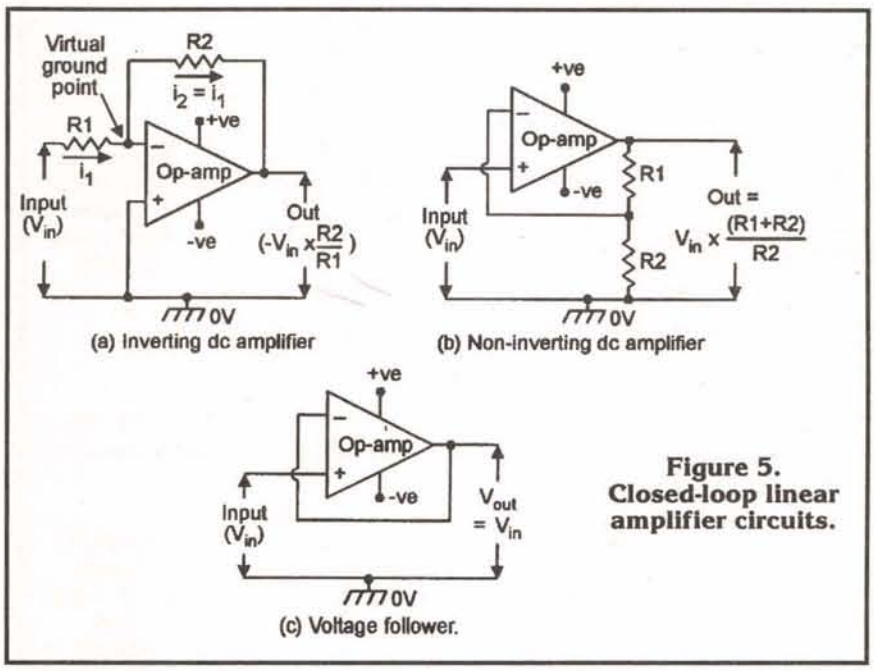


Figure 5. Closed-loop linear amplifier circuits.

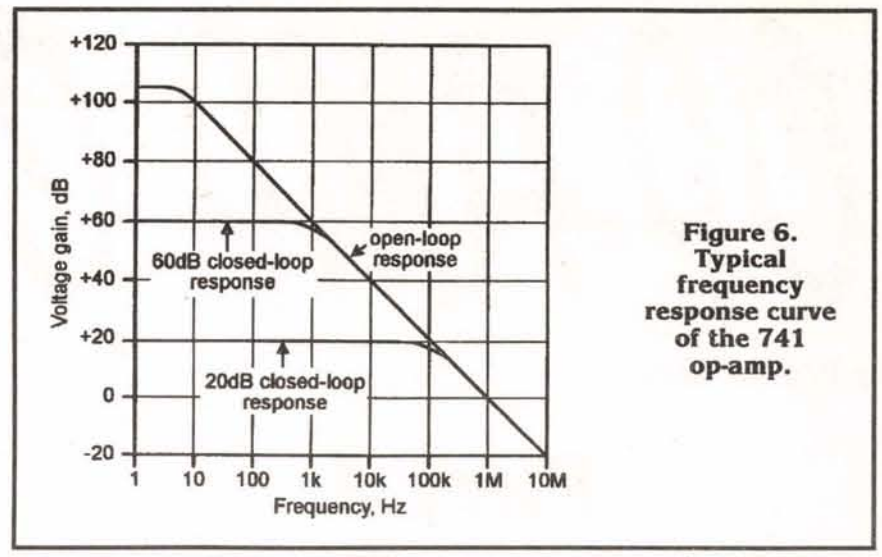


Figure 6. Typical frequency response curve of the 741 op-amp.

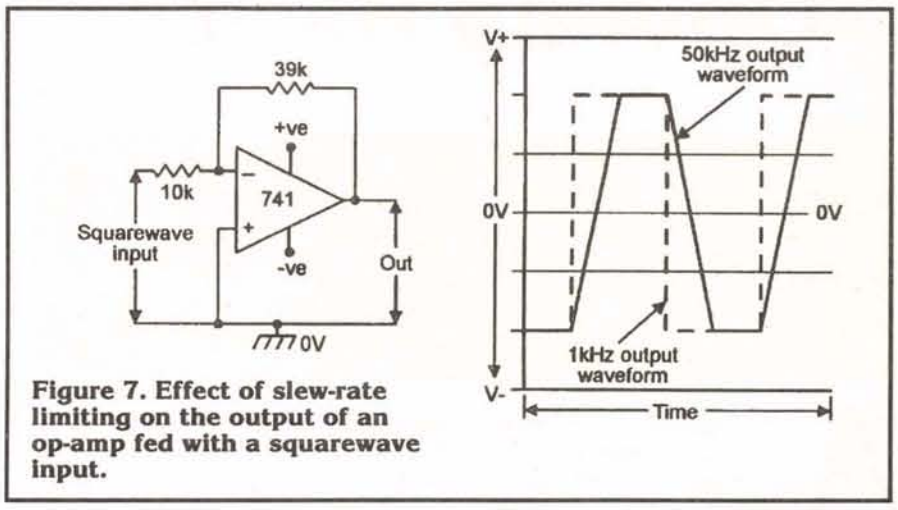


Figure 7. Effect of slew-rate limiting on the output of an op-amp fed with a squarewave input.

of which is shown in Figure 4(a). Here, a fixed reference voltage is applied to the inverting terminal and a variable test or sample voltage is fed to the non-inverting terminal. Because of the very high open-loop voltage gain of the op-amp, the output is driven to positive saturation (close to the positive rail value) when the sample voltage is more than a few hundred microvolts above the reference voltage, and to negative saturation (close to the negative supply rail value) when the sample is more than a few hundred microvolts below the reference value.

Figure 4(b) shows the voltage transfer characteristics of the above circuit. Note that it is the magnitude of the input differential voltage that determines the magnitude of the output voltage, and that the absolute values of input voltage are of little importance. Thus, if a 2V0 reference is used and a differential voltage of only 200mV is needed to swing the output from a negative to a positive saturation level, this change can be caused by a shift of only 0.01% on a 2V0 signal applied to the sample input. The circuit thus functions as a precision voltage comparator or balance detector.

CLOSED-LOOP AMPLIFIERS

The most useful way of using an op-amp as a linear amplifier is to connect it in the closed-loop mode, with negative feedback applied from the output to the input, as shown in the basic DC-coupled circuits of Figure 5. This technique enables the overall gain of each circuit to be precisely controlled by the values of the external feedback components, almost irrespective of the op-amp characteristics (provided that the open-loop gain, A_o, is large relative to the closed-loop gain, A).

Figure 5(a) shows how to wire the op-amp as a fixed-gain inverting DC amplifier. Here, the gain (A) of the circuit is dictated by the ratios of R1 and R2 and equals R2/R1, and the input impedance of the circuit equals the R1 value; the circuit can thus easily be designed to give any desired values of gain and input impedance.

Note in Figure 5(a) that although R1 and R2 control the gain of the complete circuit, they have no effect on the parameters of the actual op-amp. Thus, the inverting terminal still has a very high input impedance, and negligible signal

current flows into the terminal. Consequently, virtually all of the R1 signal current also flows in R2, and signal currents i_1 and i_2 can (for most practical purposes) be regarded as being equal, as shown in the diagram. Also note that R2 has an apparent value of R2/A when looked at from the inverting terminal, and the R1-R2 junction thus appears as a low-impedance 'virtual ground' point.

Figure 5(b) shows how to connect the op-amp as a fixed-gain non-inverting amplifier. In this case, the voltage gain equals (R1+R2)/R2, and the input impedance approximates (A_o/A)Zin, where Zin is the open-loop input impedance of the op-amp. The above circuit can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting amplifier, as shown in Figure 5(c), where the op-amp operates with 100% negative feedback. In this case, the input and output signal voltages are identical, but the input impedance of the circuit is very high, approximating A_o x Zin.

The basic op-amp circuits of Figures 5(a) to 5(c) are shown as DC amplifiers, but can readily be adapted for AC use by AC-coupling their inputs. Op-amps also have many applications other than as simple linear amplifiers. They can be made to function in precision phase splitters, as adders or subtractors, as active filters or selective amplifiers, and as oscillators or multivibrators, etc. Some of these applications are shown later in this article; in the meantime, let's look at some important op-amp parameters.

PARAMETER	Bipolar op-amps		MOSFET op-amps		JFET op-amps			
	741	NE531	CA3130E	CA3140E	LF351	LF441	TL081	TL061
Supply voltage	±3V to ±18V	±5V to ±22V	±2V5 to ±8V (5 to 16V	±2V to ±18V (4 to 36V	±5V to ±18V	±5V to ±18V	±5V to ±15V	±2V to ±15V
Supply current	1.7mA	5.5mA	1.8mA	3.6mA	0.8mA	1.8mA	1.8mA	0.2mA
Input offset volts	1mV	2mV	8mV	5mV	5mV	0.8mV	5mV	3mV
Input bias current	200nA	400nA	5pA	10pA	50pA	50pA	50pA	5pA
Input resistance, Ω	1M0	20M	1.5T	1.5T	1.0T	1.0T	1.0T	1.0T
Voltage gain, A_o	106dB	96dB	110dB	100dB	88dB	106dB	106dB	76dB
CMMR	90dB	100dB	90dB	90dB	100dB	100dB	100dB	86dB
f_T	1MHz	1MHz	15MHz	4.5MHz	4MHz	4MHz	3MHz	1MHz
Slew rate (V/µS)	0.5	35	10	9	13	15	13	3.5
IC outline	b	a	c	c	b	b	b	b

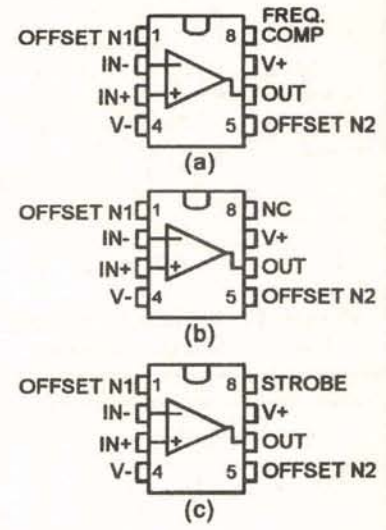


Figure 8. Parameter and outline details of eight popular 'single' op-amp types.

OP-AMP PARAMETERS

An ideal op-amp would have infinite values of input impedance, gain, and bandwidth, and have zero output impedance and give perfect tracking between input and output. Practical op-amps fall short of all of these ideals. Consequently, various performance parameters are detailed in op-amp data sheets, and indicate the measure of 'goodness' of a particular device. The most important of these parameters are detailed below.

1. A_o (open-loop voltage gain). This is the low-frequency voltage gain occurring between the input and output terminals of the op-amp, and may be expressed in direct terms or in terms of dB. Typical figures are x100,000, or 100dB.

2. Z_{IN} (input impedance). This is the resistive impedance looking directly into the input terminals of the op-amp when used open-loop. Typical values are 1M0 for op-amps with bipolar input stages, and a million megohms for FET-input op-amps.

3. Z_o (output impedance). This is the resistive output impedance of the basic op-amp when used open-loop. Values of a few hundred ohms are typical of most op-amps.

4. I_b (input bias current). The input terminals of all op-amps sink or source finite currents when biased for linear operation. The magnitude of this current is denoted by I_b, and is typically a fraction of a microamp in bipolar op-amps, and a few picoamps in FET types.

5. V_S (supply voltage range). Op-amps are usually operated from split (+ve and -ve) supply rails, which must be within maximum and

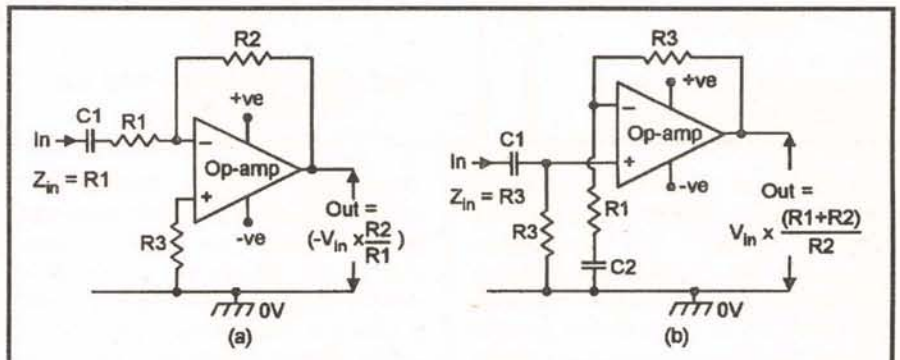


Figure 10. Basic inverting (a) and non-inverting (b) AC amplifier circuits.

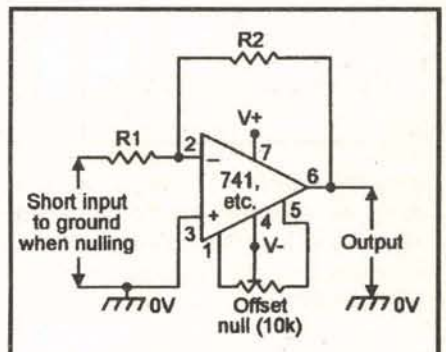


Figure 9. Typical offset nulling system.

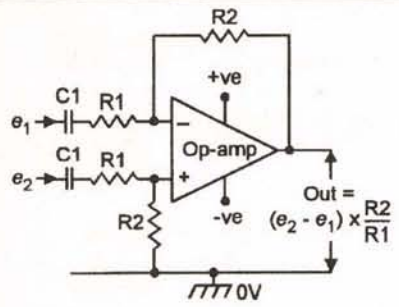


Figure 11. Differential amplifier or analog subtractor.

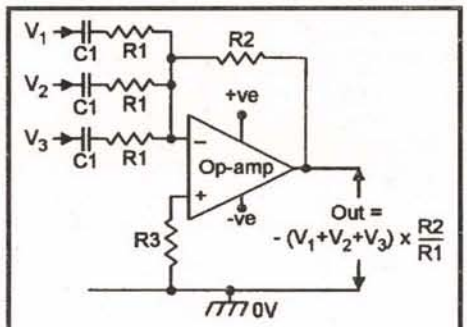


Figure 12. Inverting analog adder or audio mixer.

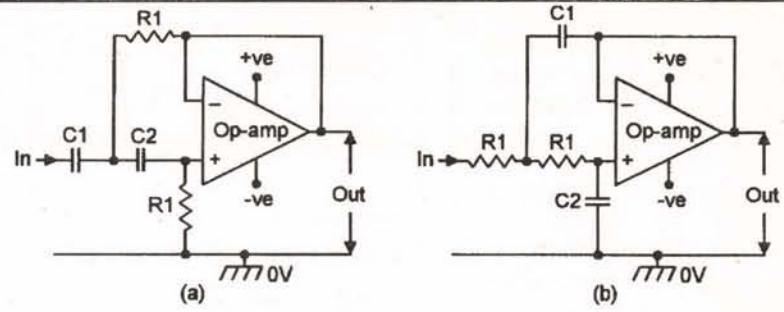


Figure 13. High-pass (a) and low-pass (b) second-order active filters.

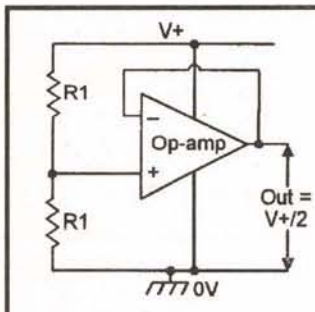


Figure 14. Supply-line splitter.

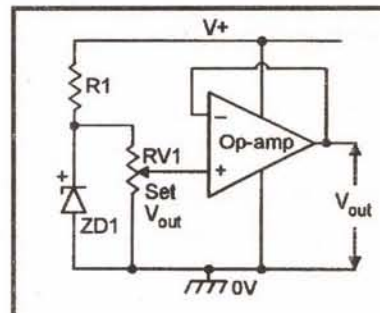


Figure 15. Adjustable-voltage reference.

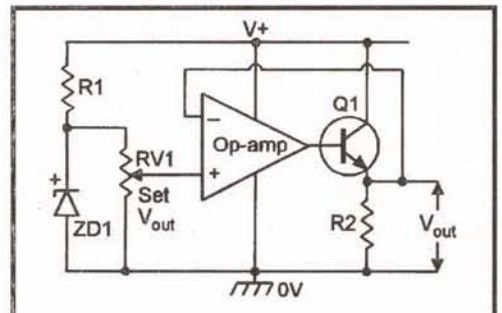


Figure 16. Adjustable-voltage DC power supply.

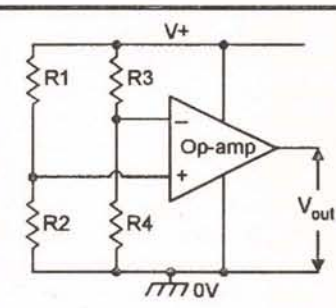


Figure 17. Bridge-balancing detector/switch.

minimum limits. If voltages are too high, the op-amp may be damaged and, if too low, the op-amp will not function correctly. Typical limits are ±3V to ±15V.

6. $V_{i(max)}$ (input voltage range). Most op-amps will only operate correctly if their input terminal voltages are below the supply line values. Typically, $V_{i(max)}$ is one or two volts less than V_S.

7. V_{io} (differential input offset voltage). Ideally, an op-amp's output should be zero when both inputs are grounded, but in practice, slight imbalances within the op-amp cause it to act as though a small offset or bias voltage exists on its inputs under this condition. Typically, this V_{io} has a value of only a few mV, but when this voltage is amplified by the gain of the circuit in which the op-amp is used, it may be sufficient to drive the op-amp output well away from the 'zero' value. Because of this, most op-amps have some facility for externally nulling out the effects of this offset voltage.

8. CMMR (common mode rejection ratio). An op-amp produces an output proportional to the difference between the signals on its two input terminals. Ideally, it should give zero output if identical signals are applied to both inputs simultaneously, i.e., in common mode. In practice, such signals do not entirely cancel out within the op-amp, and produce a small output signal. The ability of an op-amp to reject common mode signals is usually expressed in terms of CMMR, i.e., the ratio of the op-amp's gain with differential signals versus the gain with common mode signals. CMMR values of 90dB are typical of most op-amps.

9. f_T (transition frequency). An op-amp typically gives a low-frequency voltage gain of about 100dB, and in the interest of stability, its open-loop frequency response is internally tailored so that the gain falls off at a rate of 6dB/octave (= 20dB/decade), eventually falling to unity (0dB) at a transition frequency denoted f_T. Figure 6 shows the typical response curve of the type 741 op-amp, which has an f_T value of 1MHz and a low-frequency gain of 106dB. Note that, when the op-amp is used in a closed loop amplifier circuit, the circuit's bandwidth depends on the closed-loop gain. Thus, in Figure 6, the circuit has a bandwidth of only 1kHz at a gain of 60dB, or 100kHz at a gain of 20dB. The f_T figure can thus be used to represent a gain-bandwidth product.

10. Slew rate. As well as being subject to normal bandwidth limitations, op-amps are also subject to a phenomenon known as slew rate limiting, which has the effect of limiting the maximum rate of change of voltage at the op-amp's output. Figure 7 shows the effect that slew-rate limiting can have on the output of an op-amp that is fed with a squarewave input. Slew rate is normally specified in terms of volts per microsecond, and values in the range 1V/mS to 10V/mS are usual with most popular types of op-amp. One effect of slew rate limiting is to make a greater bandwidth available to small-amplitude output signals than to large-amplitude output signals.

PRACTICAL OP-AMPS

Practical op-amps are available in a variety of types of IC construction (bipolar, MOSFET, JFET, etc.), and in a variety of types of packaging (plastic DIL, metal-can TO5, etc.). Some of these packages house two or four op-amps, all sharing common supply line connec-

tions. Figure 8 gives parameter and outline details of eight popular 'single' op-amp types, all of which use eight-pin DIL (DIP) packaging.

The 741 and NE531 are bipolar types. The 741 is a popular general-purpose op-amp featuring internal frequency compensation and full overload protection on inputs and outputs. The NE531 is a high-performance type with very high slew rate capability; an external compensation capacitor (100pF — wired between pins 6 and 8 — is needed for stability, but can be reduced to a very low value (1.8pF) to give a very wide bandwidth at high gain.

The CA3130 and CA3140 are MOSFET-input type op-amps that can operate from single or dual power supplies, can sense inputs down to the negative supply rail value, have ultra-high input impedances, and have outputs that can be strobed; the CA3130 has a CMOS output stage, and an external compensation capacitor (typically 47pF) between pins 1 and 8 permits adjustment of bandwidth characteristics; the CA3140 has a bipolar output stage and is internally compensated.

The LF351, LF411, TL081, and TL061 JFET types can be used as direct replacements for the 741 in most applications; the TL061 is a low-power version of the TL081.

OFFSET NULLING

All of the above op-amps are provided with an offset nulling facility, to enable the output to be set to precisely zero with zero input, and this is usually achieved by wiring a 10k pot between pins 1 and 5 and connecting the pot slider (either directly or via a 4k7 range-limiting resistor) to the negative supply rail (pin 4), as shown in Figure 9. In the case of the CA3130, a 100k offset nulling pot must be used.

APPLICATIONS ROUNDUP

Operational amplifiers are very versatile devices, and can be used in an almost infinite variety of linear and switching applications. Figures 10 to 22 show a small selection of basic 'applications' circuits that can be used, and which will be looked at in greater detail in the remaining three episodes of this 'Op-Amp' miniseries. In most of these diagrams, the supply line connections have been omitted for clarity.

Figure 10 shows basic ways of using op-amps to make fixed-gain inverting or non-inverting AC amplifiers. In both cases, the gain and the input impedance of the circuit can be precisely controlled by suitable component value selection.

Figure 11 shows how to make a differential or difference amplifier with a gain equal to R2/R1; if R1 and R2 have equal values, the circuit acts as an analog subtractor.

Figure 12 shows the circuit of an inverting 'adder' or audio mixer; if R1 and R2 have equal values, the inverting output is equal to the sum of the input voltages.

Op-amps can be made to act as precision active filters by wiring suitable filters into their feedback networks. Figure 13 shows the basic connections for making second-order high-pass and low-pass filters; these circuits give roll-offs of 12dB/octave. Next month's episode of this miniseries will show more sophisticated versions of these basic circuits.

Figures 14 to 16 show some useful applications of the basic voltage follower or unity-gain non-inverting DC amplifier. The Figure 14 circuit acts as a supply line splitter, and is useful for generating split DC supplies from single-ended ones. Figure 15 acts as a semi-precision variable voltage reference, and Figure 16 shows how the output current drive can be boosted so that the circuit acts as a variable voltage supply.

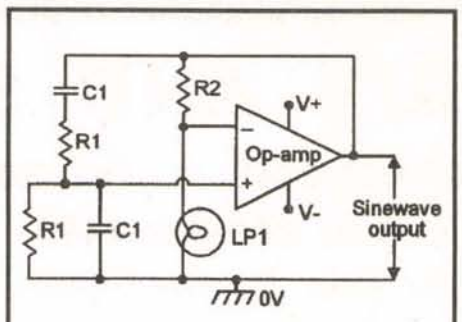


Figure 20. Wien-bridge sinewave generator.

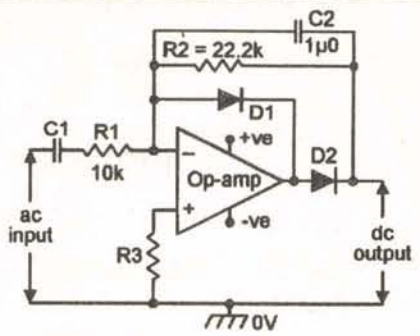


Figure 19. Precision half-wave AD/DC converter.

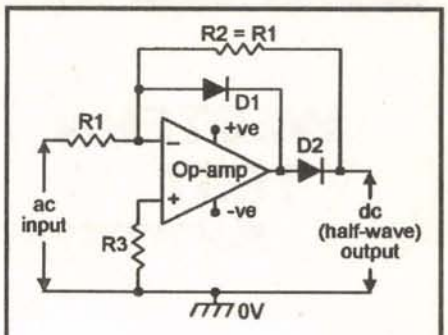


Figure 18. Precision half-wave rectifier.

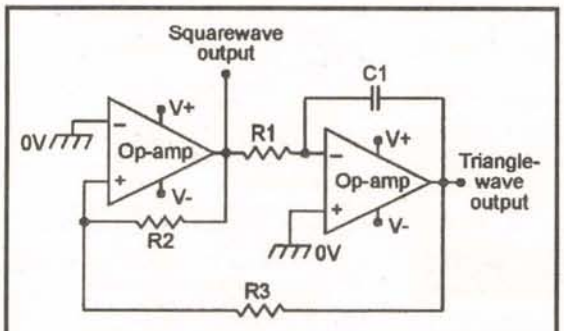


Figure 22. Sine/square function generator.

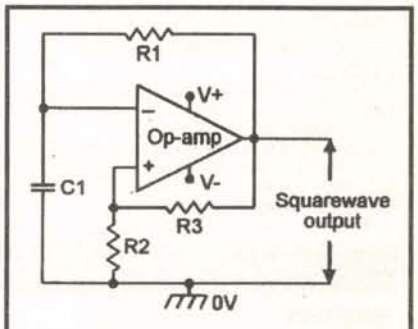


Figure 21. Free-running multivibrator.

Figure 17 shows the basic circuit of a DC bridge-balancing detector, in which the output swings high when the inverting pin voltage is above that of the non-inverting pin, and vice versa. This circuit can be made to function as a precision opto- or thermo-switch by replacing one of the bridge resistors with an LDR or thermistor.

Figures 18 and 19 show how to make precision half-wave rectifiers and AC/DC converters. These are very useful instrumentation circuits.

Finally, to complete this opening episode, Figures 20 to 22 show some useful waveform generator circuits. The Figure 20 design uses a Wien bridge network to generate a good sinewave; amplitude stabilization is obtained via a low-current lamp (or thermistor). Figure 21 is a very useful squarewave generator circuit, in which the frequency can be controlled via any one of the passive component values. The frequency of the Figure 22 function generator circuit can also be controlled via any one of its passive component values, but this particular design generates both square and triangle output waveforms. **NV**

HP 85054A Type N Calibration Kit, for HP 8510 series $1,800.00
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HP 83570A RF Plug-in, 18.0-26.5 GHz, +10 dBm levelled $6,000.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled $400.00
HP 8620C Sweep Oscillator Frame $550.00
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HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled $1,200.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled $1,650.00
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WILTRON 6647M Programmable Sweep Generator, 10 MHz-20 GHz, +10 dBm $4,500.00
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HP 436A-022/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HPIB $1,200.00
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HP 778D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port $450.00
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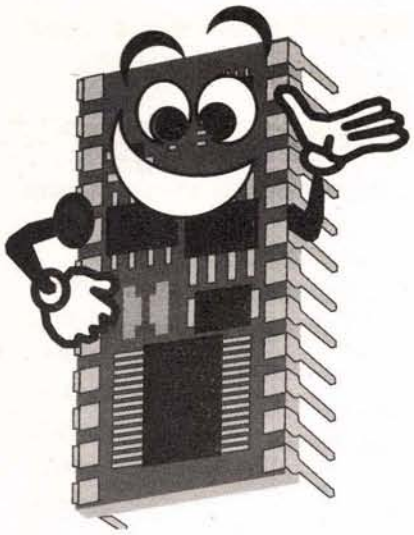
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz $300.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz $650.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz $400.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz $450.00
HP R914B WR28 Moving Load, 26.5-40 GHz $250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz $750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz $650.00
HP X870A WR90 Slide Screw Tuner $150.00
HUGHES 45322H-1110/1120 WR22 Directional Couplers, 10 or 20 dB, 33-50 GHz $350.00
HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz $750.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz $900.00
HUGHES 45721H-2000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz $1,000.00
HUGHES 45722H-1000 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $1,000.00
HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz $1,000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz $250.00
HUGHES 45752H-1000 WR22 Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz $1,400.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz $400.00
HUGHES 45773H-1100 WR19 Thermistor Mount, -20 to +10 dBm, 40-60 GHz $650.00
HUGHES 45774H-1100 WR15 Thermistor Mount, -20 to +10 dBm, 50-75 GHz $750.00
HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity $600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32.000 GHz, +18 dBm $2,000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42.000 GHz, +18 dBm $2,750.00
KRYTAR 201020010 Directional Detector, 1-20 GHz, SMA(f/f)/SMC $200.00
KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC $200.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz $450.00
MICA C-121S06 Circulator, 17.5-24.5 GHz, SMA(f/m/m) $75.00
NARDA 3000-series Directional Couplers $150.00
NARDA 3020A Bi-Directional Coupler, 50-1000 MHz, N $500.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $375.00
NARDA 3090-SERIES Precision High Directivity Couplers $225.00
NARDA 368BNM Coaxial High Power Load, 500 Watts, 2.0-18 GHz, N(m) $500.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz $900.00
NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz $950.00
NARDA 4000-SERIES SMA Miniature Directional Couplers $75.00
NARDA 4247-20 Directional Coupler, 20 dB, 6.0-26.5 GHz, 3.5mm(f) $200.00
NARDA 5070-series Precision Reflectometer Couplers $300.00
NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f) $65.00
NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) $165.00
NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz $600.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
NARDA 793FM Direct Reading Variable Attenuator, 0-20 dB, 4-8 GHz $225.00
NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB, 4-8 GHz $375.00
OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f) $50.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz $250.00
SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz $75.00
TEKTRONIX 2701 Step Attenuator, 0-79 dB, DC-1 GHz, AC or DC coupled $175.00
TRG B510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $900.00
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG W510 WR10 Direct Reading Attenuator, 0-50 dB, 75-110 GHz $1,000.00
TRG W551 WR10 Frequency Meter, 75-110 GHz $750.00
WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB $200.00
WEINSCHEL 150-110 Programmable Step Attenuator, 0-110 dB, DC-18 GHz, SMA $450.00
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) $150.00
WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) $150.00

COMMUNICATIONS

HP 37204A-003 HPIB Extender, fibre-optic connection *NEW OLD STOCK* $250.00
HP 4935A Transmission Impairment Measuring Set $600.00
HP 59401A HPIB Bus Analyzer $375.00
TAMPA MICROWAVE LAB BUC1W-02-W-CST Ku band Upconverter, 1 Watt 14.0-14.5 GHz WR75 *NEW* $225.00
TEK 1411R PAL Gen.,w/SPG12 sync;TSG11 color bars; TSG13 linearity $750.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG13,TSG15,TSG16 ..... $1,000.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG12,TSG13,TSG15,TSG16 ..... $1,100.00
TEK 1411R-opt.04 PAL Test Gen.,w/ SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 ..... $1,400.00
TEK 147A NTSC Test Signal Generator, with noise test signal $800.00
TEK 148 PAL Insertion Test Signal Generator $700.00
TEK 520A NTSC Vectorscope $750.00
TEK 521A PAL Vectorscope $750.00

MISCELLANEOUS

EG&G / P.A.R. 5302 / 5316 Lock-in Amplifier, 100 mHz-1 MHz, GPIB / RS232C $2,250.00
FLUKE 2180A RTD Digital Thermometer $500.00
HP 59307A HPIB VHF Switch $200.00
P.A.R. 5206-95,98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB $1,500.00
TEK TM5003 5000-series 3-slot Programmable Power Module $450.00
TEK TM5006 5000-series 6-slot Programmable Power Module $500.00
TEK TM504 500-series 4-slot Power Module $175.00
TEK TM506 500-series 6-slot Power Module $250.00
TEK TM515 500-series 5-slot Traveller Power Module $250.00



by Jon Williams

Stamp Applications

STAMPS IN THE LAB

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Plot Lite is a fully configurable, general-purpose graphing and datalogging utility. Stamp Plot Lite takes advantage of the BS2's **DEBUG** command, which is, in fact, the same as **SEROUT** at 9600 baud on pin 16. Stamp Plot Lite takes the information sent by **DEBUG** and deals with it accordingly:

- If the data is a decimal number, it is graphed as the analog value.
- If the data is prefixed by "%" (by using the IBIN modifier), it is assumed to be binary data and the individual channels (up to 9) are graphed as digital (ON or OFF) values.
- If the data is prefixed by "!", it is processed as one of the various Stamp Plot Lite commands.
- If the data doesn't fit either of the above categories, it is considered a general message and placed in a text box on the bottom of the screen.

When Parallax introduced the BS2, I can remember thinking about what a great lab interface it would be. It's got 16 I/O lines, all kinds of neat functions, and a serial interface to the PC that doesn't take away any of the I/O structure. Well, aside from a few experiments, I didn't do much in this regard. Thankfully, the clever guys at SelmaWare Solutions did. These guys have developed a really neat little program called **Stamp Plot Lite** that you can freely download from their site or from Parallax.

The really neat part of the program is that it requires no set-up. The Stamp sends all of the set-up information for the graph after Stamp Plot Lite is connected. Since Stamp Plot Lite is so amazingly easy to use, I won't go into a great deal of detail here. There are a couple of notes that I do want to cover though before we get into a Stamp program that uses it.

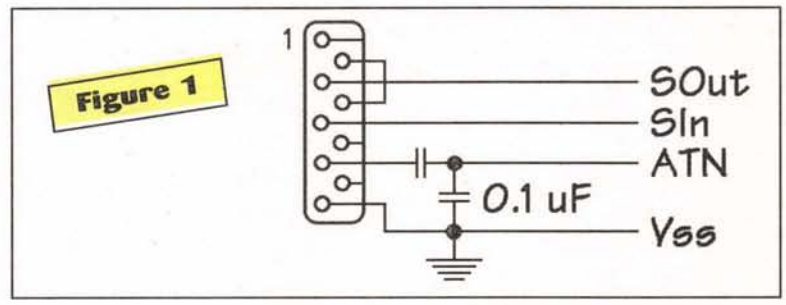
First, Stamp Plot Lite will only graph one analog value. (Note: By the time you read this article, a "pro" version that graphs multiple analog channels will be available.) The second note is on the "X" (horizontal) axis of the scale. This axis always represents seconds as Stamp Plot Lite will time stamp information as it arrives (the time stamp is relative to the start of the graph). If you want to graph for a specific period, you'll need to express the period in seconds to keep things straight.

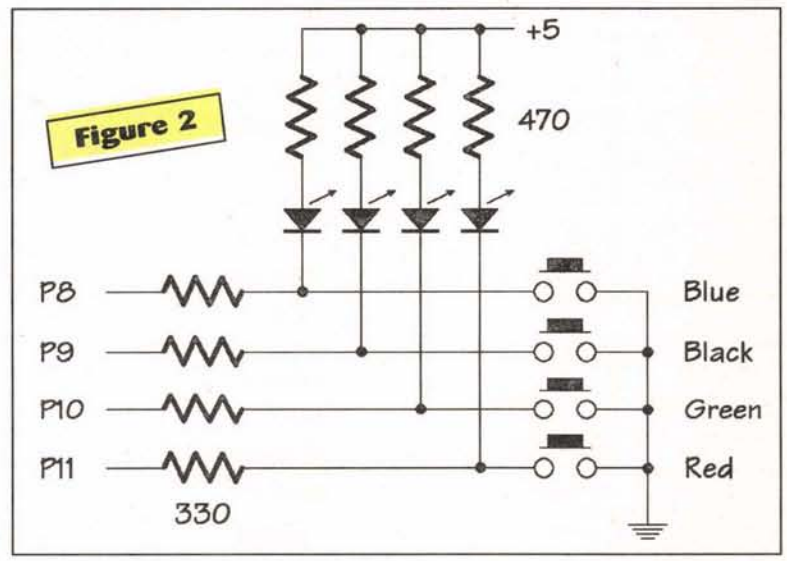
Since Stamp Plot Lite is easier to explain by putting it through its paces, let's assemble some simple hardware and give it a run.

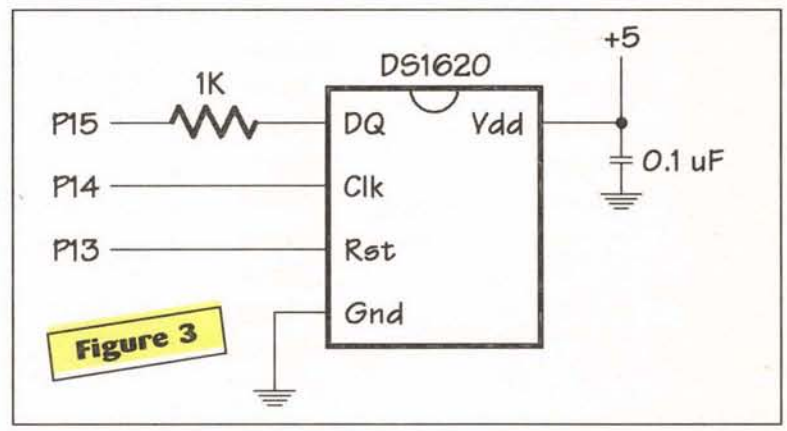
Project Hardware

If you have a Parallax BASIC Stamp Activity Board (BSAC) and a Dallas Semiconductor DS1620 temperature sensor, you're ready to rock-and-roll. If you don't, the schematics in Figures 1, 2, and 3 will get you there.

Figure 1 is the programming port and **DEBUG** interface. The



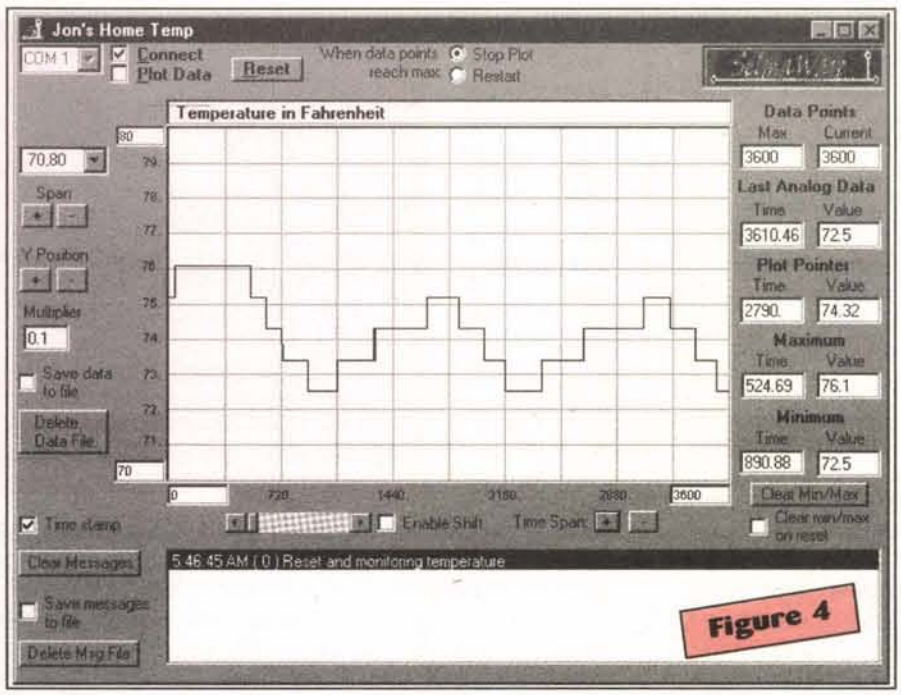




capacitors on the ATN line allow the Stamp to be reset by the PC, but will block a steady state on the serial DSR line. This will be important later when we connect the Stamp to a terminal program. Note that if you have an older BSAC that only has one capacitor, you'll want to replace it with a two-pin header and removable jumper. The jumper will be installed for programming and removed for general serial communications.

Figure 2 is the button inputs and LED outputs (that will be used a little later). In case you're wondering why we've split the resistor on each I/O line into two ... this configuration protects the I/O pin if it is in a HIGH (5 volts) state and the button gets pressed. The 330-ohm resistor limits the current to about 14 milliamps – a safe level for the pin.

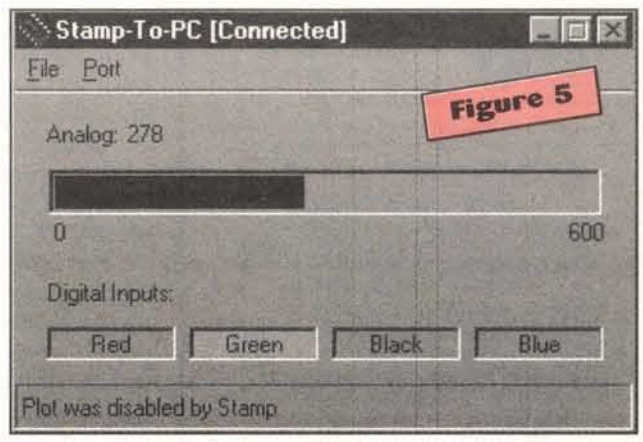
Figure 3 is the interface to the Dallas DS1620 temperature sensor. Since we've covered the DS1620 on several occasions, we



won't go into any detail about its workings. Refer to past articles by Scott Edwards and me for operational details of the DS1620.

How Well Is That A/C Working?

For reasons I can't explain, I'm nutty about knowing the temperature. That's probably why we're using the DS1620 again. It also gives me an opportunity to see the accuracy of my air conditioner's thermostat and I suppose how well the insulation in my apartment is working.



Take a look at Listing 1 (TEMPPLOT.BS2). The purpose of this program is to measure the temperature every second for an hour and send it to Stamp Plot Lite for graphing.

Let's talk specifically about the interface to Stamp Plot Lite. We'll start in the section labeled **Init_Graph**. The first thing we do is issue the reset command, **!RSET**. This will clear the contents of the Stamp Plot Lite screen. Notice that the **DEBUG** command is terminated with **CR** (carriage return character – same as 13). This is very important. The **CR** character lets Stamp Plot Lite know that the string has been entered and can be processed.

The next several commands are used to set up the graph. We'll start with the "Y" (vertical) axis. The **!SPAN** command sets the lower and upper limits of the graph. Since we're interested in monitoring the temperature in my living room, we've used "**!SPAN 70,80**" to set the lower limit of the graph to 70 degrees and the upper limit of the graph to 80 degrees.

The next command – **!AMUL** – is very clever. This command stands for "Analog Multiplier." What Stamp Plot Lite does is multiply the analog value by this multiplier before sending it to the graph. This is great for converting raw sensor data to values that are meaningful. In our case, temperature is

```
' Nuts & Volts - Stamp Applications
' July 2000 (Listing 1)
'
'=============================================================================
' Program... TEMPPLOT.BS2
' Author.... Jon Williams
' Started... 29 MAY 2000
' Updated... 29 MAY 2000
'=============================================================================

' -----[ Program Description ]---------------------------------------------
'
' Plot temperatures measured by a DS1620 using Stamp Plot Lite from
' SelmaWare Solutions (www.selmaware.com)

' -----[ Revision History ]------------------------------------------------
'

' -----[ I/O Definitions ]--------------------------------------------------
'
Rst     CON     13                      ' DS1620.3
Clk     CON     14                      ' DS1620.2
DQ      CON     15                      ' DS1620.1

' -----[ Constants ]-------------------------------------------------------
'
' DS1620 commands
'
RTmp    CON     $AA                     ' read temperature
WTHi    CON     $01                     ' write TH (high temp)
WTLo    CON     $02                     ' write TL (low temp)
RTHi    CON     $A1                     ' read TH
RTLo    CON     $A2                     ' read TL
StartC  CON     $EE                     ' start conversion
StopC   CON     $22                     ' stop conversion
WCfg    CON     $0C                     ' write config register
RCfg    CON     $AC                     ' read config register

' -----[ Variables ]-------------------------------------------------------
'
tmpIn   VAR     Word                    ' raw data from DS1620
halfBit VAR     tmpIn.Bit0              ' 0.5 degree C indicator
sign    VAR     tmpIn.Bit8              ' 1 = negative temperature
tempF   VAR     Word                    ' degrees F in tenths

' -----[ EEPROM Data ]-----------------------------------------------------
'

' -----[ Initialization ]---------------------------------------------------
'
Init_DS1620:
        HIGH Rst                                ' alert the DS1620
        ' use with CPU; free run mode
        SHIFTOUT DQ,Clk,LSBFIRST,[WCfg, %10]
        LOW Rst
        PAUSE 10                                ' allow DS1620 EE write
        HIGH Rst
        ' start temp conversion
        SHIFTOUT DQ,Clk,LSBFIRST,[StartC]
        LOW Rst

Init_Graph:
        DEBUG "!RSET", CR                       ' clear graph
        DEBUG "!SPAN 70,80", CR                 ' disply 70 - 80 degrees
        DEBUG "!AMUL 0.1", CR                   ' convert from tenths
        DEBUG "!CLMM"                           ' clear min/max values
        DEBUG "!TMAX 3600", CR                  ' 1 hour scale
        DEBUG "!PNTS 3600", CR                  ' graph every second
        DEBUG "!MAXS", CR                       ' stop when graph full
        DEBUG "!TSMP ON", CR                    ' enable time stamping

        DEBUG "!TITL Jon's Home Temp", CR       ' set window title
        DEBUG "!USRS Temperature in Fahrenheit", CR ' graph legend
        DEBUG "!CLRM", CR                       ' clear messages
        DEBUG "Reset and monitoring temperature", CR ' message box

        DEBUG "!PLOT ON", CR                    ' enable plotting

' -----[ Main ]------------------------------------------------------------
'
Main:   GOSUB GetTemp                           ' get the raw temperature
        IF sign = 0 THEN NotNeg                 ' if positive, okay
        tmpIn = 0                               '  - otherwise make zero
NotNeg: tempF = (tmpIn * 9) + 320               ' convert to 10ths F
        DEBUG DEC tempF, CR                     ' send to Stamp Plot Lite

        PAUSE 990                               ' wait about 1 second

        GOTO Main                               ' do it again

' -----[ Subroutines ]-----------------------------------------------------
'
GetTemp:
        HIGH Rst                                ' alert the DS1620
        SHIFTOUT DQ,Clk,LSBFIRST,[RTmp]         ' read temperature
        SHIFTIN DQ,Clk,LSBPRE,[tmpIn\9]         ' get the temperature
        LOW Rst
        RETURN
```

STAMPS IN THE LAB

going to be sent to Stamp Plot Lite in tenths of degrees (if the air temperature is 73.5 degrees, the Stamp will send 735 to the PC). By using the multiplier, we will correctly display our temperature data.

Finally, we'll use **!CLMM** to clear any previously stored minimum and maximum values.

Now it's time to set up the "X" (horizontal) axis. **!TMAX** tells Stamp Plot Lite how wide the graph should be. Remember that this value is in seconds. In our case, we want to watch the temperature for an hour – 3600 seconds. **!PNTS** tells Stamp Plot Lite how many data points we want to collect. Since we want to fill the screen with data, we'll set the number of points to 3600; one data point per second for an hour. **!MAXS** causes the graph to stop when the maximum number of data points is reached.

The command **!TSMP ON** enables time stamping. The time stamp is relative to the start of the graph and is expressed in seconds.

The next few commands are designed to give information to the user about what's being monitored, graphed, and (possibly) logged. **!TITL** sets the Stamp Plot Lite window title. **!USRS** puts a message in the user status box. This is the narrow box located just above the graph. **!CLRM** clears the general message box (located below the graph). The last **DEBUG** command has no specific formatting character and is assumed to be a general message. It is written to the general message box and stamped with the time-of-day and offset from reset.

The last thing we need to do is tell the graph to start plotting. This is accomplished with the **!PLOT ON** command.

Okay, we've set up the graph so let's start sending some data. The first thing we do is grab the current air temperature from the DS1620. Remember that the data returned is expressed in half degrees using the Celsius scale. Bit8 of the temperature is the negative indicator. Since we're measuring indoor temperatures, we're probably not ever going to see this bit set – but we'll check it, just to be safe (and if it is set, my goldfish is going to be really angry ...).

The conversion to Fahrenheit probably looks familiar, if not a bit funky. The reason that there is no divisor (usually 5) in the equation is that the raw temperature reading is in half-degree increments. This makes converting to tenths pretty easy. Once we've done that, we'll send the temperature to Stamp Plot Lite with a **DEBUG** command that is terminated with **CR**.

Since it takes a little bit of time to read, convert, and transmit the temperature, we'll set our **PAUSE** value to 990. This will give us almost exactly one second between readings.

Now we just need to start Stamp Plot Lite, click on the Connect check box, and start our Stamp program (or restart it by pressing the reset button on the BSAC). Take a look at the screen shot in Figure 4. This shows the result of measuring the temperature in my living room for one hour. What we can see is that with a thermostat setting of 74, the temperature fluctuated between 72.5 and 76.1 degrees. It was a warm morning when I took the readings; almost 85 degrees outside.

Pretty neat, isn't it? Even with a very simple program. Stamp Plot Lite offers a lot of other cool features, including the ability to save the collected data to a file. And it's free! You can't beat that.

BASIC to BASIC

After working with Stamp Plot Lite for a while, I got inspired to play with ideas I had about connecting the Stamp to a PC – the guys at SelmaWare had shown me the way. Now, I'm not interested in writing a graphing program, Stamp Plot Lite is already there and works great. What I would like, however, is a program that can display information collected by the Stamp and perhaps even do more advanced processing with raw sensor data.

Resources:

Jon Williams
3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

Parallax
599 Menlo Drive, Suite 100
Rocklin, CA 95756
(888) 512-1024
www.parallaxinc.com

SelmaWare Solutions
www.selmaware.com

As a starter, we'll write a Visual Basic program that will be compatible with most of the Stamp Plot Lite commands. Once we get that working, we can move on to bigger things.

Listing 2 is the Visual Basic code for the project. Keep in mind that this project – and any VB project that does serial communications – will require the MSComm control, which is found in only the Professional and Enterprise editions. Since our focus here is on receiving and processing the Stamp Plot Lite commands, that's where we'll keep our focus.

The first thing we need to do is set up the MSComm control. The code to do this is found in the **Form_Load** event handler so that it gets set up when the program is started. The **Settings** parameter is set to "9600,N,8,1" to make it compatible with the **DEBUG** output from the Stamp. Other key parameters that we pay attention to are **RThreshold** and **InputLen**. We set both of these to 1 so that we can process each character as it arrives. Finally, we need to set the **InputMode** to text (comInputModeText) since we're sending text strings from the Stamp.

Okay, now that we're set up, here's how our program works. With the comm port selected and opened, the program waits for a character to come in. When it does, the **MSComm1_OnComm** event gets fired. We grab the character from the serial port and check to see if it's a carriage return (character 13). If it's not, we'll add it to our own buffer. When a carriage return is received, we send our buffer to the subroutine called **ProcessBuffer**.

The first thing that **ProcessBuffer** does is check the first character for "!" or "%" since these characters have special meaning from Stamp Plot Lite. Let's assume that the first character was an exclamation point. This indicates a Stamp Plot Lite command, so we'll handle it separately with a subroutine called **DoCommand**.

DoCommand starts by looking for a space character in the buffer. A space is used to separate the command from any parameters. Experienced programmers might suggest that we could have just grabbed the first five characters from the buffer since the Stamp Plot Lite commands have a fixed length. Yes, we could have, but then we'd have had to gone back and grabbed the parameters for each command that uses them. It seemed easier to look for the delimiter (space) and extract the parameter string at the beginning. If a command uses parameters, we already have them.

Now that we have our command (and sometimes a parameter string), we can process our compatible list with **Select Case** structure. When a command sends a single numeric parameter (like !AMUL), the parameter is converted with the **CLng** function. We have to keep in mind that Visual Basic Integers are signed, so Longs are used in our program to deal with PBASIC's unsigned Integers.

What VB doesn't offer, however, is a binary-to-decimal conversion function. This is no surprise, since binary numbers are rarely necessary in PC applications. We

Continued on page 60

ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:

TJBYERS@aol.com

or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.

What's Up:

Gadgets galore! Got a one-of-a-kind problem, or just need a unique circuit? This month's column is full of them. Starting with control switches ranging from touch plate to temperature control to a unique motor relay. Have sneaky creature problems? Here are solutions for everything from gophers to deer. And the usual assortment of tips and tricks.

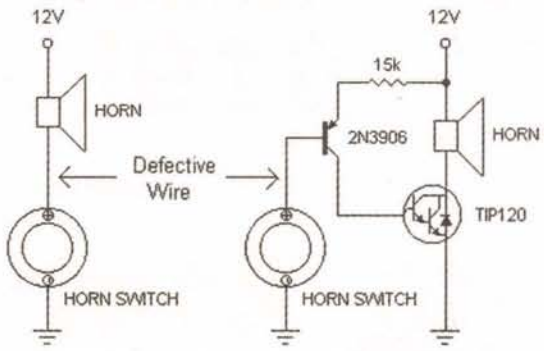
Horn Quick Fix

Q - I own a 1984 Toyota Corolla that has a bad wire buried deep inside the dash, of course, which is preventing the horn from sounding and passing state inspection. The wiring from the battery positive through the fuse to the horn is okay. But from the horn to the horn switch, the wire resistance measures between 1k and 15k when the horn switch is actuated. My idea is to make a transistorized relay circuit that can take the wire resistance and amplify it to drive a relay that will actuate the horn. I don't have the knowledge to design this circuit, so any help would be greatly appreciated.

Mark Donaldson
Newport News, VA

A - Yes, I can provide a quick fix for this "phantom" wire problem, but I can't guarantee it will hold for the life of the car — or past tomorrow, for that matter. The problem is that your mysterious changing resistance — which is affected by temperature, pressure, shape of the wire, and current flow — can conceivably go from 15k to 100M at any given moment.

That said, the first thing I'd do is make the horn voltage operated rather than its present current operated state. Your existing circuit is wired accordingly.



FACTORY **MODIFIED**

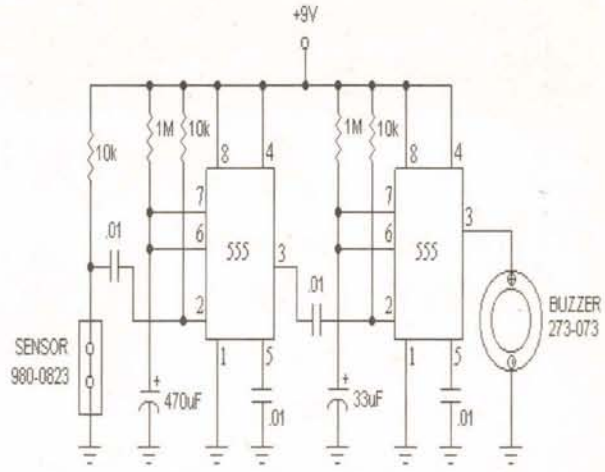
The reason the horn doesn't sound is because the defective wire is dropping all the voltage across it, like a resistor. The answer is to replace the defective wire with a transistor switch, in this case, a TIP120 Darlington transistor. A second transistor, a 2N3906, is used to trigger the Darlington ON and honk the horn. This circuit will work reliably with wire resistances up to 150k, beyond that the engine compartment temperature is going to be a deciding factor.

Laundry Done!

Q - I am a retired 70-year-old who lives alone out in the piney woods of north Georgia on a meager Social Security check. I also have a washing machine that does not signal when it is finished. How can I rig up a simple, inexpensive device that will sound a loud buzzer or beeper for about 30 seconds or so to let me know when this machine has finally finished? I have access to mail-order places, and RadioShack.

D. Dunbar
via Internet

A - My wife and I agree on at least one thing: when it comes to a washing machine, they make a lot of noise. So after examining a lot of options, I decided on using the noise and vibrations a washer produces to make a universal "washer finished" alarm.



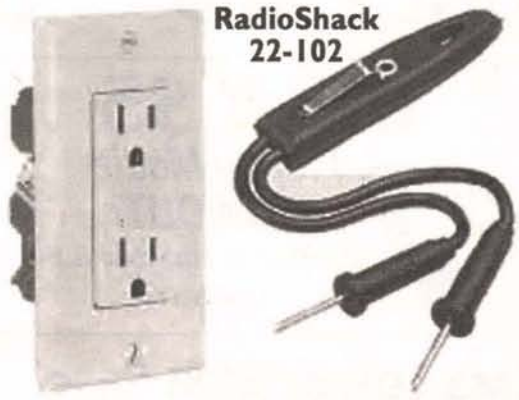
This timer circuit is built around a security alarm vibration detector (RadioShack 980-0823). Inside this sensor is a pendulum-like device that breaks the circuit when a vibration is detected, as if somebody tried to kick in your front door or smash a car window. When this sensor is mounted on the side of a washer, the motions of the machine will output a string of pulses while it is running. These pulses trigger a five-minute timer in the first 555 chip. As long as the vibrations continue for five minutes, the alarm thinks the washer is in operation. But if it detects no noise for five minutes, it triggers a 30-second alarm. It's that simple. Moreover, the circuit is battery operated. Between cycles it's a good idea to turn the battery off to conserve battery life and prevent false alarms should somebody bump against the washing machine. Just remember to turn the alarm on when your start your wash load and off when you unload the machine.

Cheap Power Line Tester

Q - In your column around the Fall of 1999, you had a schematic of a circuit with a short-wire (antenna) placed near 120VAC mains that would give a contact closure or such to allow signaling that power has been restored after an outage. Since we live in a very rural area, I can't observe my neighbors to know if power has been restored. Could you help with the year and month of that back issue?

Richard Filchock
via Internet

A - What you are referring to is a burned-out-bulb indicator for Christmas Tree lights. While this would work for you, I have a simpler solution. Place a neon indicator across your power lines as shown below.



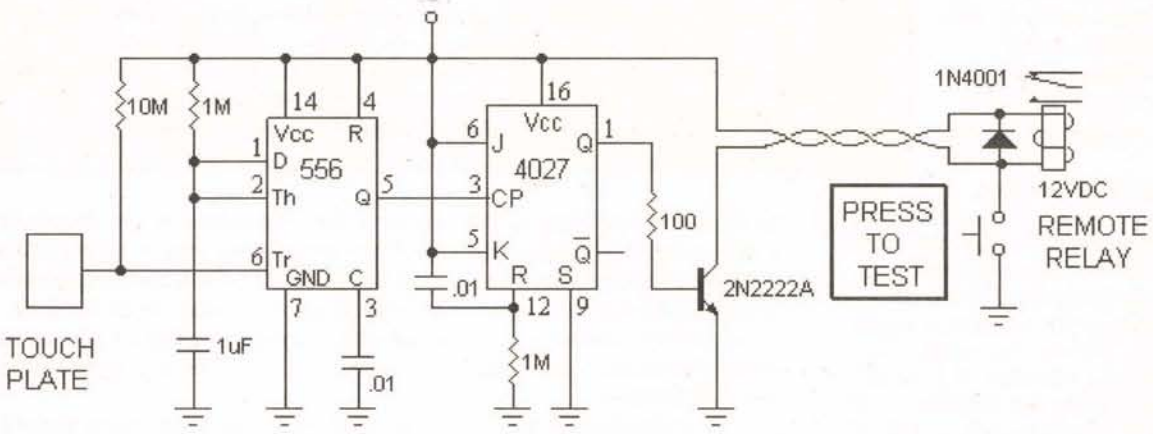
The neon circuit tester, which is a RadioShack line tester (22-102; $1.99), uses virtually no power of its own and can be "plugged" into any open outlet. If you don't have a live outlet, it can be connected to your breaker box and routed to a visible location using a "weather-proof" lamp cord (the kind used for outdoor Christmas lights).

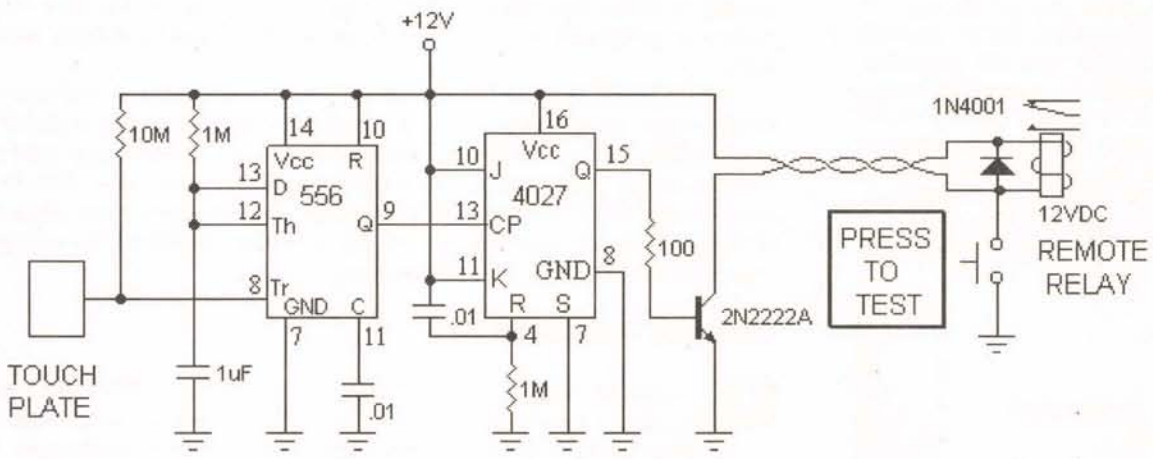
Touch Control Switch

Q. Recently, with my father now deceased, we decided it best to have my 92-year-old mother move from Florida and live with us. She is extremely arthritic and is no longer able to operate normal switches. My father had designed and constructed numerous touch control circuit boards for use throughout the house to turn on/off the lamps, TV, radio, and other appliances. Now that she's here, I want to provide the same convenience. I would appreciate it if you can provide me with a high-quality touch control switch to operate high-power appliances, like a heat lamp (500 to 700 watts). If a circuit isn't available, could you recommend a source of touch switches, either kit or commercial?

Stan Kaplan K1WTF
via Internet

A. Here is a simple circuit designed around a 555 timer, actually a 556 dual timer, and a 4027 dual J-K flip-flop.





This circuit only works inside, where your body acts as an antenna and picks up stray 60-Hz line currents. When you touch the plate, it injects a hum into the trigger input of the timer, which is configured in the monostable (one-shot) mode, and outputs a short pulse to the flip-flop. This will turn on the relay. The next time you touch the sensor place, the flip-flop toggles and turns the relay off. On, off, on, off with each touch of the plate. The touch plate can be any piece of metal or copper clad PCB. If you only need one touch switch, replace the 556 with a 555 and use only the top half of the 4027. Here's a pin conversion chart.

Function	555	556a	556b
GND	1	7	7
Trigger	2	6	8
Output	3	5	9
Reset	4	4	10
Control	5	3	11
Threshold	6	2	12
Discharge	7	1	13
Vcc	8	14	14

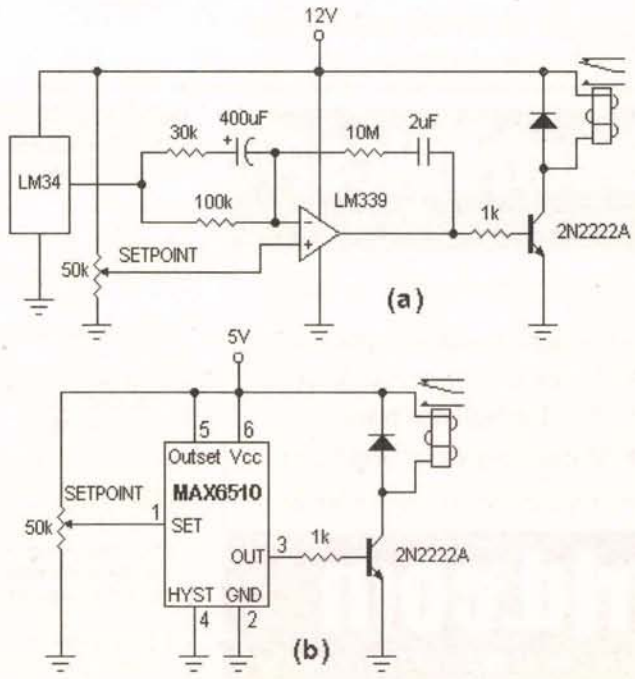
Temperature Control Switch

Q. Do you have a schematic of a thermally-controlled relay using an LM34 and a comparator? It should have a simple adjustment to set the triggering of the relay.

J. M. Drawes
Ft. Wayne, IN

A. The LM34 is a precision temperature sensor whose output voltage is linearly proportional to the Fahrenheit temperature (the LM35 is its Centigrade counterpart). This characteristic makes it very simple to build an accurate temperature-controlled relay using a single comparator. The 400-uF capacitor conditions the input signal; the 10 meg and 2 uF cap form a hystersis feedback loop that prevents the relay from seeking (chattering) around the setpoint.

Another solution is the MAX6510 temperature switch from **Maxim (800-998-9872; www.maxim-ic.com)**. All that's needed to make a temperature-controlled relay are four external components. Everything else is built into the chip, including the temperature sensor, comparator, and programmable hystersis.



Stop! Thief!

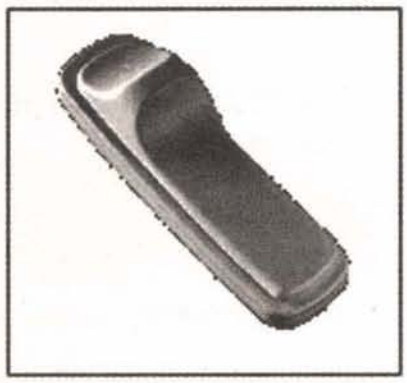
Q Can you make a drawing of those big heavy tags that are punched through department store clothing and describe how they work?

WA4YOG
via Internet

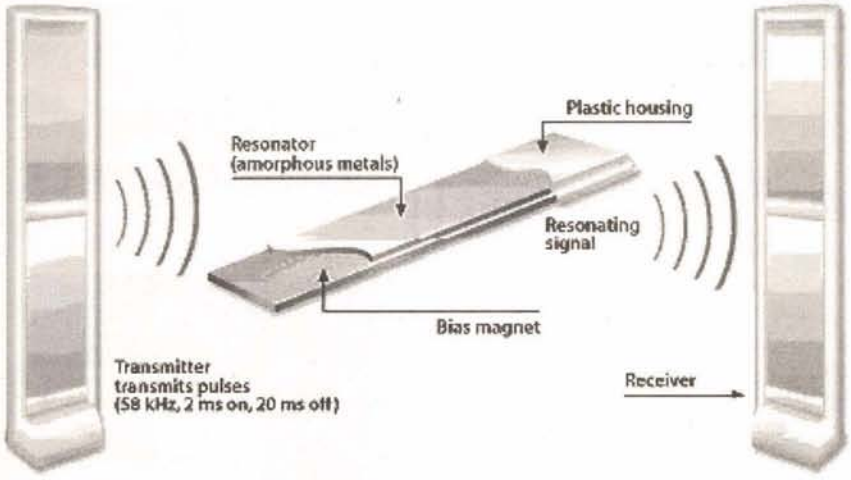
A These tags are anti-shoplifting devices that let you try on the garment but not walk out of the store without paying for it. Generally classified as Electronic Article Surveillance (EAS) devices, these tags come in many shapes and sizes, and use a variety of technologies to deter shoplifters, including RF and electromagnetic (EM).

The newer acousto-magnetic system, which has the ability to protect wide exits and allows for high-speed label application, is fast replacing the older technologies. Acousto-magnetic labels characteristically appear in a small, white plastic housing that is about 40 mm in length, 8 to 14 mm wide (depending on the type), and just under one millimeter thick.

EAS Reusable Hard Tag



Acousto-magnetic EAS systems use a transmitter to create a surveillance area where tags and labels are detected. The transmitter sends a radio frequency signal (of about 58 kHz) in pulses, which energize a tag in the surveillance zone. The pulse is transmitted for a duration of 2 mS at 20-mS intervals. The tag contains a highly magnetostrictive strip, which means that when you put the tag material in a magnetic field, it physically shrinks. The stronger the magnetic field, the smaller the metal becomes. In an acousto-magnetic tag, the metal actually shrinks and expands about one-thousandth of an inch over its full 1.50 inch length in sync with the transmitter frequency. When the transmit signal pulse ends, the metal continues to ring like a tuning fork. The oscillations, which last for about 5 ms, in turn, generate a magnetic pulse that produces an electromagnetic wave.



While the transmitter is off between pulses, the tag signal is detected by a receiver. A microcomputer checks the tag signal to ensure it's at the right frequency, occurs in time synchronized to the transmitter, at the proper level, and at the correct repetition rate. If the criteria are met, an alarm occurs. The receiver only "listens in" during the break. That's why acousto-magnetic systems can operate under more sensitive conditions than other systems. Conventional metals — such as the iron in shopping carts — do not respond during the break in the magnetic field transmission and therefore cannot trigger a false alarm.

To remove most hard tags, a detacher/releaser is necessary. Today's detachers, which basically unlock the tags, are designed so that they cannot be copied or purchased by shoplifters. Some detachers are hand-held, others are fixed.

Alarm labels currently in use are one-bit systems. That means that they simply supply the information as to whether or not something is present. Labels of the future will be a multi-bit system — an identification label that can also supply information as to which articles and how many of them are in the detector area. This could mean a reduction in shopping time, since such labels would allow customers to roll the shopping cart up to the cash register, where all the articles would be read electronically.

Cool Web Sites

Have questions? These web sites have answers.

First, did you notice how ads automatically pop up when you leave some web sites? Pretty annoying, huh? It won't happen to you if you use AdSubtract, a small background program that blocks cookies, ads, and pop-up windows. AdSubtract is free from
www.adsubtract.com

Not all domains end in .com, .org, or .edu. Different countries use different suffixes, usually two letters. If you encounter a Web site with a unique two-letter domain extension, look at these two web sites for its country equivalent.
www.webopedia.com/quick_ref/topleveldomains/countrycodeA-E.html
http://musclememory.com/fogarty/domain_codes.html

The ultimate collection of secrets and undocumented tips: 49 ways to navigate, upgrade, and customize Win 95/98, Me, and 2000.
www.pcworld.com/features/article.asp?aid=36742

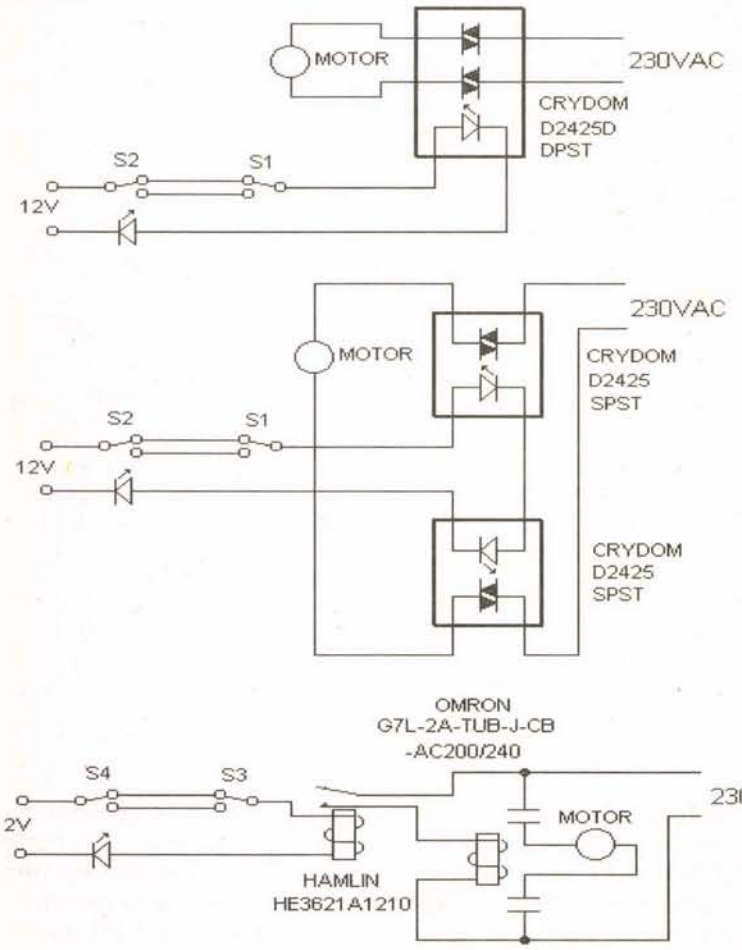
Remote Motor Switch

Q I plan to control a 2-HP, 240VAC motor with a DPST relay. I want to be able to switch the motor on and off from two locations: one switch at the motor and the other 1/4 mile away. There are three conductors, rated for low voltage/low current in the range of 12 to 24 volts, available for the relay. The power source for the relay can be at either end, but I would prefer that it be at the remote switch. Furthermore, at the remote switch I would like to have an LED to indicate when the relay is energized. My thought is to have a pair of SPDT switch in a classical "three-way" set-up, such as is used for hallway lights. However, I can't figure out how to wire this so the LED lights when the relay is on and the motor is running. How best to do this?

I also need to know whether the relay contacts need to be rated for the running current of the motor or the starting current? Finally, are there any solid-state relays rated for 2 HP motors, and are they available in DPST configuration?

Mike Bruss
via Internet

A. Let's take the last questions first, about the type and rating of the relay. Motors have two current ratings: start and run. The run current depends on the physical load on the shaft of the motor; the heavier the load, the higher the current. Typically, a 2 HP motor draws 12 amps at 230 volts under a full load. Starting currents are higher and also depend on the shaft load. In what is called the locked-rotor condition, where the load is heavier than the motor can lift from a stall (as often happens in compressor/refrigeration motors), the current for a 2 HP motor can reach up to 65 amps. And yes, the relay contacts have to handle this current for a little while, anyway. Often the contacts are rated for continuous (run) and start (surge) currents. They will also list for how long the contacts can handle the surge current before they fail. And yes, there are solid-state relays called contactors that can handle loads up to 125 amps — and beyond — in both DPST and SPST configurations. Here is how to wire them.



Notice that I have used the three-way switch you suggested, because it's simple and it works every time. When selecting solid-state relays for inductive loads, like motors, make sure they have SCR outputs as opposed to triac. SCRs are more robust and often contain snubbers. If you want to use an all mechanical relay version, I've included that, too. The coil of the motor relay is rated 230VAC, which is energized via a lower voltage relay. In both the solid-state end electromechanical versions, the LED (which is wired in series with the relay power source) will light when current flows through the relay "coil." Notice that a current limiting resistor isn't needed for the LED; the current is limited by the coil resistance of the relays.

Barking Up The Wrong Tree

Q. We have a barking dog next door that is driving us crazy. And the owner could care less! I am looking for a project/circuitry that would generate sound in the animals hearing range similar to the collars that emit a tone whenever the dog barks. There is a fence between our yards, so I could possibly mount the device on the fence and have it emit automatically every time the dog barks. I am sure that this would solve the problem quickly.

Tom Foglesong
via Internet

A. I get this question a lot, so I need to respond with an appropriate, non-electronics answer. All dog experts agree that incessant barking is a complex problem that's not easily solved — especially using ultrasound. The problem is that acknowledging the barking by a sound, petting, or food is counterproductive. It simply encourages more barking to receive the "reward." Your setting off an ultrasonic sound simply reinforces the annoyance you are trying to stop.

I wish I had a simple answer, but I don't. It really takes a dog physiologist to determine if the barking is caused by neglect, abuse, boredom, lack of roaming room, or a host of other problems — including disorders that can lead to aggressive behavior. Your best bet is to talk to your neighbor and see if you can find the root of the problem and treat it accordingly. The only "quick" cure that seems to be effective is a collar that sprays a citronella mist — an offensive odor — into the dog's muzzle at each bark. I'm no dog expert, just a dog owner. But take my word for it, ultrasonics isn't the answer.

Barking Up The Right Tree

Q. I'm in need of a diagram to build an ultrasound circuit that reaches the ears of dogs, above the human range, to keep them out of my garden. I want a circuit that works on an outdoor source of 9 volts to 12 volts.

Jim L.
Newport Richey, FL

A. Unlike the question above ("Barking Up The Wrong Tree"), your situation is different than trying to control an animal from afar. You simply want to protect a defined parameter. That I can do with electronics — with a little help from a nearby water source. Okay, I won't keep you in suspense. Both dogs and cats hate getting wet unless they do it on purpose. Plants love getting wet. Now you know the secret.

What you need to do is set up an electronic "fence" that triggers a sprinkler when breached. This should prevent cats from making your garden their personal bathroom, and keep dogs from turning into roto-tillers. I'm only going to give a broad overview of the methods used to create a perimeter, because they vary so widely in size and shape.

• Light. The most defined perimeter is a beam of light. These are the classic methods for preventing thefts of prized museum objects as seen so often in a James Bond flick or "Mission Impossible" episode. Pros: Inexpensive, readily available, and easily installed. Cons: Requires precision alignment, needs regular cleaning, and is susceptible to ground fog.

• Infrared Motion. These sensors trigger when a moving warm body enters its scanning field. They are used almost exclusively in the automatic "entry" lights so popular with automatic floodlight lamps. Pros: Cover wide, irregular areas; require minimal cleaning; and are easily installed. Cons:

Sensitivity varies by ambient light, are short lived outdoors, and react only to motion (not stationary objects, like squatting cats).

• Ultrasonics. This is much like radar, but in the audio range. An ultrasonic pulse, typically in the 50kHz range, senses when an object enters its perimeter. Pros: Very tolerant of weather conditions, can detect stationary intruder objects, and zero maintenance. Cons: Expensive and not readily available for home use.

The first two sensors can be found at any RadioShack under the umbrella of security alarms. I'll leave the plumbing up to you. Before I go, check out the following web site before you decide to build or buy:
www.biconet.com/critter/sprinkler.html

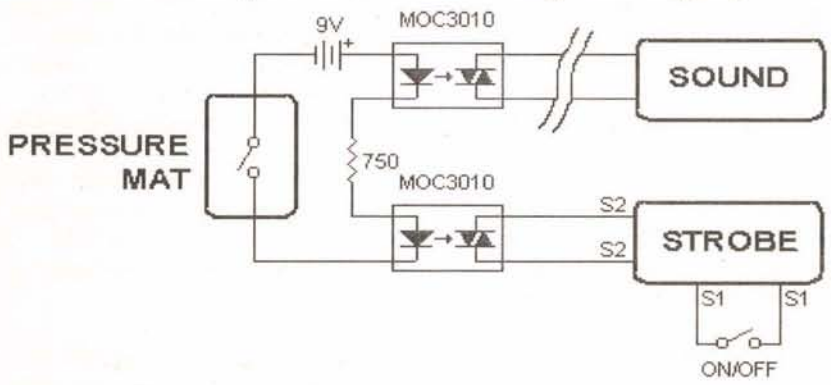
Out, Out Damn Skunk

Q. We live in a semi-rural area and have to lock the kitty door at night to prevent local skunks from walking in and helping themselves to the cat food. I have built a flap that locks down over the kitty door. However, the skunks try and scratch their way through the flap. While I am confident they can't get in, the scratching and banging at 3:00 a.m., which can last up to 10 minutes, can drive one nuts.

I want to add a small electrical discharge device like an electric fence. When we lock the flap, it will become part of the zapper, which will have a wire mesh for the other electrode. I don't want to kill the critters, just sting them enough to let them know this is not the door to be knocking on. Can you provide a cheap circuit that would do this?

Dave Johnson
via Internet

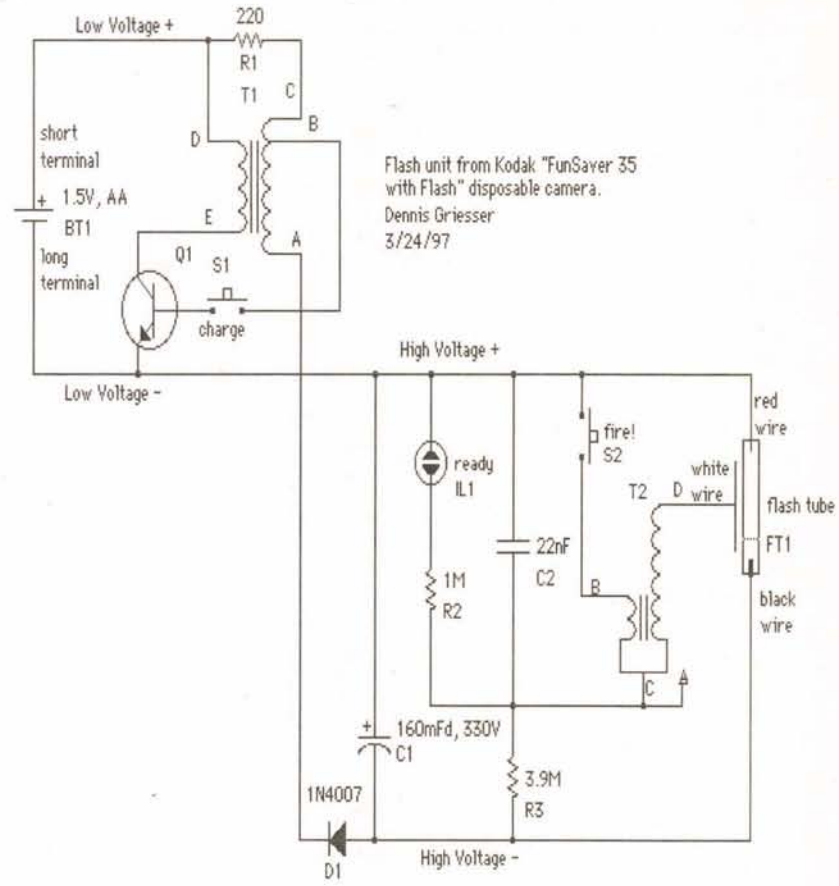
A. Yes, but listen to this solution first. I had the same problem a while back with raccoons, and my experience with them and their cousins showed me that they are skittish creatures — especially if startled. Which leads me to take the following path. My solution uses a pressure mat that switches on a strobe light and activates a recording of a barking dog.



I bought the pressure mat from American Science & Surplus (847-982-0870; www.sciplus.com) as part of a "Barking Dog" gag device ($6.50). The toy comes in three versions, including pig sounds, but the part that's important to us is the mat switch itself.

Both the sound board and the flash board use different power supply voltages and neither have anything in common other than a switch-operated trigger input. Consequently it needs an isolated interface, like an MOC3010 optoisolator. Notice that there are three major components: a pressure mat, sound card, and flash unit. Each are handled separately and you can substitute any sound device you wish, including a piezo buzzer, and any flash unit.

The flash unit comes from a disposable flash camera, like the Kodak FunSaver 35 or similar. You can probably talk a one-hour film place into giving you one for free (they throw them away) or you can buy one from American Science & Surplus (22905) for $2.75. There will be differences between various models, but here's what you can expect.



Both switches are momentary and need to be replaced. S1 becomes the OFF/ON switch and the optoisolator replaces the shutter switch (S2). Notice that the MC3010 has a triac output, which means it's not direction sensitive; the output pins are reversible. The LED diode, however, is polarity sensitive.

The way I built the unit was to snip the pressure pad cord from the sound unit and splice in a longer cable, which I ran inside the house where the nine-volt battery and MC3010 are housed. This unit needs no power switch because current is drawn only when the mat is stepped on. Next, I mounted the sound and flash boards in individual enclosures (more modularity), installed them strategically around the back door, and plugged them into the switch box.

The nine-volt battery should last several months. For the sound and flash units, I'd replace the AA batteries with D cells, either alkaline or rechargeable, to extend battery life.

Still think a zapper is the answer? Then read the following question, "Dear, Deer ... Outta Here."

Dear, Deer ... Outta Here

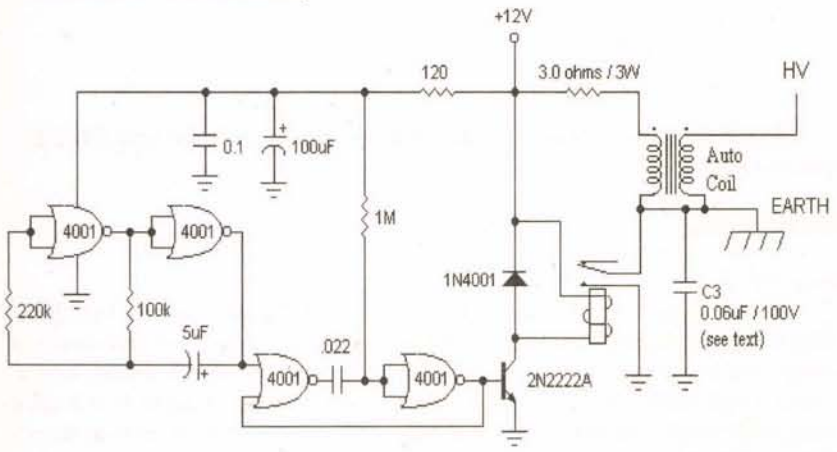
Q. I have a small stand of peach trees that add much-needed cash flow to our fixed income. We love these trees a lot. Unfortunately, so do the local deer, who are willing to travel great distances to partake of their succulent leaves. I am told that a small fence charger will chase them away. Is this true and can you provide details or information on these devices?

Mike "Mickey D" Desmond
via Internet

A. Well, it seems we've run the full gambit of nuisance critters in this column, so why not deer? Because deer are virtually unaffected by water and bright lights (ask any motorist who has collided with a starry-eyed deer on a rainy night), I agree that a fence charger is the correct answer.

I'm not sure about about your small orchard, but most have limited access to AC line power. Consequently, I've designed this fence charger to run off a 12-volt lead-acid battery that can be recharged.

Operation of this zapper is identical to the way an ignition coil ignites the spark plugs in your car's engine — in fact, it uses a lot of the same parts. Based on a design by Charles F. Kettering, the kettering ignition is based on the concept of a quickly collapsing magnetic field. First an inductor (coil) is connected to a battery, where current flows and builds up a magnetic field. At a given point, a switch (analogous to the points in a car) is opened, current ceases to flow, and the magnetic field collapses — which, in turn, induces a high voltage EMF (electro-magnetic force) in the inductor. In the kettering design, there is a secondary coil wrapped around the inductor, which creates a transformer. The turns ratio is typically 100 to 1, which means whatever voltage is induced in the primary is multiplied by 100 times in the secondary. Let's say the magnetic collapse generates 250 volts in the primary, that translates to 25,000 volts in the secondary.

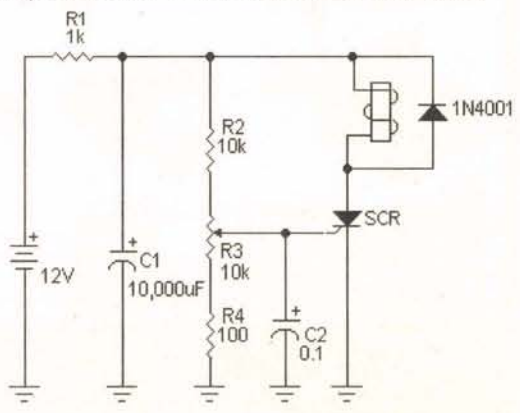


In my design, I use the same parts as used in a car, including an ignition coil you can salvage from almost any car prior to 1986. I've had best results with GMC originals and Delco replacements. A relay, like a RadioShack 275-248, performs the function of the points. C3 is a critical part of the circuit, and should be retrieved from the car when you steal the coil or purchased to match the coil. That's because the inductor doesn't collapse in one big dump, but resonates with a damped oscillation that leads to higher energy output to the secondary. Without the correct capacitor, all you get is a wimpy spark.

The rest of the design is straightforward logic design, where two NAND gates are used as a free-running oscillator and the other two are configured as a monostable multivibrator. The timing combination produces about one spark every two seconds; enough to get the deer's attention but not enough to do harm.

Thumper Revisited

Just to round out this critter round-up, for those readers who have underground pests, like gophers, I provided a solution in the Sep. 1997 issue called the "Electronic Gopher Chaser." Basically, it's a wooden post driven in the ground that has a "hammer" on its head that echoes an irritating drum beat that drives the grub eaters crazy. A back issue can be ordered from the Nuts & Volts web site, www.nutsvolts.com, for $5.00 prepaid.



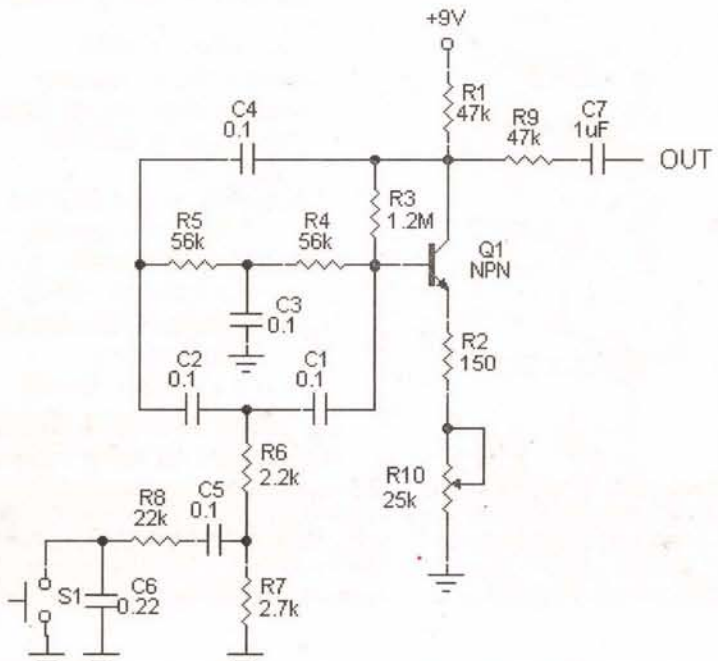
TJ Byers
Q & A Editor

Ding-Dong Update

Q - In the Feb. 2001 , there is a circuit for a "CMOS Ding-Dong Chime" by Dennis Eichenberg (page 62). I built it and was disappointed to find that it just sounded like a two-tone alarm rather the ding-dong sound from old doorbells. Could you provide a schematic for the old doorbell sound?

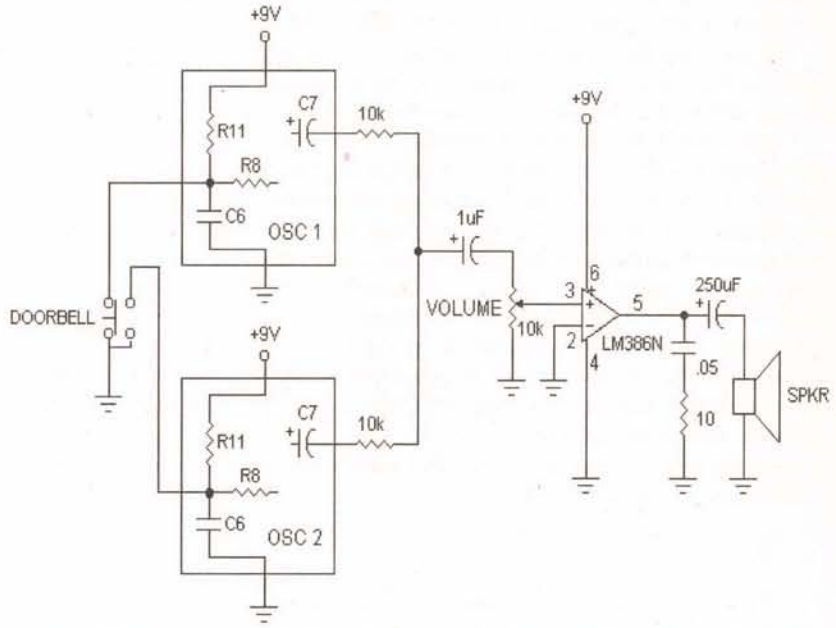
Ben
via Internet

A - You are indeed correct about the sound. The doorbell described in the Feb. 2001 issue is a simple two-tone sound generator where two oscillators of different frequencies jump from one tone to the other. A true bell sound, on the other hand, isn't a sustained tone, but a "damped" oscillation — commonly called ringing. Another difference is that bells generate sinewaves, not the squarewave of Mr. Eichenberg's design.



In the sinewave generator above, Q1 is configured as a standard twin-T oscillator — with a twist. The feedback gain is less than 1, which means the oscillator won't oscillate. That is until you press S1. Grounding R8 injects a pulse in the "tank" circuit, which starts Q1 oscillating. Because the feedback isn't large enough to sustain oscillation, though, the amplitude of the waveform slowly diminishes to nothing. The higher the gain — which is controlled by R10 — the longer the sound is sustained before fading away. This dampening of the oscillator duplicates the mechanical dampening found in the sound of a bell.

For a ding-dong sound, you need two oscillators, one for each tone, an SPDT switch, and an amplifier. The sound of the bell is determined by the value of C1 and R10, and you'll want to experiment with different values to obtain the exact tone you're looking for.



(See Mailbag for a reader's solution to the "CMOS Ding-Dong Chime" dilemma. — TJ)

MAILBAG

Dear TJ:

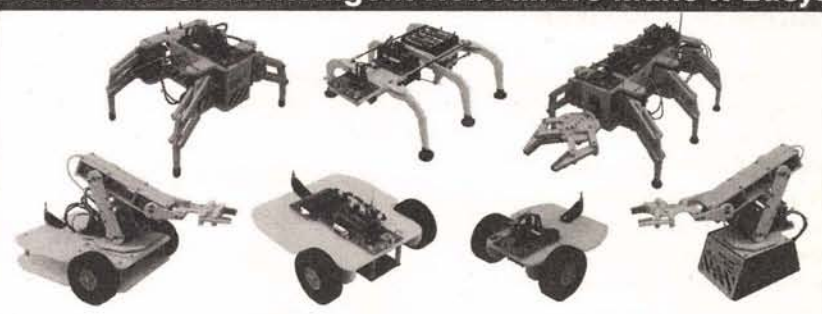
Ray Marston served up a great article on optocouplers in the Feb. 2000 issue. This is a keeper issue. But he forgot somebody. One opto that was not mentioned is the LH 1191. The manufacturer is Infineon and it comes in the typical six-pin DIP. Details can be found at **www.icmaster.com**. It is a solid-state relay which I've used on numerous occasions to provide an easy interface to external circuits.

Derek Casari
via Internet

Dear TJ:

In regard to the "CMOS Ding-Dong Chime" article on page 62 of the Feb. 2001 issue, it works fine after I made a couple of changes. First, I changed C2 from .05uF to 0.5uF, then changed R2 to 10k. I also used multi-turn trim pots for R2 and R3 which made it much easier to tune for a good sounding chime note.

Roger Hamel KG8XC
Cedarville, MI



Events

CALENDAR

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

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Events Calendar
430 Princeland Court
Corona, CA 92879
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

JULY 2001

July 1

PA - WILKES-BARRE (LEHMAN) - Hamfest. Luzerne County Fairgrounds, Rt. 118. FCC exams. Talkin: 146.61 (PL 82.5). Murgas ARC, Bob Michael N3FA, 570-288-3532. Email: wb3faa@aol.com

July 4

PA - BRESSLER - Hamfest. Emerick Cibort Park. 8am-3pm. VE testing. Talkin: 146.16/76. W3UU Harrisburg RAC, Pete deVolpi K3PD, 717-705-1370 weekdays. 717-938-8249 eves 6-9pm & weekends. Email: w3uu@aol.com Web: http://members.aol.com/w3uu/

July 6-7

MI - LANSING - Swapmeet. Holiday Inn South. 6am-3pm. MI Antique RC, Mark Oppat, 734-455-4169. Email: moppat@flash.net

July 7

CT - GOSHEN - Hamfest. Southern Berkshire ARC, Lee Collins K1LEE, 860-435-0051. Email: lee@leecollins.com
IN - INDIANAPOLIS - Central Division Convention. Indianapolis Hamfest Assn., Rick Ogan N9LRR, 317-257-4050. Email: oganr@in.net Web: http://www.indyhamfest.com
MI - PETOSKEY - Hamfest. Central Elementary School, 410 State St. 8am-12pm. VE testing. Talkin: 146.68-. Straits AREA ARC, Tom Sorrick W8IZS, 231-539-8459
NC - SALISBURY - Hamfest. Rowan ARS, Ralph Brown WB4AQK, 704-636-5902. Email: rbrown@salisbury.net Web: http://www.qsl.net/w4exu/
WI - OAK CREEK - Hamfest. American Legion Post #434, 9327 S. Shepard Ave. 6am-8pm. Talkin: 146.52 simplex. The South Milwaukee Amateur Club, POB 222, South Milwaukee, WI 53172-0102

July 8

IL - PEOTONE - Hamfest. Kankakee Area Radio Society, John "Chip" Moore K9IOC, 815-933-1323. Email: karsfest@yahoo.com Web: http://www.w9az.com
OH - BOWLING GREEN - Hamfest. Wood County ARC, Bob Boughton N1RB, 419-354-1811. Email: hamfest@wcarc.bgsu.edu Web: http://wcarc.bgsu.edu/flyer.html
PA - PITTSBURGH - Hamfest. North Hills ARC, Milton Moratis W3XX, 412-364-0399. Email: mmoratis@juno.com Web: http://nharc.pgh.pa.us

July 12-13-14

MA - WORCESTER - 10-10 Int'l Convention. Ed Emco W1KT, 508-853-3333. Email: w1kt@aol.com Web: http://www.qsl.net/kc1fv/convent.html

July 13-14-15

UT - BRYCE CANYON - Convention. Ruby's Inn. Utah Hamfest Committee, Kathy Rudnicki N7JSH, 801-547-9218. Web: http://www.utahhamfest.org

July 14

CO - LOVELAND - Hamfest. Larimer County Fairgrounds. VEC exams. Talkin: 145.115. NCARC, Rod Cerkoney N0RC, 970-225-0117. Email: n0rc@arrl.net Web: http://www.qsl.net/n0rc/hamfest
GA - GAINESVILLE - Hamfest. Lanierland ARC, Terry Jones W4TL, 770-967-6364. Email: w4tl@arrl.net Web: http://www.mindspring.com/~w4tl/hamfest.htm
ME - UNION - Hamfest. Pen-Bay ARC, Will Chadwick WC1W, 207-785-2739. Email: wilchad@tidewater.net
TX - TEXAS CITY - Hamfest. Tidelands ARS, Joe Wileman AA5OP, 409-945-6794. Email: aa5op@aol.com Web: http://www.tidelands.org

July 15

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., Steve Finberg W1GSL, email: w1gsl@mit.edu (Nick Altenbernd KA1MQX, 617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
MO - WASHINGTON - Hamfest. Zero Beaters ARC, Keith Wilson K0ZH, 636-629-2264. Email: w0bob@arrl.net Web: http://www.hyti.net/~w0bob/zbarc
NJ - AUGUSTA - Hamfest. Sussex County Fairgrounds, Plains Rd., off Rt. 206. Talkin: 147.90/30, 222.90/224.50, 146.52 simplex. Sussex County ARC, Dan Carter N2ERH, 973-948-6999. Email: n2erh@email.com Web: http://scarcnj.org
NY - BATAVIA - Hamfest. Genesee Radio Amateurs, Randy Boyle K2RLB, 716-948-9679. Email: racboyle@iinc.com
PA - KIMBERTON - Hamfest. Fire Co. Fairgrounds, Rt. 113. Talkin: 146.835-, 443.80+ CTCSS 131.8. Mid-Atlantic ARC, Bill Owen W3KRB, 610-325-3995. Email: gem@op.net Web: http://www.marc.org/hamfest.html

July 20-21

FL - MILTON - Hamfest. Milton ARC, Walter Yarbrough WA4TFR, 850-994-7335. Email: wa4tfr@worldnet.att.net

July 20-21-22

MT - EAST GLACIER - Convention. Glacier/Waterton Int'l Hamfest Committee, Gerry Leach VE6BVZ, 403-285-5547. Email: leachg@cadvision.com
WA - EVERETT - DX Convention. Everett Holiday Inn, Exit #186 off I-5, 128th St., SE. Western WA DX Club, Ward Silver N0AX, 206-463-9173. Email: hwardsil@wolfenet.com Web: http://www.wwdxc.org/convention

July 21

IA - DES MOINES - Convention. The Triple H Net, James Young W7FTT, 760-249-3698. Email: w7ftt@qsl.net Web: http://www.qsl.net/triplehhh/index.html
LA - SLIDELL - Hamfest. Slidell City Auditorium. 8am-2pm. VE testing. Talkin: 147.27/87 PL 114.8. Ozone ARC, Wayne Wenner AC5YB, 985-863-2048. Email: ac5yb@arrl.net
MN - BRAINERD - Hamfest. Brainerd Area ARC, Al Doree W0RC, 218-575-2404. Email: w0rc@arrl.net Web: http://www.uslink.net/~brdham
NC - CARY - Hamfest. Cary Community Center. 8am-2pm. Talkin: 145.39 -6. Cary ARC, Herb Lacey W3HL, email: n4nc@arrl.net
NY - FRANKFORT (UTICA) - Hamfest. Utica ARC, Bob Decker AA2CU, 315-797-6614. Email: ktrnd@borg.com
OH - WELLINGTON - Hamfest. Lorain County Fairgrounds. VE exams. Northern Ohio ARS, John Schaaf K8JWS, 216-696-5709. Email: k8jws@arrl.net Web: http://apk.net/noars/noarsfe.htm
PA - BERWICK - Hamfest. Jonestown Mountain Repeater Assn., Charles Hooker AD3L, 570-864-2571. Email: chooker@epix.net
TN - DAYTON - Hamfest. Rhea County ARS, Tom Mize KO4SY, 423-570-0840 or 423-775-2480. Email: ko4sy@arrl.net Web: http://www.volstate.net/~ko4sy
TX - SHERMAN/DENISON - Hamfest. North Texas Hamfest Committee, Gene Hodge K5DPS, 903-893-6082. Email: kc5aft@gte.net Web: http://home1.gte.net/wb5dcu/nortex00.html

July 22

IL - SUGAR GROVE - Hamfest. Waubonsee Community College, Rt. 47 at Harter Rd. VEC exams. Talkin: 147.210 (+600) PL 103.5/107.2. Fox River Radio League, Maurice L. Schietecatte W9CEO, 815-786-2860. Email: w9ceo@arrl.net Web: http://www.frrl.org/hamfest.html

July 26-27-28-29

TX - FT. WORTH - Hamfest. Central States VHF Society, Lilburn Smith W5KQJ, 817-596-3539. Email: lilburn@mesh.net Web: http://www.csvhfs.org

July 27-28

OK - OKLAHOMA CITY - Hamfest. OK State Fair Park, Intersection I-40 and I-44. Hobbies, Arts & Crafts/Modern Living Bldg. Fri: 5-8pm, Sat: 8am-5pm. Talkin: 146.82. Central OK Radio Amateurs, Inc., email: corahams@swbell.net Web: www.geocities.com/heartland/7332

July 28

ME - LINCOLN - Hamfest. Ella Burr School. VE testing. Bagley ARC, Sylvia M. Cockburn N1JNR, 207-732-5185 or David Baker 207-794-3398
NC - WAYNESVILLE - Hamfest. Western Carolina ARS, Pat Kelsey WA4OLA, 828-236-0181. Email: wa4ola@arrl.net Web: http://wcars.org
NV - RENO - Hamfest. Int'l Game Technology parking lot, 9295 Prototype Dr. Sierra Nevada ARS, Bill Massie K7NHP, 775-246-3756. Email: k7nhp@arrl.net
OH - CINCINNATI - Hamfest. Diamond Oaks Career Development Campus, 6375 Harrison Ave. 7am-1pm. VE exams. Talkin: 146.670- and 146.925-. OH-KY-IN ARS, Lynn Ernst WD8JAW, 859-657-6161. Email: wd8jaw@arrl.net Web: http://www.qsl.net/k8sch

July 29

MD - TIMONIUM - Hamfest. Timonium Fairgrounds, York Rd., off I-695, I-83. VE exams. BRATS, Mayer Zimmerman W3GXK, 410-786-6839. Email: w3gxk@arrl.net Web: www.bratsatv.org
OH - RANDOLPH - Hamfest. Portage County Fairgrounds, St. Rt. 44. 8am-4pm. VE exams. Portage ARC, Joanne Solak KJ3O, 330-274-8240. Email: ljsolak@apk.net Web: http://parc.portage.oh.us
SD - CLEAR LAKE - Hamfest. Deuel County ARC, Rob Schmidt N0TAW, 605-874-2778. Email: rjtaw1@itctel.com

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E-Mail: info@agishows.com
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Web: ncshows.com

Peter Trapp Computer Shows
603-272-5008
Web: www.petertrapp.com

Events CALENDAR

AUGUST 2001

August 3-4

TX - AUSTIN - Convention. Austin ARC, Austin Repeater Organization, & TX VHF-FM Society, Joe Makeever W5HS, 512-345-0800. Email: w5hs@arrl.net

August 4

IL - CARLINVILLE - Hamfest. Macoupin County Fairgrounds, Rt. 4 I-55 exit 60. 7am-12pm. Talkin: 146.82-. Macoupin County ARC, Tim Jones KA9VIV, 217-627-2355. Email: ka9viv@yahoo.com
MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. Email: ka8aip@centurytel.net Web: http://www.oscoda.net/icare/
MO - SPRINGFIELD - Hamfest. University Plaza Trade Center. 8am-1pm. VE testing. Talkin: 146.910-. Southwest MO ARC, Woodie Moore W0ODY, 417-833-2248. Email: w0ody@arrl.net Web: http://www.smarc.org
NY - ITHACA - Hamfest. Tompkins County Airport. 7am-2pm. VE exams. Talkin: 146.970-. Tompkins County ARC, Dave Flinn W2CFP, 607-533-4797. Email: dave@starflinn.com Web: http://www.compcenter.com/~tcarc
OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790. Email: kb8kpj@cs.com
PA - LEWISTOWN - Hamfest. Decatur Township Fire Co. Grounds. Talkin: 146.91. JVARC & Decatur Township Fire Co., Richard Yingling, 717-242-1882
VA - VINTON - Hamfest. William Byrd High School, Washington Ave. 9am-3pm. Talkin: 146.985 (-600). Roanoke Valley ARC, Dave Miller 540-977-3142. Email: dmiller@rev.net

August 4-5

WA - SPOKANE - Convention. Spokane RA, NW Tri-State ARO, Palouse Hills ARC, Inland Empire VHF Club, & Kamiak Butte, William Craze KC7YSF, 509-326-5353. Email: warchief@cet.com

August 5

IN - ANGOLA - Hamfest. Land of Lakes ARC, Sharon Brown WD9DSP, 219-475-5879. Email: sharon.1.brown@gte.net
NY - WILLIAMSVILLE - Western NY Section Convention. Greater Buffalo Hamfest & Expo. Main Transit Fire Hall, 6777 Main St. Talkin: 147.255. Lancaster ARC, Luke Calianno N2GDU, 716-634-4667. Email: luke@towncountryflorist.com Web: http://hamgate1.sunyerie.edu/~larc
VA - BERRYVILLE - Hamfest. Clarke County Ruritan Fairgrounds. VE exams. Talkin: 146.82-. The Shenandoah Valley ARC, Brian Mawhinney WB3FUM, 540-665-0761. Email: WB3FUM@arrl.net

August 11

IL - QUINCY - Hamfest. Western IL ARC, Bob Crockett N9KUT, 217-222-4467. Email: w9awe@arrl.org Web: http://www.qsl.net/w9awe
MD - WESTMINSTER - Hamfest. Reese Firemen's Carnival Grounds, Rt. 140. Carroll County ARC, Inc., email: k3pzn@arrl.net web: www.qis.net/~k3pzn
MI - JACKSON (VANDERCOOK LAKE) - Hamfest. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058. Email: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn
NY - WESTMORELAND - Hamfest. Rome Radio Club, Russell Schorer KB2MAS, 315-853-8739. Email: kb2mas@gpoconnect.net
WA - LONGVIEW - Hamfest. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076 after 6pm weekdays. Email: kb7ado@aol.com Web: http://www.qsl.net/nc7p/swapmeet.htm
WI - BARABOO - Swapfest. Sauk County Fairgrounds. 7am-12pm. VE testing. Yellow Thunder ARC, Steve Schulze N9UDO, 608-356-2313. Email: n9udo@arrl.net Web: http://www.qsl.net/ytarc/
WV - HUNTINGTON - Hamfest. Veterans Memorial Field House, 2590 5th Ave. 8:30am-2pm. VE testing. Talkin: 146.76-. TARA, Garry Ritchie W8OI, 304-733-1300. Email: tarahams@juno.com Web: www.qsl.net/tara

August 12

CA - GOLETA (SANTA BARBARA) - Hamfest. Santa Barbara ARC, Alan Soenke WA6VNN, 805-562-2694. Email: ajsoenke@aol.com Web: http://www.sbarc.org
IA - AMANA - Hamfest. Cedar Valley ARC, Chuck Bassett N0OUTS, 319-378-0448. Email: n0outs@rf.org Web: http://cvarc.rf.org/
IL - PEOTONE - Hamfest. Will County Fairgrounds. 6am-3pm. Talkin: 146.52 simplex, 146.64 (-107.2). Hamfesters RC, Inc., Robert Nelson WB9WFR, 708-756-7984. Email: wb9wfr@aol.com
IN - GREENTOWN - Hamfest. Lions Club Fairgrounds. 8am-1pm. VE testing. Talkin: 146.91 & 146.79. Kokomo & Grant County ARCs, L. B. Nickerson K9NQW, 765-668-4814. Email: k9nqw@skyenet.net Web: http://www.netusa1/~ka6nqwnick/hamfest.html
KY - LEXINGTON - Hamfest. National Guard Armory adjacent to airport. 8am-4pm. VE sessions. Talkin: 146.760-. Bluegrass ARS, John Barnes KS4GL, 859-253-1178. Email: ks4gl@juno.com Web: http://www.BluegrassARS.org/
MN - ST. JOSEPH - Hamfest. St. Cloud ARC, Jack Maus W0MBD, 320-685-8295. Email: w0mbd@arrl.net Web: www.w0sv.org
NJ - BAYVILLE - Hamfest. Jersey Shore ARS, Ed Genoino WA2NDA, 609-971-2792. Email: wa2nda@aol.com Web: http://www.jsars.org
PA - MATAMORAS - Hamfest. Matamoras Airport Park, off Exit 53, I-84. Talkin: 146.760 -600, 100 Hz PL, 145.350 -600, 100 Hz PL. Tri-State ARA, Carl Will

Events CALENDAR

KB3DHN, 570-828-7622. Email: kb3dhn@mercurylink.net Web: http://www.qsl.net/k3tsa/
PA - SHREWSBURY - Hamfest. Shrewsbury Firehouse. VE testing. Talkin: 146.700. Southern PA Group, Hilltop Transmitting Assn., & York White Rose ARC, John Salony 717-741-1780. Cecil Mundorff 717-927-6662. Web: www.carli-online.com/hamfest

August 18

KS - CHANUTE - Hamfest. Chanute Area ARC, Charlie Ward WD0AKU, 316-431-6402
NJ - OAKLAND - Hamfest. American Legion Hall, 65 Oak St. Talkin: 147.49 in, 146.49 out. Ramapo Mountain ARC, Steven Oliphant N2KBD, 973-962-4584. Email: rmarc@qsl.net Web: http://www.qsl.net/rmarc
OH - FRIENDSHIP - Hamfest. Portsmouth Radio Club, Jack King KB8NBI, 704-372-5811

August 19

CO - GOLDEN - Convention. The Denver Radio Club, Ron Taylor K0HRT, 303-989-3978. Email: k0hrt@arrl.net Web: http://www.qsl.net/w0tx
IN - LAFAYETTE - Hamfest. Tippecanoe County Fairgrounds. 8am-2pm. VE exams. Talkin: 147.135+ & 443.775+ PL 88.5. Tippecanoe ARA, David Dull WB9BRX, 765-743-8305. Email: dave@dullville.com Web: www.w9reg.org
KS - SALINA - Hamfest. Central Kansas ARC, Ron Tremblay WA0PSF, 785-827-8149. Email: tremblay@midusa.net
MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., Steve Finberg W1GSL, email: w1gsl@mit.edu (Nick Altenbernd KA1MQX, 617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
OH - WARREN - Hamfest. Warren ARA, Renee McCaman KB8SVF, 330-847-8478. Email: mccaman@cboss.com Web: http://www.onecom.net/wara

August 25

FL - TAMPA - Hamfest. TARC Club House, right next to ball field. 8am-1pm. Talkin: 147.105+. Tampa ARC, Biff Craine K4LAW, 813-265-4812. Email: k4law@arrl.net Web: http://www.hamclub.org
IN - LAPORTE - Hamfest. LaPorte County Fairgrounds, St. Rd. 2 West. 7am-1pm. Talkin: 146.52, 146.61-, PL 131.8. LPARC, Neil Straub WZ9N, 219-324-7525. Email: nstraub@niia.net Web: www.geocities.com/K9JSI
MO - COLUMBIA - MO State Convention/CMRA Hamfest. National Guard Armory, Hwy 63. Central MO RA, Dale Huffington AE0S, 573-875-6170. Email: dale@tranquility.net Web: www.qsl.net/cmra/hamfest2001.htm
NY - MARGARETVILLE - Hamfest. Margaretville ARC, Lester Bourke KB2DCE, 845-586-2324. Email: bourke@catskill.net Web: http://www.catskill.net/marc
WV - WESTON - Hamfest. WV State ARC, Ann Rinehart KA8ZGY, 304-768-9534. Email: ka8zgy@arrl.net Web: http://www.qsl.net/wvsarc

August 26

IL - DANVILLE - Hamfest. Vermilion County ARA Communications Center, Harrison Park West Addition, off I-74. VE testing. Talkin: 146.820 (-600). VCARA, email: VCARA@Talk.to
IL - JOLIET - Hamfest. Bolingbrook ARS, Thomas Ballard N9LJY, 630-739-3740. Email: tb1303@mediaone.net Web: http://geocities.com/k9bar/
MO - ST. CHARLES - Hamfest. VFW Hall, 66 VFW Ln. 6:30am-1pm. VE testing. Talkin: 146.670-. St. Charles ARC, Kenneth Fieser KB0VLN, 434-428-4383. Email: kfieser@aol.com Web: http://www.qth.com/wb0hsi/
NY - YONKERS - Hamfest. Yonkers ARC, Tommy Monzon W5ACT, 914-533-2892 or 203-794-2665. Email: w5act@arrl.net Web: http://www.yarc.org
PA - NEW KENSINGTON - Hamfest. Skyview Radio Society, Robert Livrone N3WAV, 724-339-9607. Email: n3wav@arrl.net Web: http://www.microconnect.net/~ggross/skyview.htm
TN - LEBANON - Hamfest. Short Mountain Repeater Club, Roger Hughes W4IV, 615-893-5623

SEPTEMBER 2001

September 1

CA - VACAVILLE - Hamfest. Vaca Valley RC & Western States Weak Signal Society, Larry Hogue W6OMF, 707-452-9701. Email: w6omf@cwnet.com
CANADA - ON - OTTAWA (CARP) - Hamfest. Ottawa ARC, Greg Danylchenko VE3YTZ, 613-236-9291. Email: fleamarket@oarc.net Web: http://oarc.net/fleamarket
NM - ALAMOGORDO - Hamfest. Alamogordo ARC, June Richmond K5BHE, 505-437-0298. Email: k5lrw@zianet.com Web: http://www.zianet.com/AARC/

September 1-2

CT - ENFIELD - Conference. Eastern VHF/UHF Society & North East Weak Signal, Bruce Wood N2LIV, 631-265-1015. Email: bdwood@erols.com
NC - SHELBY - Hamfest. Shelby ARC, John Ledford W4JL, 704-482-4507. Email: w4jl@shelby.net Web: http://www.shelby.net/n4fan

September 7-8

AR - MENA - Hamfest. Queen Wilhelmina State Park. 7am-5pm both days. VE testing. Queen Wilhelmina Hamfest Assn., Charlotte Lee KC5DOR, 870-642-7656 home or 870-642-2234 ext. 107 work. Email: clee1948@yahoo.com

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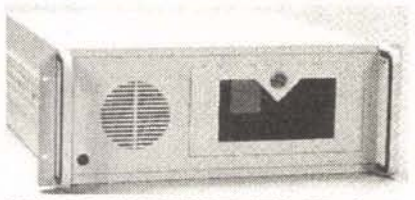

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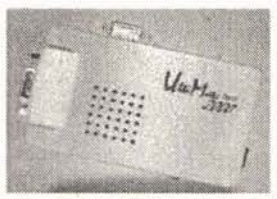

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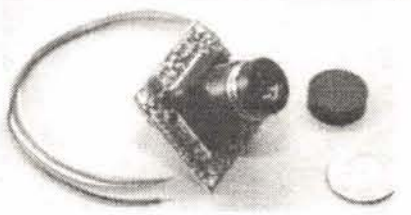

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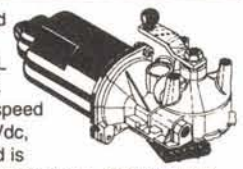

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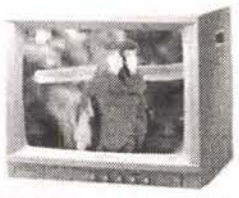

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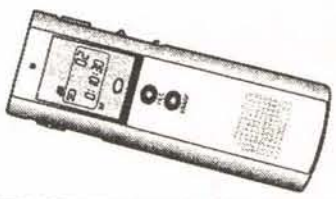

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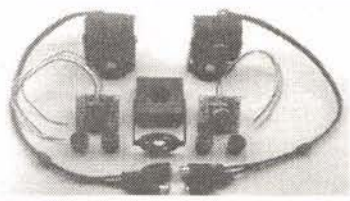

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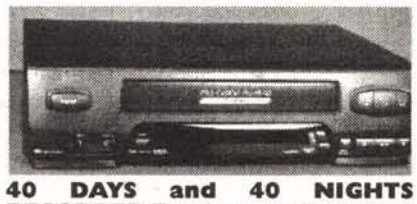

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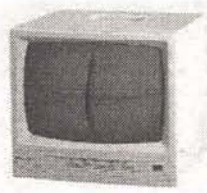

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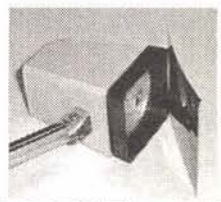

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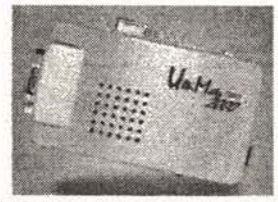

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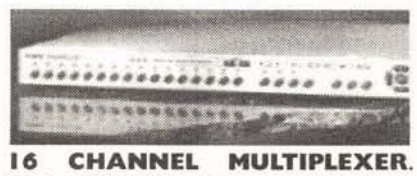

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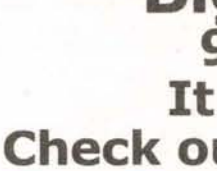

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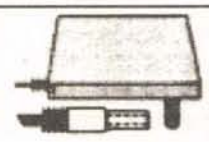

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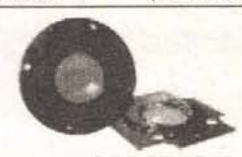

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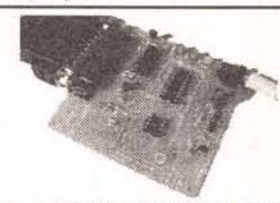

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Continued on page 58

GARDENBOT "THE GREEN MACHINE"

Photo 1 — GardenBot outside on the lawn. Not shown are any of the sensors, nor the tilt/pan sensor platform since these features have not been added yet.

by Daniel Ramirez

Imagine, if you will, a lawn cart containing gardening tools, a watering can, and topsoil which follows you around the lawn while you fertilize and water your plants. Or — better yet — a lawn cart which gives each plant the correct amount of water and plant food. Imagine a lawn cart which travels across the yard in neat rows while spreading fertilizer or grass seed for you; a lawn cart which starts, stops, turns, or follows you on command, using such simple voice commands as: Start, Stop, Left, Right, or Follow.

Best of all, if a child or pet runs across the cart's path while it's in motion, the cart would stop automatically at a safe distance.

With a GardenBot in your garage, how would the Jetsons ever keep up with you?

Does all of this sound like science fantasy? It may, but this was my personal vision for the ideal yard and garden robot, and the average hobbyist can actually assemble a version of it for his or her own use.

My GardenBot is still in the developmental stages and does not yet perform all of the tasks described above, but I hope to have it up to that level of functionality as I keep working on it.

It may be difficult for the reader to duplicate my version of the GardenBot, since many of the components used in its construction were either surplus or one-of-a-kind items. However, inspiration, creativity, and persistence are the keys to building any successful robot. Hopefully, you will gain inspiration for your own robotics project from this article.

Of course, I can't take sole credit for the GardenBot idea. I had seen large robots of a similar type described in Karl Lunt's book *Build Your own Robot* [1], Gordon McComb's book *Robot Builder's Bonanza, 2nd Edition* [2], and various sources on the Internet. Also, I have to credit Isaac Asimov's three laws of robotics described in his book *I Robot* [3] not only for inspiration, but for some of the basic safety designs which prevent the machine from injuring a person.

Science fiction films and TV have been influential. In particular, *Forbidden Planet*, *Kronos*, *The Day the Earth Stood Still* and, of course, *Star Wars* were inspirational; and let me not forget the Battle Bots program or the classic 1960's TV series *Lost in Space*!

But the biggest single inspiration for my own GardenBot was the 1970 science fiction film *Silent Running*, in which a group of robots help to maintain a forest inside a biosphere on a spaceship heading for a new world.

Genesis of the GardenBot

Last spring, I was at the checkout line of the local hardware store when I spotted a green lawn cart in a nearby aisle. The cart was made of ABS plastic, had four wheels, a large cargo section, and shelves on either side. Suddenly, I was inspired by the idea of a robot that would automatically follow me around the lawn like a pack horse while carrying tools, topsoil, fertilizer, and seed bags. I had seen ads for robot lawn mowers ... Why not an all-purpose gardening robot? I checked the price of the cart. It was a little high, but the germ of an idea had been planted to build the GardenBot.

A few weeks later on a return trip to the same hardware store, I noticed that the cart was on sale for $50.00. That decided it! This time the green lawn cart was added to my purchases, and I justified the extra expense by telling myself that if the GardenBot idea never came to fruition, I could at least use the cart for its original intended purpose.

Through summer and fall, however, the cart sat in the basement, unused, while other projects occupied my time. By December, I finally had time to experiment with the GardenBot idea. However, winters in New England can be long and cold, and this last was exceptionally so, providing little opportunity for testing the GardenBot outdoors. Knowing that it would not be practical to test it outdoors until spring, I began construction, doing all testing in the basement.

The cart as seen in Photo 1, turned out to be the perfect shape, color, and weight for my purpose. Although it had four durable plastic ABS tires, I decided that the two rear tires — connected with a galvanized steel axle rod — had to go. I replaced them with two heavy-duty, air-filled, rubber tires. The two front wheels — mounted on free-wheeling casters — were perfect for skid-steering the robot. The plastic outer shell with shelves on either side of the cart and the large bay with sliding door allowing easy removal of cargo seemed to be ideal. In general, I thought it was a well-made and ergonomic design for a traditional lawn cart.

GardenBot's Mission

At this point, I began to seriously consider what purposes and functions my robot should perform. Beyond simply aiding the homeowner with yard work, I began to visual-

GardenBot's Features

The following is a list of the GardenBot's features:

Dimensions:
Length: 39 inches
Width: 25 inches
Depth: 10 inches

Payload Capacity: 175 lbs.

Actuators:
2 Geared DC motors
2 RC Servo motors used to tilt/pan the sensor platform
Sensors:
1 Polaroid 6500 Sonar Ranger
4 Sharp GP2D12 IR detectors used for IR ranging
1 Sharp GPIU57X IR receiver for the Sony TV remote control
8 Micro Switches used for bumpers and cat whiskers
1 Microphone
Processors:
1 Parallax, Inc. Stamp BSX microcontroller
1 Microchip PIC18C452 microcontroller

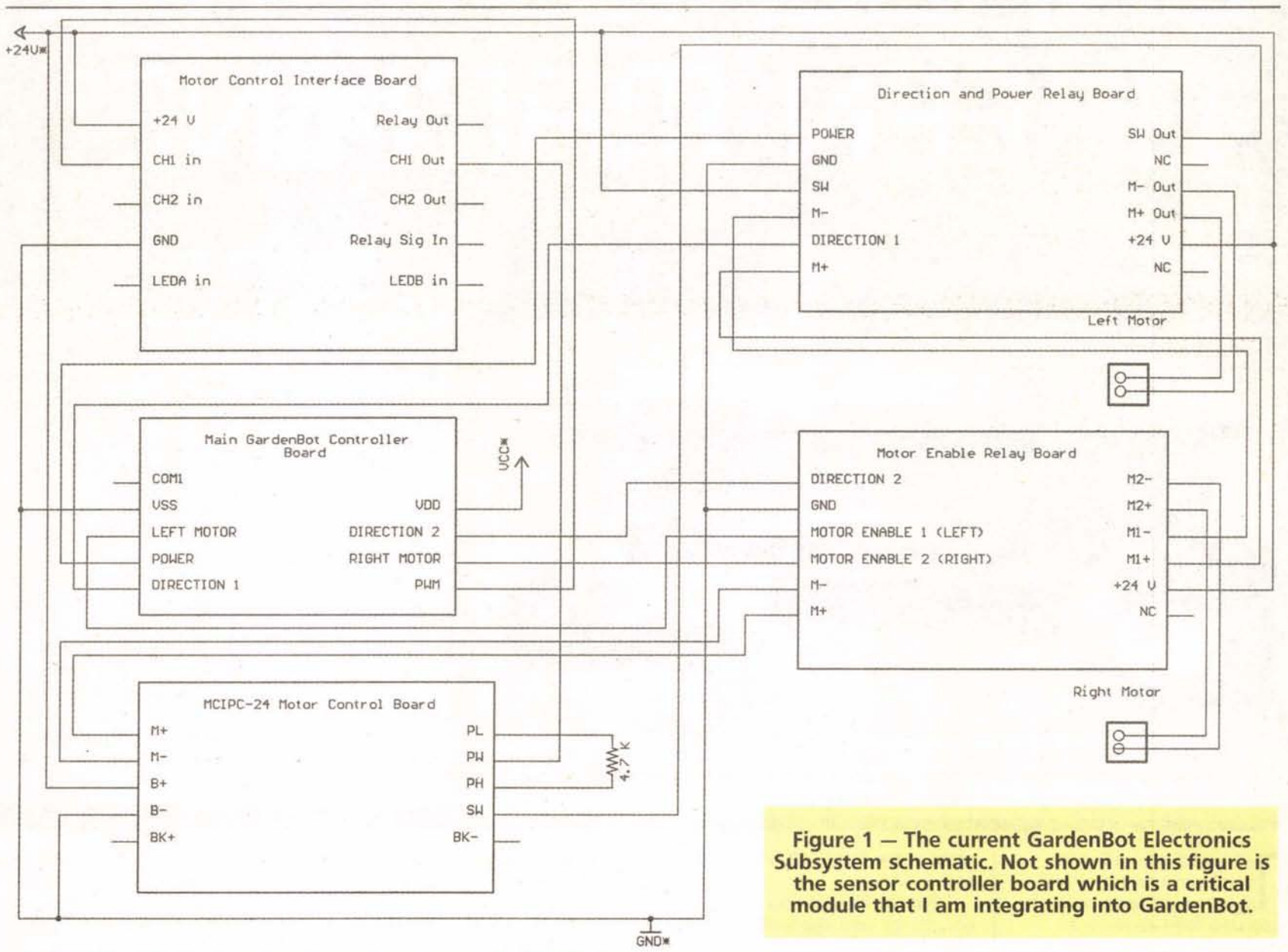

Figure 1 — The current GardenBot Electronics Subsystem schematic. Not shown in this figure is the sensor controller board which is a critical module that I am integrating into GardenBot.

ize a versatile, low-cost machine which could spread fertilizer or grass seed on a small-to-medium sized lawn, following a pre-defined pattern.

It would be able to carry up to 175 pounds of miscellaneous material, such as gardening implements, topsoil, fertilizer, and seed bags.

Best of all, I visualized it as a potential tool for the handicapped homeowner who might not be able to carry some of the heavier items.

The more I thought about its potential, the more possibilities I saw. For example, the GardenBot could be used to scan a field for antique tools and coins by attaching a metal detector to the front. The robot could be programmed to automatically scan a flat field for metal targets. Approximate locations of the metal targets could be determined by using a GPS receiver and saved to EPROM or disk, or they could be transmitted directly to the treasure hunter.

On a more serious note, I envisioned how a similar low-cost robot equipped with a mine detector could spare lives on the battlefield.

My final vision for a GardenBot-type robot was the use of a larger version in agriculture, on tree farms, and in reforestation projects. Potentially, such a machine might even be useful to the National Park Service.

Building the GardenBot

The GardenBot, as it developed, became a mixed brew of old, new, and recycled components. Besides the garden cart, several items went into its construction, including an antique erector set to build the electronic card cage and sensor platform. One recycled six-volt and two recycled 12-volt lead-sealed batteries were used for power.

The electronics boards consist of a Stamp BSX main controller board, a 24-volt PWM DC motor control board, a motor control interface board, a direction and power relay card, a motor enable relay card, and a sensor controller board.

I purchased the two surplus, Swiss-made, geared DC motors for

Photo 2 — Snapshot of a bolt with a 10 mm diameter hole through it.

Photo 3 — Snapshot of a 5/8 x 3" bolt before it is drilled, along with the nut and the locking pin.

Photo 4 — Picture of one of the six-inch angled steel brackets used in making the heavy-duty motor mounts.

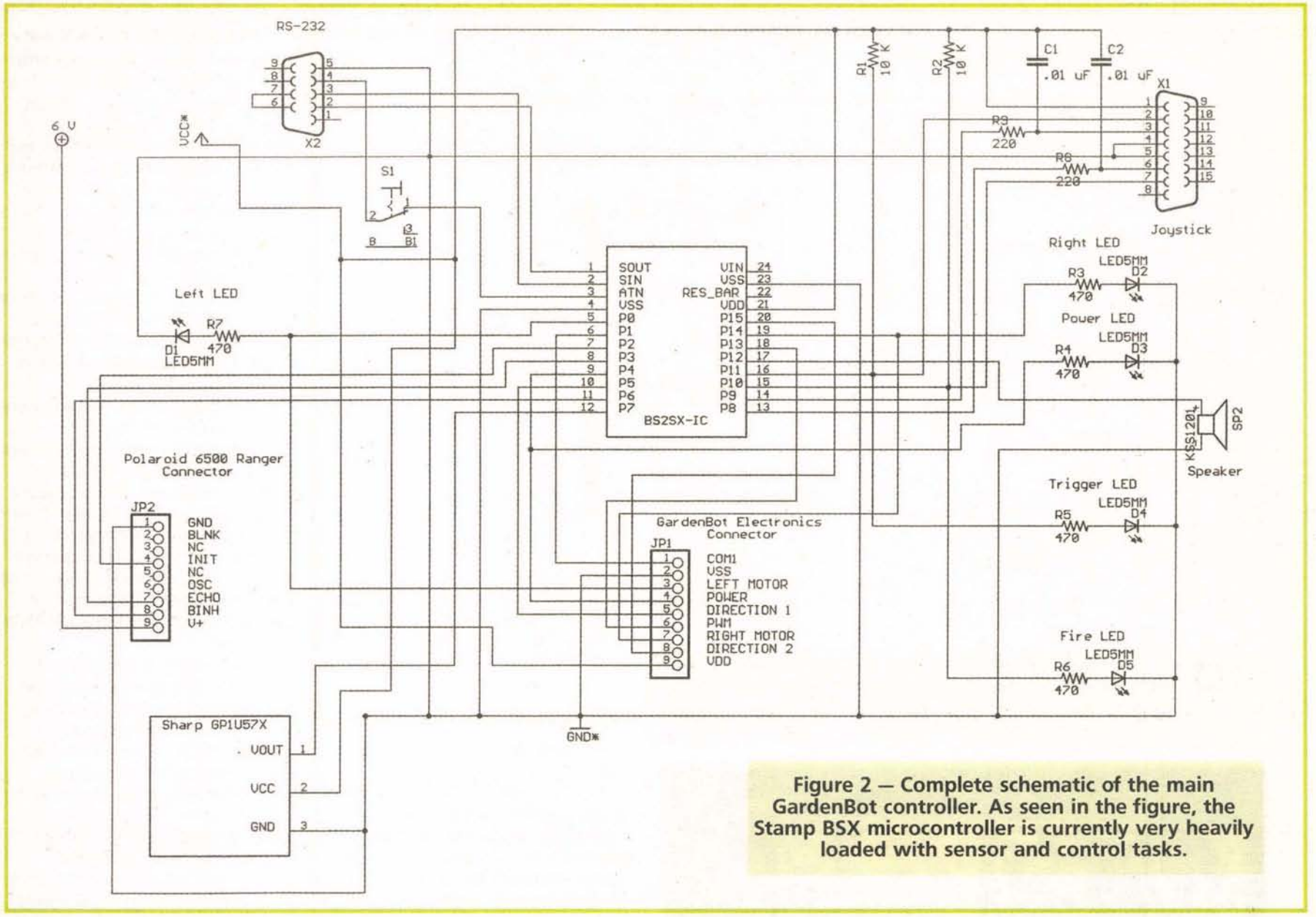

Figure 2 — Complete schematic of the main GardenBot controller. As seen in the figure, the Stamp BSX microcontroller is currently very heavily loaded with sensor and control tasks.

$10.00 each from Diverse Electronics Services. These are very powerful motors, rated at 354 in.-lb., although their maximum speed of 35 revolutions/minute at 24 volts is not very fast. For safety's sake, I think that this slower speed is advantageous in case the robot should malfunction and go astray.

The motors are well-made of high-grade steel alloy, weighing about 2.5 lbs. each. The shaft and gearbox are perpendicular to the main motor axis. The shaft measures 10 mm diameter, is 25 mm long, and has a slot at the end with a small hole drilled through it. Each has three 6 mm threaded screw mounts forming a triangle on the gearbox, ideally suited for attachment to the GardenBot frame. Unfortunately, according to the Diverse website (http://members.tripod.com/~divelec/hbridge.html),

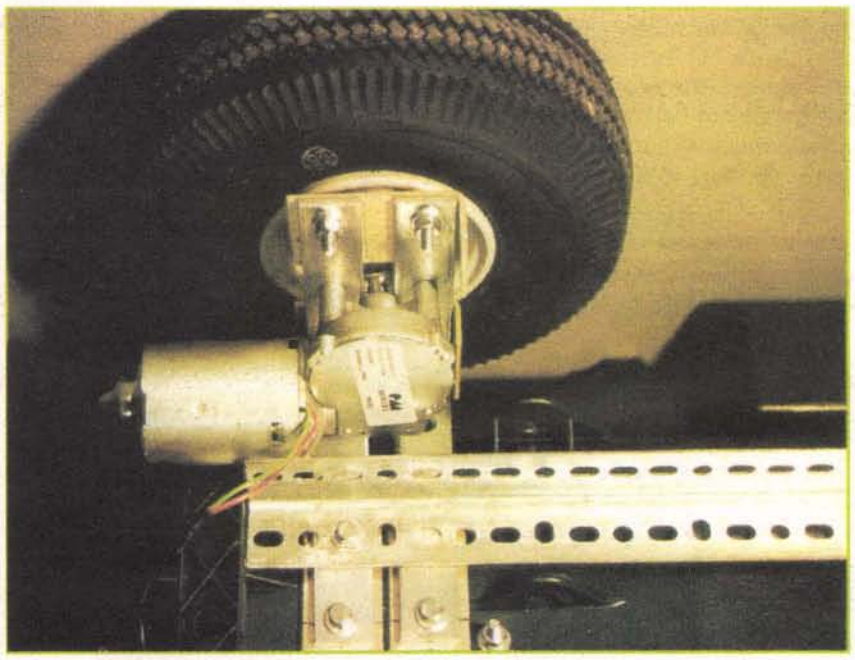

Photo 5 — The completed motor mounts with the motor attached. Note how the motor mounts are bolted to the steel frame.

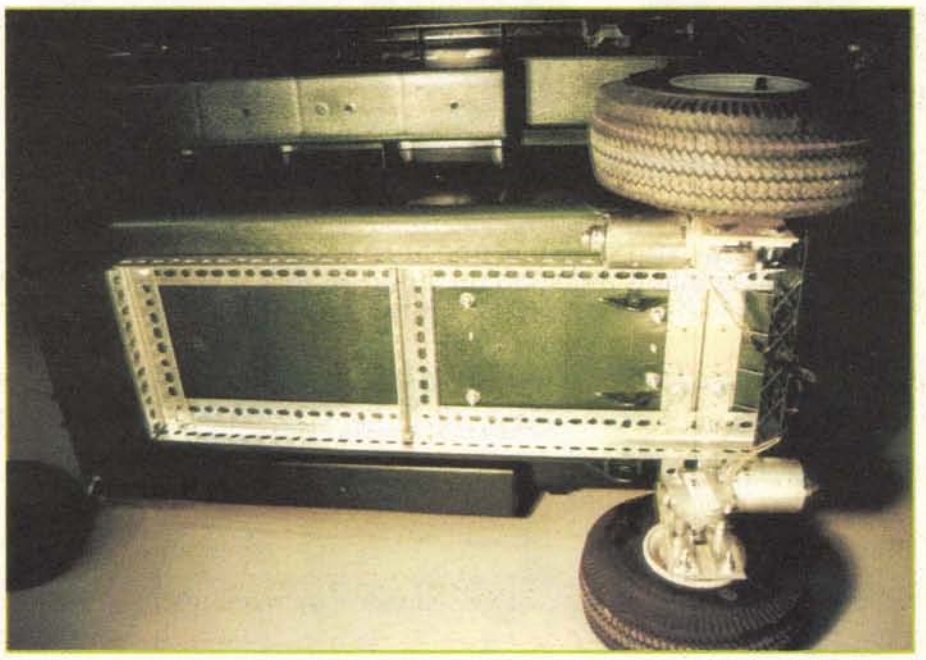

Photo 6 — The rectangular 28" x 9 " steel frame fastened underneath to GardenBot's plastic bottom.

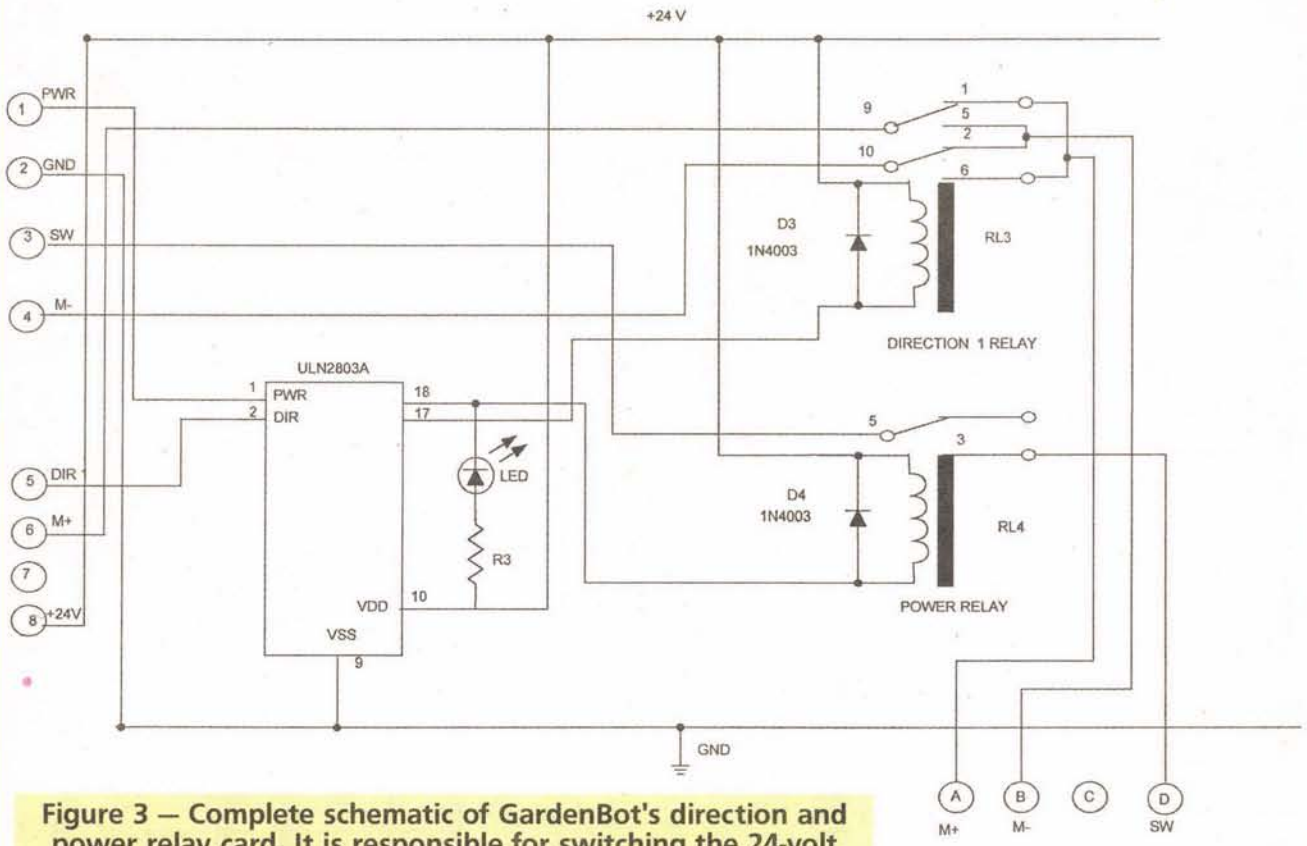

Figure 3 — Complete schematic of GardenBot's direction and power relay card. It is responsible for switching the 24-volt power supply to the motors and also responsible for changing the left motor direction.

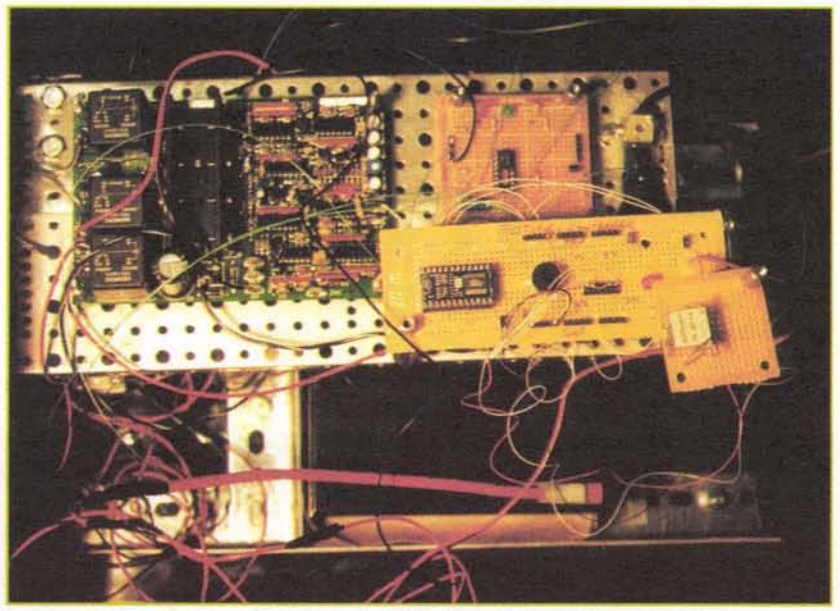

Photo 7 — Three of the electronic modules visible from the top. Also shown is the Sharp GPIU57X IR receiver module that is mounted on a post so that it is visible to the Sony TV remote control.

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[1] Lunt, Karl *Build Your Own Robot!*, AK Peters, Limited
[2] McComb, Gordon *Robot Builder's Bonanza, 2nd Edition*, McGraw-Hill Professional

Book Group
[3] Asimov, Isaac *I Robot*, Bantam Doubleday Dell Publishing Group
[4] Jones, Joseph, L., *Mobil Robots – Inspiration to Implementation*, AK Peters

Limited
[5] Everett, H. R., *Sensors for Mobile Robots*, AK Peters, Limited

Datasheets:
[6] Microchip Technology, Inc., *PIC18CXX2 Data Sheet*, document #DS39026B, 2000

eliminated.

I had to search through many hardware stores before I was able to find a 10 mm drill to bore a hole 3/4" inches deep along the main axis of a 5/8 x 3" bolt, as seen in Photos 2 and 3, to be used for the motor shaft adapter. I also drilled a small hole across the head of the bolt to match the hole on the motor shaft in order to put a cotter pin through the bolt and motor shaft. It took a few attempts and a few bolts, using an 8" drill press, to bore the required bolts with a 10 mm shaft through the center. A machine shop or school could do this work much more easily.

Heavy-duty motor mounts were needed to support the weight of the GardenBot and its cargo. I used two six-inch steel angled brackets from the hardware store to mount each motor, using the three 10 mm threaded screw mounts provided.

The idea to use these brackets was not originally mine either. I had purchased these motors months before through an ad I saw in *Nuts and Volts*.

I was trying to find a way to mount these motors which would not require the use of a machine shop or specialized tools, when I stumbled upon a site on the web (www.theonespot.com) which described using these motors along with the same Diverse 24-volt DC motor control board for a robot. The website also had a great description of the completed robot.

Using the design I saw there, I added thick aluminum panels to the angled brackets in order to fortify them, as shown in Photos 4 and 5.

The next step was to build a rectangular steel frame 28" x 9" inches shown in Photo 6. I used slotted angled iron rails from the hardware store to support the bottom of the lawn cart and to attach the motor mounts. This relieved the plastic bottom of the cart from undue stress.

Then I drilled 1/4" diameter holes at evenly spaced intervals

these particular motors have sold out.

Other surplus 12-volt or 24-volt motors could be substituted, but they might require modifications to the motor mounts and wheel shaft. Such motors can be removed from discarded electric toy cars, electric car windows, and electric bicycles.

For example, I recently saw a 12-volt electric window motor in the *Nuts and Volts* ad section for sale from Resources Un-Ltd. (www.resunltd4u.com) for $20.00.

I got the idea of using a direct drive motor shaft adapter to mount the tires to the motors from Karl Lunt's book [1]. By using the direct drive mount, the need for gears, pulleys, timing belts, or chains which would add undesired weight and complexity to the robot, was

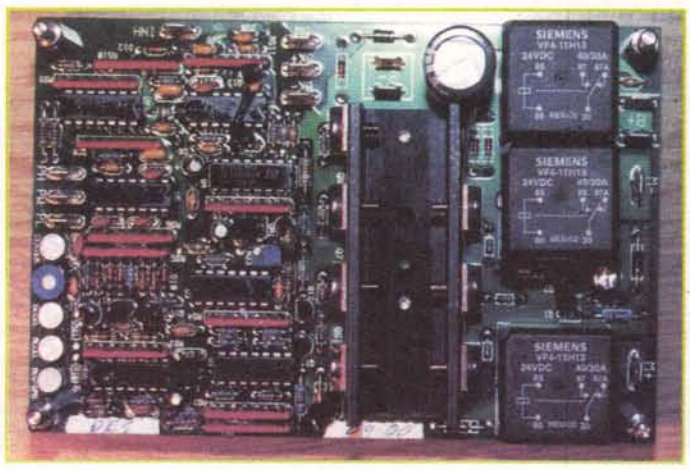


Photo 8 — Picture of the MCIPC-24 motor control board. As can be seen it is a heavy-duty motor controller, well worth its price.

along the bottom of the cart, using the rectangular steel frame as a guide, and bolted it to the bottom of the cart using 1/4" hex bolts, nuts, and washers.

To attach the motor mounts, I drilled 1/4" diameter holes through the bottom of the cart near the original rear axle locations, while making sure that the motor mounts were perpendicular and connected to the steel frame. The slotted angled iron rails were easy to cut using a fine hacksaw.

GardenBot's Sensors

The sensor suite for the GardenBot includes a Sharp GPIU57X IR receiver, a Polaroid 6500 Sonar Ranger, four Sharp GP 2D12 IR detectors, a microphone for voice recognition of verbal commands, micro-switches, bumper switches, cat whiskers, and other contact sensors.

Future additions to the sensor suite will include environmental and navigation sensors such as: temperature, pressure, relative humidity, rain gauge, wind speed, voltage, a video camera, a line follower sensor, a GPS receiver, and a Vector 2X electronic compass.

GardenBot's Electronics

The electronics modules that give GardenBot much of its personality are shown in Figure 1 and Photo 7. As seen in the figure, there are five modules that currently make up the brains and nervous system of the robot. These modules are connected together as shown to form the robot's electronic subsystem. Not shown in Figure 1, is the new sensor controller board that I recently completed, but have not yet integrated into GardenBot. The modules and their associated figures are:

1) Main GardenBot Controller Board also labeled "Joystick Controller" (Figure 2).
2) MCIPC-24 Motor Control Board (See Diverse site).
3) Motor Control Interface Board (See Diverse site).
4) Direction and Power Relay Card (Figure 3).
5) Motor Enable Relay Card (Figure 4).
6) PIC18C452 Sensor Controller Board (new).

The Main GardenBot Controller

The main controller is based on a Stamp BSX and is responsible for receiving operator commands from a Sony TV remote control or a joystick. A Sharp GPIU57X IR receiver is used to decode the commands from the TV remote. If a joystick is connected, it is read using the Stamp rctime function.

The Stamp processes the commands and performs selected actions based on a set of behavioral algorithms. The Stamp also sends PWM commands to the motor control interface board, the relay cards, and the servo used to scan the sensor platform.

MCIPC-24 Motor Control Board

The 24-volt PWM motor control board shown in Photo 8, was purchased from Diverse Electronics Services for $40.00. It's an H-Bridge controller, featuring Pulse Width Modulation (PWM) speed control for forward and reverse directions. It can continuously drive a motor with up to 35 amps.

One controller is capable of driving two DC geared motors without overheating. The Stamp microcontroller is used to control the speed by varying the PWM, using the Pulsout command. The 12-volt DC geared motors require a more expensive 12-volt PWM speed controller, also available from Diverse Electronics Services.

Motor Control Interface Board

In order to drive the PWM of the MCIPC-24 motor control board, I had to build the motor control interface board, pictured in Photo 9, that was recommended by Diverse which doubles the Stamp PWM voltage 2X from a range of 2-4 volts to a range of 4-8 volts.

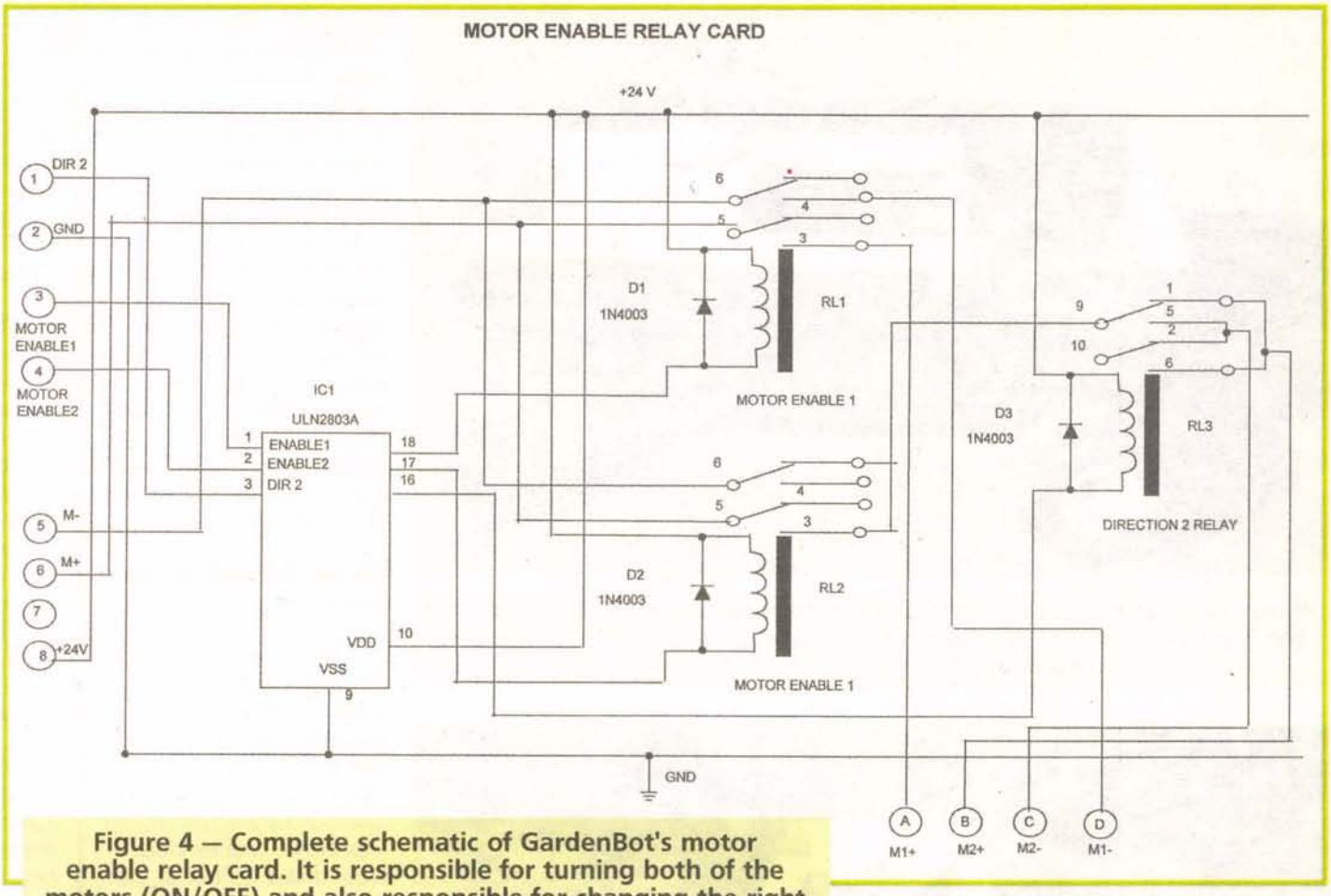


Figure 4 — Complete schematic of GardenBot's motor enable relay card. It is responsible for turning both of the motors (ON/OFF) and also responsible for changing the right motor direction.

The board schematic is supplied with the PWM speed controller documentation and is also available at the Diverse website. The Diverse website also has many other examples of using Stamps with these controllers and motors, and they sell a complete heavy-duty DC motor connection kit EVS-1 for $100.00.

Direction and Power Relay Card

The direction and power relay card seen in Photo 9, is used to

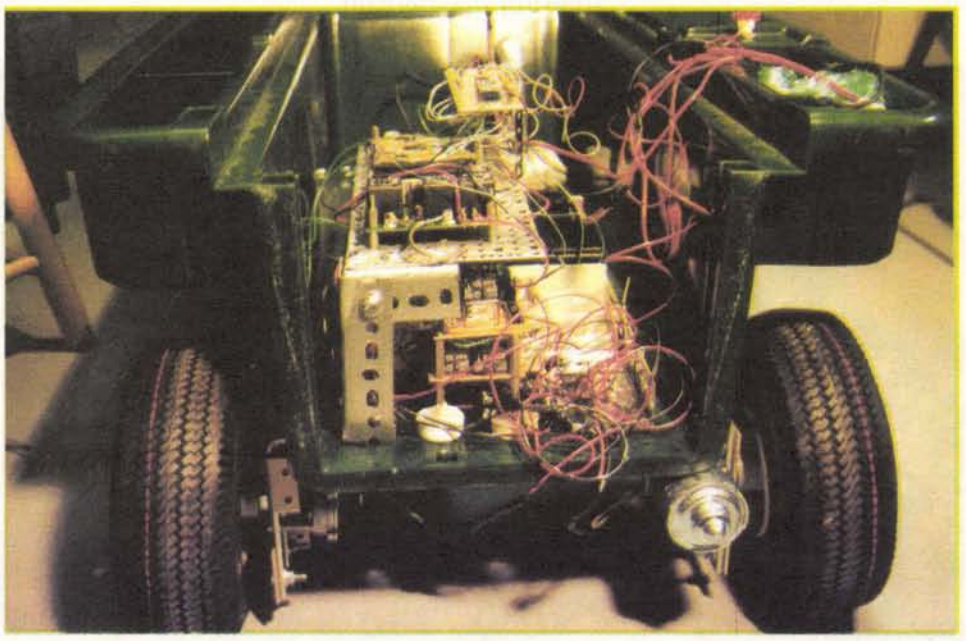


Photo 9 — Rear view of the robot with the sliding back panel removed, showing both the direction and power relay card and the motor enable relay card. These cards are stacked on top of each other and are directly in front. Also shown is the spaghetti wire connecting all the electronic modules.

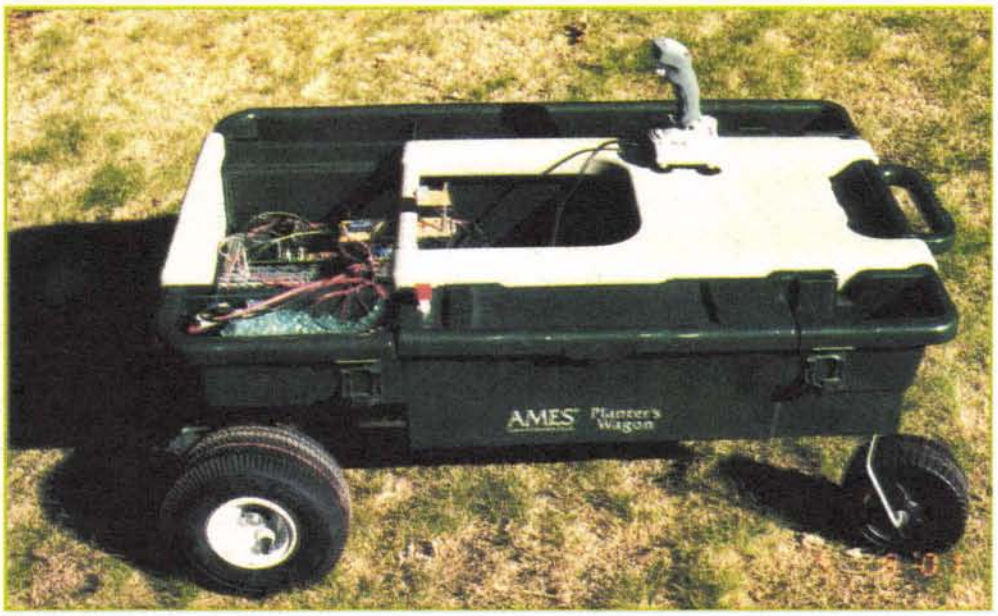


Photo 10 — Clear view of the red emergency stop button. It also shows the joystick (teaching pendant) used to manually move the robot and also used to train it with robotic behaviors.

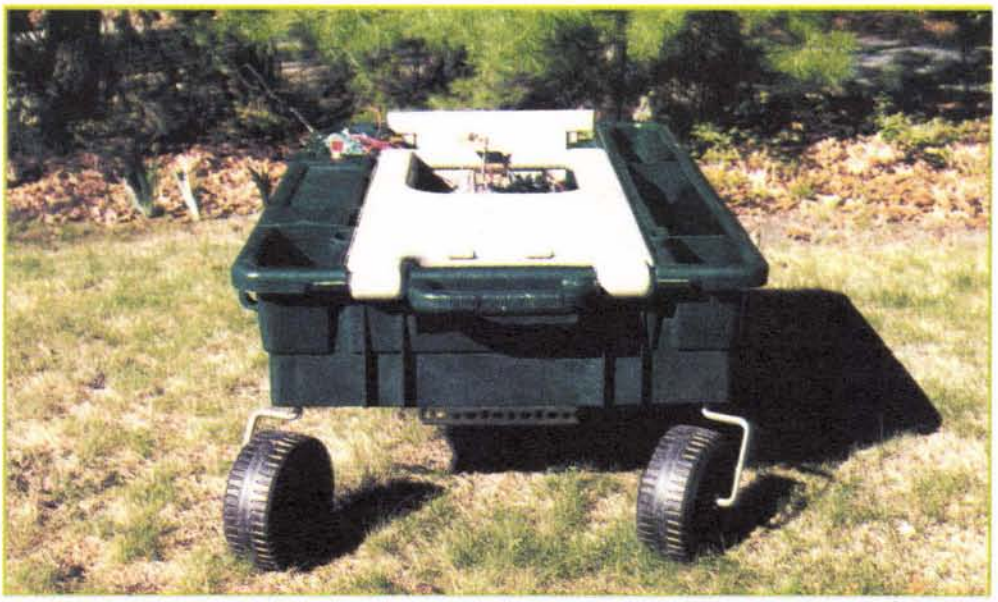


Photo 11 — Front view of the robot showing the current steering mechanism.

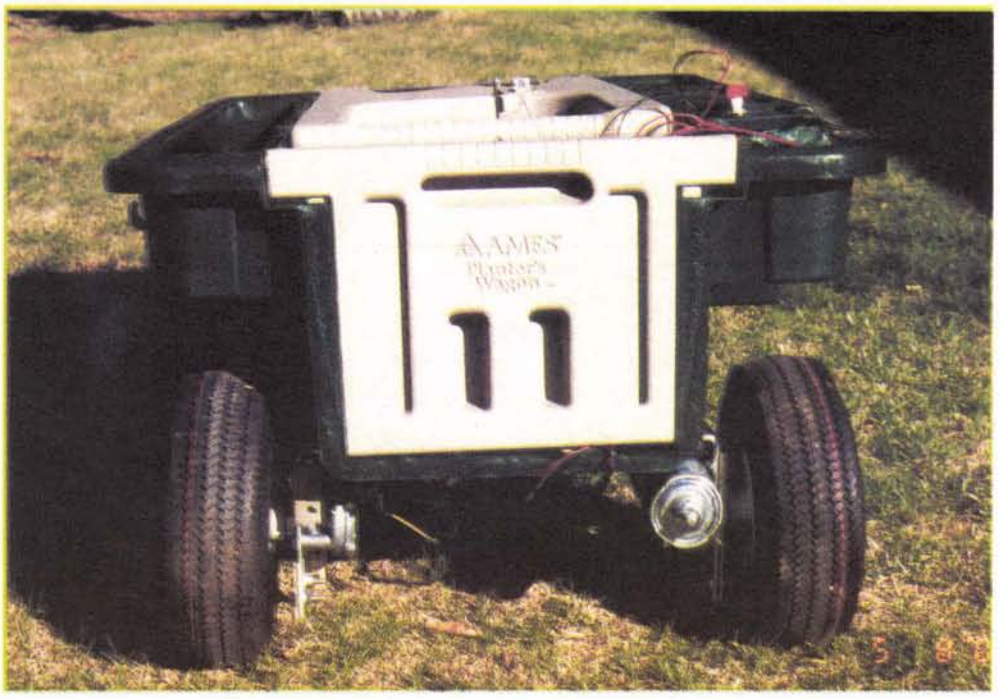


Photo 12 — Rear view of the robot with the back panel in place.

switch the power to the MCIPC-24 motor control board (ON/OFF) and to change the direction of the left motor (clockwise, counter-clockwise) under control of the main GardenBot controller board. The reasons that I decided to use electro-mechanical relays for this project, was to avoid having to purchase a second MCIPC-24 motor control board in order to get independent control of both motors, since it could drive at least two motors without overheating.

Motor Enable Relay Card

The motor enable relay card also seen in Photo 9, is used to independently turn (ON/OFF) either the left motor or the right motor and to change the direction of the right motor (clockwise, counter-clockwise) under control of the main GardenBot controller board. It works in conjunction with the direction and power relay card. Ideally, the functionality of both of these cards should be integrated into a single board, and I am currently working on a new design that does just that.

PIC18C452 Sensor Controller Board

The PIC18C452 sensor controller board, is a board that I recently completed that will be used to read and process all of GardenBot's sensors, thus freeing the main GardenBot controller board from these duties. Its fast processing speed (40 MHz) and its ability to execute floating-point algorithms will be fully utilized to implement advanced robotics behaviors.

The Emergency Stop Button

The red emergency stop button shown in Photo 10 is crucial to the safe operation of the GardenBot. In the event of an emergency or if the batteries run low and cause the controller to become confused, the operator can stop the GardenBot by cutting power to the motors with the button. This red button is lit by a bulb when powered on and is visible even in daylight. I recommend an emergency stop button for any large robotics project. The robot can also be stopped by issuing the stop command via the Sony TV remote.

The Software

The control algorithms are written in PBASIC. They include reading the sensors, sending commands to the various actuators, and performing robotic behavioral algorithms. The basic GardenBot commands are Forward, Reverse, Left, Right, Faster, Slower, and Stop. Other more advanced behaviors to be developed are Avoid, Home, Learn, Follow, Seed, Water, and Fertilize.

The "Avoid" behavior will be used for obstacle avoidance and follows Asimov's first law of robotics. Obstacles include walls, trees, persons, or animals within the scanning range of the sonar and IR sensors. The GardenBot will perform this function by first obtaining sensor readings from the sensor controller board and using them to determine if a collision with an object is imminent or a collision has already taken place, by comparing them to thresholds.

"Follow" is a behavior currently under development which will cause the GardenBot to follow an IR Beacon (IR LED) worn by the gardener as he/she walks around the lawn, much in the way that a pack mule followed the early settlers out west. The IR Beacon can be an LED on a ring, or it may be mounted on a small box worn on the gardener's belt.

"Learn" is an important behavior which is already utilized in the performance of most of the other behaviors. It allows the gardener to teach the GardenBot boundaries and paths for seeding, fertilizing, and watering. It does this by using a joystick control or the Sony IR remote to teach it desired behaviors which are then saved to a serial EEPROM for playback.

Future Software and Hardware Improvements

Field testing on my own lawn has shown that major modifications to the GardenBot's steering are needed, as seen in Photo 11. By adding a rack-and-pinion type mechanism and a powerful RC servo to steer the cart, or by attaching two additional DC motors to the front wheels and using "tank" steering, I may be able to improve its maneuverability on rough terrain.

Currently, the GardenBot performs well, traveling across a level surface, such as the concrete floor

in my basement using either front wheel drive or rear wheel drive.

Another problem exists with the relay cards that can independently switch either motor ON/OFF, but only in one direction at a time. I am currently working on a relay board that requires additional relays to independently switch both the motors and their directions at the same time, so that GardenBot can make tighter turns.

The "Fertilize" and "Seed" functions, which are currently under development, will give the GardenBot the ability to fertilize or seed a lawn using a modified grass seed spreader. Fertilizing or seeding will be carried out using pre-determined patterns, such as straight, serpentine, rectangular, or diagonal rows. A level sensor within the spreader will indicate when its empty and needs to be refilled with grass seed or fertilizer.

I plan to improve the spreader with the addition of a small DC motor which rotates the impeller to control the radius of spreading without depending on the speed of the GardenBot.

Software and hardware upgrades to the GardenBot are necessary to enable it to water small trees and plants with the "Water" command. The GardenBot will follow a predetermined path to water plants using a modified electric squirt gun. Relays and valves need to be added to control the flow of water and to control the water pump or squirt gun. The GardenBot can either carry a large tank in its cargo area or it can drag a light hose around the garden for watering tasks.

Another future software upgrade which will be added soon to the GardenBot controller will replace the Stamp BSX, which is already overburdened with control tasks, with either a Stamp BSP or a PIC18C452 microcontroller. The advantage of using the Stamp BSP is that it does not require hardware modifications, except for I2C connections.

The PIC18C452 will require a new controller board, but it will be able to support algorithms that require floating-point support. The software will be ported from the Stamp BSX to the Stamp BSP or to the PIC 18C452 microcontroller.

All new bus connections to electronic boards and modules will be using an I2C interface, if possible. I plan to use an RF transmitter/receiver (900 MHz) for tele-presence and remote control experiments.

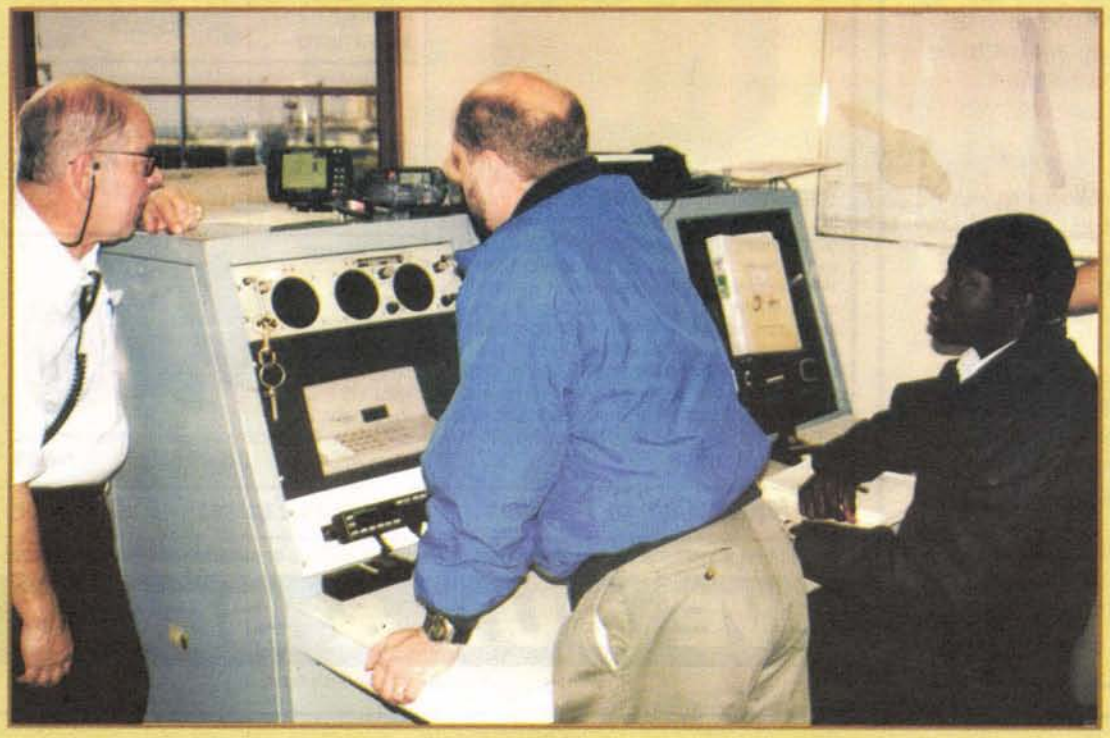
I'm currently integrating a sensor controller board that is based on a Microchip PIC18C452 microcontroller into the GardenBot. By distributing sensor-related processing to the sensor controller board, the robot will be able to react more quickly to its environment. Due to its modular nature, this board may also be integrated into other robot designs. I also plan to integrate the Vector 2X electronic compass and the sensory voice recognition modules into the GardenBot as time permits.

Experimentation with obstacle avoidance techniques such as Virtual Force Fields (VFF) and Vector Field Histograms (VFH) as described in *Sensors for Mobile Robots* [5], will be possible when most of the previously mentioned upgrades are in place. Navigational techniques such as PID Motor Control, Circumnavigation, Triangulation, Trilateration, Odometry, Dead Reckoning, and Beacons described in *Mobile Robots* [4], are yet to be explored with the GardenBot.

Conclusion

Building large robots involves many issues related to safety and performance. Unfortunately, time and article length limitations do not allow me to go into more detail in the robot's construction, in particular, the robot's electronics and software.

These details and the robot's performance in the field could be explored in a future article. I would not recommend that a robot – such as the GardenBot – be used as a toy for small children. At this point, it is basically an experimental platform for carrying out robotics research. **NV**



US Coast Guard Auxiliary's William Scholz testing the VHF DSC distress radio system in Los Angeles Harbor.

AUXILIARY TO COAST GUARD — DSC CHARTING WORKS!

by Gordon West

Coast Guard Station Los Angeles sees VHF DSC position polling first hand during Coast Guard Auxiliary VHF DSC tests.

A marine VHF transceiver, capable of digital selective calling for under $300.00, is offered by Standard Horizon in the 25-watt spectrum. This relatively inexpensive DSC-ready radio meets all of the basic SC-101 DSC recreational radio guidelines, plus some added features that must be seen on a C-Map display to be appreciated.

"Digital selective calling is an essential element of the Global Marine Distress Safety System, promulgated by the International Marine Organization (IMO) which replaces human watch standards on commercial vessels with an automated radio watch," comments William Scholz, Division 3 Communications Officer, United States Coast Guard Auxiliary, 11th District.

"Digital selective calling, while often thought of as a means of issuing an automated Mayday, has many capabilities beyond Mayday," adds Scholz, describing the unique nine-digit number which the vessel owner or operator secures from Boat U.S. for domestic voyaging, or from the Federal Communications Commission (FCC) when cruising beyond local waters.

VHF manufacturers like ICOM, SEA, Standard Horizon, Raytheon, and Ross have all made it relatively clear on how this number is key-entered into their 25-watt VHF marine radio equipment.

It should be noted that mariners not closely reading instructions may inadvertently lock themselves out of this straightforward number assignment because the equipment has built-in safeguards to purposely lock out repeated random number entry.

On Standard Horizon equipment, a concealed jumper plug could allow the dealer to reset the equipment in the field. On ICOM America VHF transceivers, a software upload is required to clear repeated MMSI keystrokes.

We have also discovered Boat U.S. is taking down much more information on the MMSI registration than the FCC, but mariners should only sign up with a single number, either from Boat

A boat's radio room needs a single red button to send a DSC mayday — now they have it!

U.S. or the FCC.

But as Auxiliarist Scholz points out, there is plenty more that the MMSI identified marine VHF transceiver may do than just elicit a Mayday call. The *individual* call would allow you to store other MMSI numbers of friends, clients, and fishing buddies, and to send them an individual DSC call that would take your DSC number and leave it on their DSC transceiver, even if their radio operation was unattended, but the equipment left on. Much like leaving a message on someone's answering machine.

"We take DSC signaling even further with a MMSI number and have the capability of getting a confirmation ring-back between Standard Spectrum radios, even including the other radio's embedded running GPS position," explains Scott Iverson, Standard's technical man who truly knows their equipment inside and out.

"This is called position polling, and one Spectrum user can extract the position of another Spectrum equipment user without the other operator needing to do anything with his Standard Spectrum DSC-ready radio," explains Iverson, busily setting up his equipment for the Coast Guard demonstration at Station Los Angeles in San Pedro, CA Harbor.

Seeing a latitude and longitude in degrees, minutes, and fractions of a minute even gets better with Standard Communication's integrated Spectrum radio and their monochrome or color chart displays — a Standard Spectrum feature is an NMEA position output datastream that would take not only their own position, but any polled position and have it show up on their monochrome or color C-Map cartography driven display. And it was this feature that prompted the United States Coast Guard Auxiliary to conduct a demonstration with the United States Coast Guard Group, Los Angeles, in San Pedro Harbor and outside of the Los Angeles/Long Beach breakwater.

Three U.S. Coast Guard Auxiliary vessels would be equipped temporarily with DSC-capable VHF radios, interfaced with GPS position receivers. Each vessel would be interrogated every few minutes for about one hour while they were underway to determine their position. These vessels could also interrogate each other, and see their position relative to the other equipment they have position polled.

At shore at the United States Coast Guard Group, Los Angeles station, a Standard Spectrum radio and two different chart plotters running C-Map cartography would illustrate repeated position polling, along with an icon of the vessel polled, along with their assigned MMSI number.

"Three sources of equipment assistance were of particular value and, in fact, the test would not have been possible without their help," comments Bill Scholz. "Standards Communications loaned two Horizon Spectrum radios, along with a third unit tied into their two new chart plotters — one color," adds Scholz.

"ICOM America loaned an M502 marine VHF, and all of these radios were pre-tested and their MMSI numbers were entered into their memory," comments Scholz. Each Coast Guard Auxiliary vessel would use its FCC and tactical call signs for shipboard operation, and the coast station was operating under this author's private coast station license at a temporary location, WMD.

On April 11th of this year, all three Coast Guard Auxiliary vessels were dispatched to gen-

A modern powerboat VHF digital selective call console, including both VHF and SSB signalling.

eral locations within 10 miles of Coast Guard Group, Los Angeles station. Vessel Bill, Fish! was directed to proceed out through Angel's Gate, offshore, about one mile from the breakwater, and then turn parallel to the breakwater heading east. Moonlight Express was directed to proceed parallel to the shore within the breakwater, heading east. Sea Kaye III was dispatched out through Angel's Gate and then to take up a heading of approximately 225 degrees magnetic.

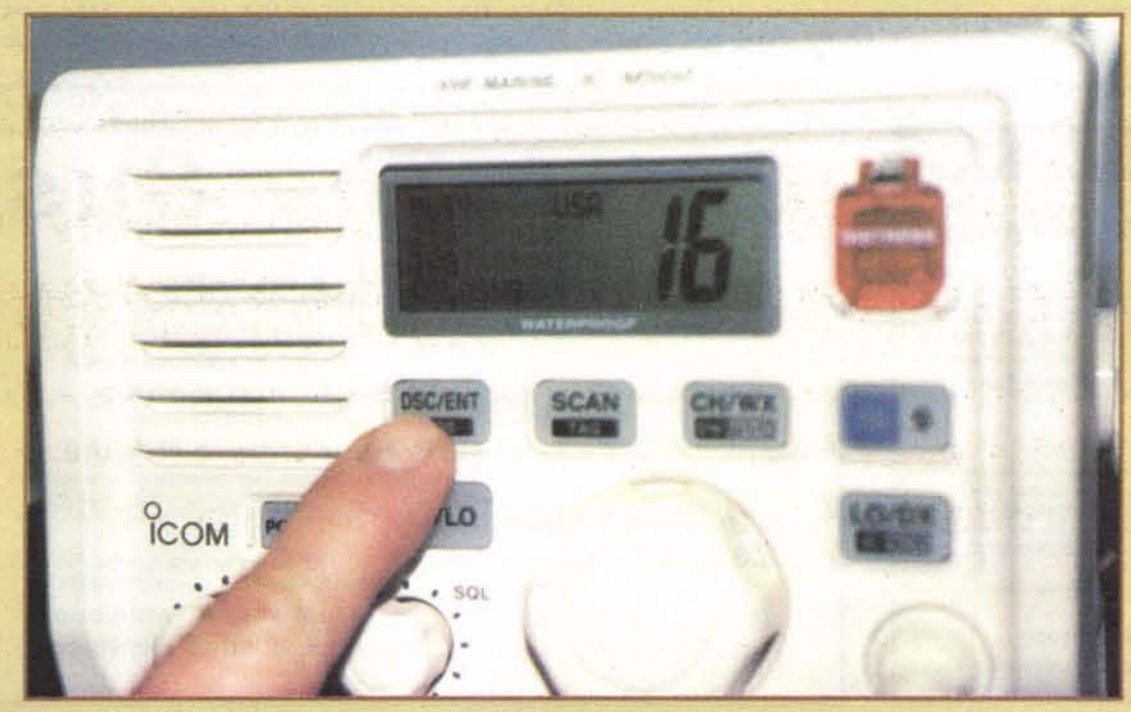
"Beginning with the departure of the vessels from the harbor, the vessel's radios were position polled every three to five minutes, and the results were displayed on one or both Standard chart plotters, and where appropriate track lines were drawn," comments Scholz.

"Moonlight Express was requested to proceed to duck behind the Queen Mary to test reception of position information from a location traditionally difficult to reach via radio from station Los Angeles. The majority of the DSC position polls went through loud and clear," adds Scholz.

It was interesting to watch the reaction of the Coast Guard radio watch personnel as vessel positions began to show up on the screen. The

Boat positions seen graphically on a standard horizon DSC plotter system screen.

The horizon spectrum DSC VHF radio will automatically echo a position polling request.



operation of position polling is relatively easy on the Standard Horizon equipment — push the call key and bring up the position polling box, push the key one more time and select which vessel you want position polled, push the call key one more time, and the radio sends out the DSC databurst on marine VHF Channel 70.

When a Standard Spectrum was polling another Standard Spectrum, the reply was almost instant — the sending radio would receive a reply, and would begin ringing much like a telephone. Simultaneously, the chart plotter was now showing a box with a new updated position, and a couple of keystrokes on the chart plotter would then put the polled vessel's position as an icon and MMSI number on the screen. The actual latitude and longitude would also be kept, automatically, in a position polling log.

On the ICOM transceiver, the operator would manually push a button to send out the position poll information as requested. We were not sure if two ICOM units could actually do this "hands free" as all of the Standard Spectrum units were doing without the other operator needing to do a thing.

It is my opinion that position polling and some of the advanced DSC capabilities among pleasure craft radio may be brand specific, and right now Standard Horizon appears to be the one "pushing the envelope" with capabilities to output any position polled onto their proprietary software built into their C-Map based monochrome or color chart plotters.

While other brands of DSC recreational radio equipment may also have the capability of position polling, Standard Horizon takes the unique step of outputting the polled position NMEA sentence to proprietary software to show a graphic position on their companion C-Map display.

"We proved the viability of VHF DSC position polling for tracking Coast Guard Auxiliary vessels in and around the San Pedro Channel area," comments Scholz.

"Clearly, this test proves the great potential for assisting the maintenance of current and accurate position information without adding to

The ICOM VHF DSC radio must have a button pushed to send back a position request signal.

The big red DSC button will bring a prompt reply to a digital mayday call.

the workload of the coxswain and crew of Auxiliary vessels on patrol. Further, we demonstrated that it is practical with the right kind of training for a U.S. Coast Guard Auxiliary vessel to gather position information directly from a distressed vessel equipped with DSC and GPS, without the need to involve the persons onboard the distressed vessel to push any buttons," finalizes Scholz.

Auxiliarist Scholz reported to Richard Van Leir, DSO-CM, that a good idea would be a training module to be created for Auxiliary coxswains and crew in the correct and effective use of digital selective calling as an on-water tool for distress monitoring and vessel tracking purposes. He envisions the module to be available no later than August, 2001.

PROBLEMS AND IMPROVEMENTS

As the technical advisor for this project, and also a U.S. Coast Guard Auxiliary member and radio instructor (Flotilla 2-7), there are still some improvements that may be made to DSC polling.

I would first like to see complete compatibility between different manufacturer VHF DSC transceivers. Some will automatically return a polled location request, yet others, even hooked up to a running GPS, won't return a position request unless the operator specifically pushes a button. Maybe this is an on-purpose "safeguard" so that someone unknown might figure out where you are automatically.

It would be nice if position polling could be automated where the shoreside station would regularly receive updates on where everyone is without having to individually poll each station. I am told that this idea is not feasible due to international DSC regulations on how stations conduct their digital transmissions on VHF Channel 70. Too many stations all squawking their positions automatically every couple of minutes could certainly clog the network and conceivably cover up a Mayday call. Wouldn't it be nice if an alternate channel would accept automatic DSC position polling without any operator action, much like professional radio automated identification and wireless tracking.

Manufacturers must continue to work closely with the National Marine Electronics Association (NMEA) to define position polled sentence readouts, both from the polled station back to the interrogator, plus the NMEA sentence from the interrogator's VHF to the electronic chart display.

Sometimes the fractions of a minute are abbreviated, sometimes deleted, sometimes rounded off, but ideally would contain three significant numbers to resolve positions down to six feet.

There needs to be better education by everyone to boaters about how a DSC emergency call is relayed. Not everyone in our DSC test (including myself) was absolutely sure how each brand of radio would react when receiving a distress call on VHF Channel 70, and what everyone's individual radio might do to relay that call "down the line."

There are also questions on how recreational SC-101 radios guard Channel 70 for an incoming DSC call. Is this a priority sampling of Channel 70, or a simple quick-scan of Channel 70 that could be interrupted for prolonged periods of time if the radio is open-squelch on another channel, such as the public correspondence frequency? There were also questions on how many times the DSC call may be repeated in a single databurst, just in case a scanning receiver comes up on Channel 70 right in the middle of a DSC call. Unlike the required higher-category DSC equipment on GMDSS-equipped commercial vessels, the recreational DSC radio does not have a dual running receiver. Yet, there is technology to receive signals within the same band on a single receiver, yet on separate frequencies. Amateur radio two-meter transceivers have been doing this for years.

Finally, were the United States Coast Guard personnel looking on impressed with what they saw on the screen? Absolutely, yes. Their most common question was when would their specific station begin receiving any type of DSC equipment to better guard the marine VHF airwaves for an emergency call.

But if local Southern California United States Coast Guard Auxiliary members continue to get recognition and support for their DSC efforts, Southern California may be one of the first areas of the country to rejuvenate the United States Coast Guard Auxiliary's role in providing a life-saving service of monitoring VHF Channel 70 for any incoming DSC routine or emergency calls. If you have a local United States Coast Guard Auxiliary flotilla in your area that may be looking for information about this important demonstration-test in Southern California, they should contact William Scholz, United States Coast Guard Auxiliary, SO3-CM, e-mail w1hijcw@aol.com. Appreciation to Scott Iverson of Standard Communications for the loan of the equipment, and to Richard Van Leir, DSO-CM, for supporting probably the very first test in the United States with the United States Coast Guard Auxiliary and the United States Coast Guard radio station for digital selective calling emergency, position polling, and a fascinating chart display to all responding DSC-equipped stations. **NV**

Build a Simple Infrared Illuminator

by Fernando Garcia

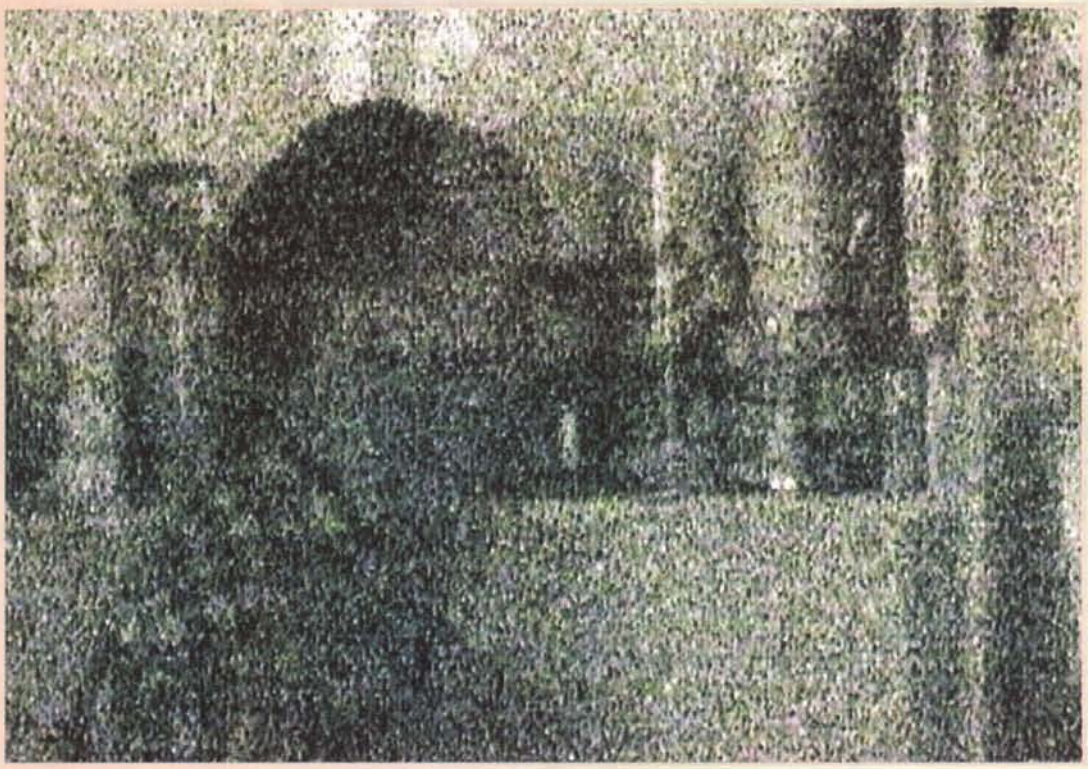


Photo 1: Un-retouched photo taken in almost complete darkness.

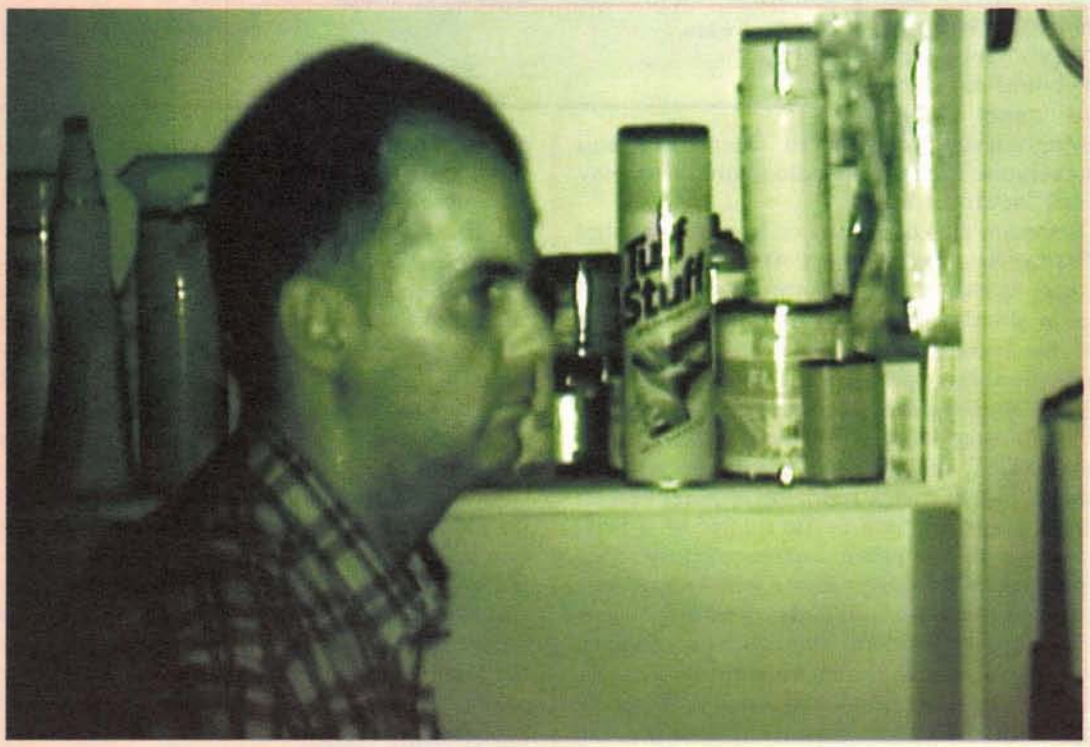


Photo 2: Same environment, but with the IR illluminator turned on. For the person, it still was almost complete darkness.

Video cameras have both shrunk their size and reduced their cost thanks to CCD (Charge Coupled Device) technology. Applications previously considered beyond the reach of the average person are now easily accessible.

One of the most fascinating applications is the capability to see in the dark. From surveillance systems to wildlife observation, nighttime conditions offer very exciting viewing conditions.

Actually "seeing in the dark" is a misnomer. Although newer CCD cameras can see to illumination levels below 1 lux, there still must be some sort of radiated energy for the camera to see. The good news is that we need not constrain ourselves to visible light radiation, most B/W and a few color CCD cameras are also sensitive to IR (infrared) radiation.

Therefore, we can illuminate an area with IR light, while maintaining the darkened condition (from the eye's perspective), but allowing the camera to "see in the dark." The project described here is a simple-to-build, battery-powered IR illuminator that will allow precisely that.

From surveillance systems to wildlife observation, nighttime conditions offer very exciting viewing conditions.

Infrared light is that part of the spectrum whose wavelength is between about 700 nanometers (red color) to about 100 micrometers (microwaves). The longer wavelength limits are known as far-infrared and is what we perceive as heat. Although sensors do exist that allow to actually detect heat (for true, see-in-the-dark capabilities), the low-cost cameras and IR LEDs operate in the near-infrared range. This range is just below the color red to about 1,500 nanometers. This project operates in the near-infrared range.

A stunning result of what this project can achieve is shown in Photos 1 and 2. Photo 1 shows the video output of a camera operating under very low light conditions. The extremely noisy picture shows a shadow moving into a garage area. There is no doubt that somebody is lurking there, but the complete lack of detail does not allow you to determine whether the person is a friend or not. Photo 2 – under the exact same darkened conditions, but with the IR illuminator turned on – now shows up substantially clearer. Although the picture is still grainy, the detail is enough to allow reading of some labels and to see the person which happened to be (fortunately!) a friend.

Before you attempt to build this project, a simple experiment is recommended to determine whether your video camera is IR-compatible or not. In a darkened room, illuminate a small area with the IR light coming from your TV or VCR's

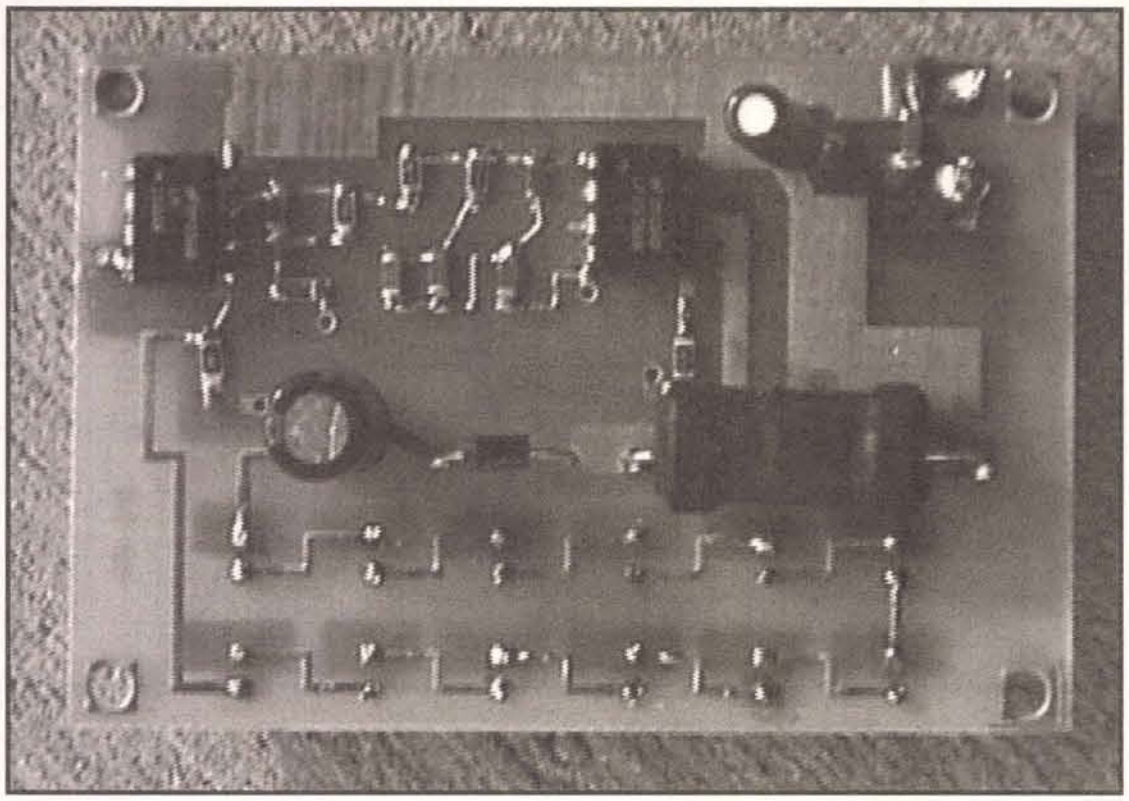


Photo 3: Assembled board, component side.

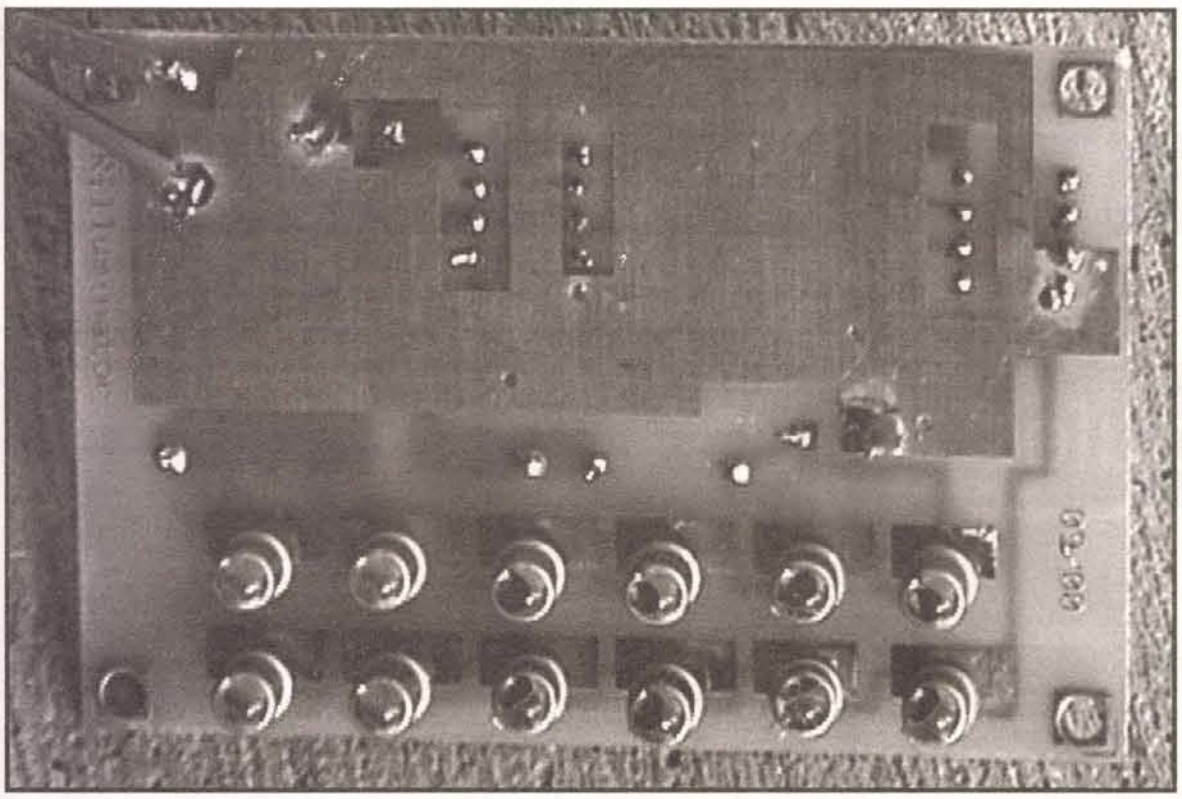


Photo 4: Assembled board, solder side. Note the IR LEDs.

remote control. These devices employ IR LEDs to transmit signals, and if you can see the flashing light through the viewfinder, then the camera is suitable for this project.

Circuit Description

LEDs are current-driven devices, and therefore cannot be connected across a voltage source – like a battery – without some current limiting device. In its simplest form, this is a resistor.

Although a very inexpensive solution, it suffers the drawbacks of poor current regulation with a varying input voltage and the waste of a large amount of energy. This is important if we plan the circuit to be portable, meaning batteries will supply the power.

A linear regulator in a constant current mode would avoid the current variations but is also very wasteful, dissipating most of the battery's power as heat. Therefore, a switch mode regulator was chosen for this project. The circuit described here maintains a 1% current regulation over an input range of 9 to 14 volts, while still maintaining 87% efficiency.

The selected switch mode regulator is the LM3578, part of National Semiconductor's Simple Switcher® family. The devices in this family are extremely versatile and easy to use, and all include a flexible PWM controller and a transistor power switch integrated within the same silicon die. Only a few passive components are required to build a complete supply.

Unlike its cousins with fixed frequencies, the LM3578 regulator (U1) allows the switching frequency to be set externally. As shown in the schematic of Figure 1, this is achieved with capacitor C2 for a frequency in the neighborhood of 80 kHz. This versatile device also permits the power transistor switch to be connected in a variety of configurations. In this circuit, the device is connected as a boost topology. The boost topology always produces an output voltage higher than the input.

This is required because the series-connected string of IR-LEDs (D2 through D13) will have a combined voltage drop between 17.5 and 20 volts – a voltage larger than the battery voltage range for which we expect the circuit to work.

The boost converter works by storing energy on inductor L1 during the power switch "on" time, and then releasing it in series with the battery during the "off" time by means of Schottky diode D1. The energy

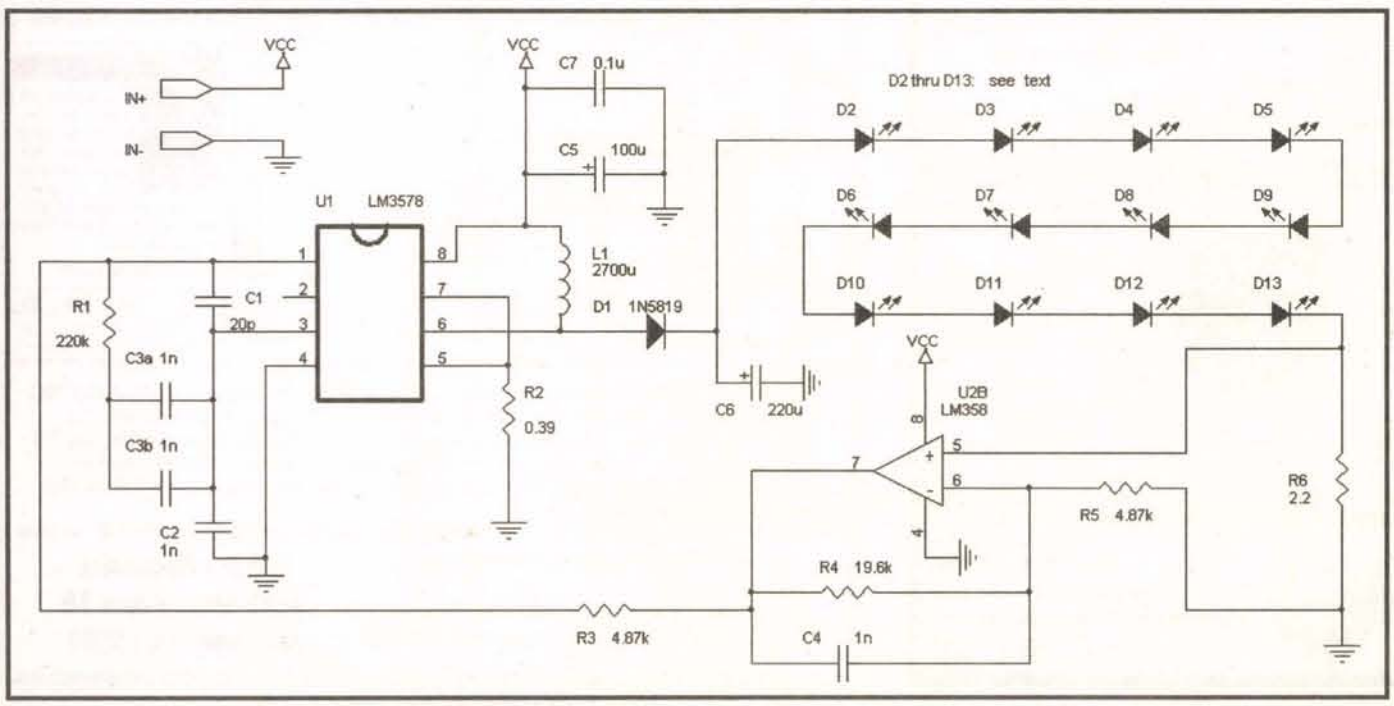


Figure 1: Project Schematic. U1 is a "Simple Switcher" from National.

pulses are delivered to capacitor C6 which smoothes out the voltage. To prevent damage during an overload condition, resistor R2 senses the current across the switch, and disables the circuit if its voltage drop exceeds 110 millivolt. C1, R1, C3, and R3 are a loop compensation network required for stability.

So far, all the above description has been textbook circuitry right from National's data sheet. What is different in this application is the feedback circuit. As previously mentioned, for a LED load, we require a constant current regulator. Therefore, we need to take a LED current sample, which is accomplished by R6.

To maintain a high efficiency, the voltage drop across R6 should be a small fraction of the total LED voltage drop. Unfortunately, U1 requires a feedback level of around one volt, which would mean a 5% to 6% efficiency penalty in the current sense resistor. Therefore, operational amplifier U2 and resistors R4, R5 provide the necessary voltage gain of around five to employ a much smaller current sense resistor. Capacitor C4 provides high frequency roll-off to prevent switching noise feeding into the feedback loop.

With the values shown, the LED current is regulated to approximately 90 milliamps. The higher the current, the brighter the LED will shine, but we must be careful not to exceed the maximum steady state current rating of 100 milliamp. The chosen current level provides a safety margin while maximizing the light output.

A few words about IR LEDs: There are two commonly available families of IR LEDs, depending on its peak wavelength and semiconductor material. This is shown in Figure 2. The AlGaAs devices usually have a peak spectral response around 880 nanometers. On the other hand, GaAs devices have a peak response around 940 nanometers.

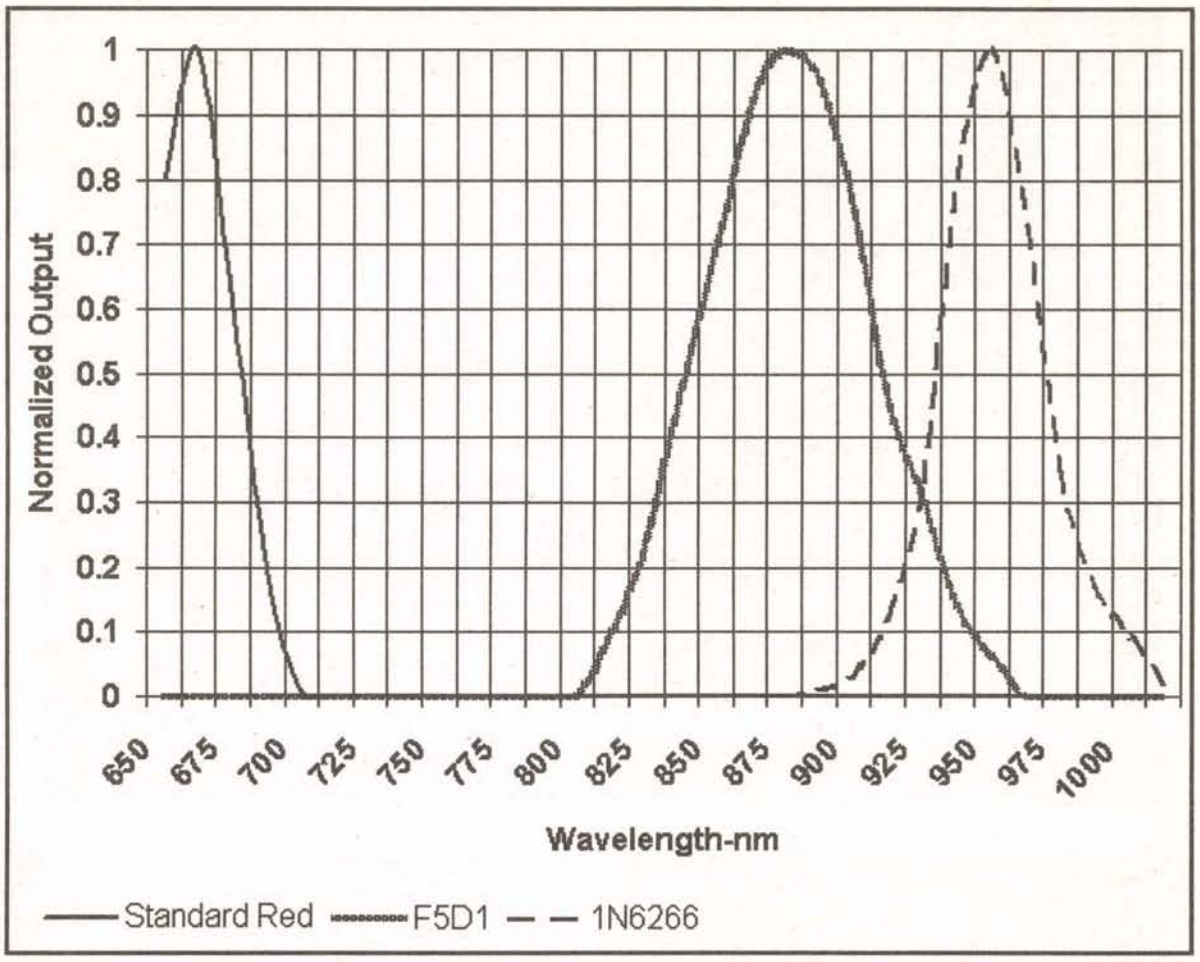


Figure 2: Infrared LED response. A standard red LED response is shown as a reference.

The response of a 660 nanometer, "standard" red LED is shown for comparison purposes. In general, the longer wavelength LED devices are

more efficient in converting current into light. Therefore, a 940 nm device such as the 1N6266 would provide greater illumination capability than the 880 nm device such as the F5D1. The caveat could be if the camera's response has decreased excessively at this wavelength, which may offset any LED efficiency improvement.

Since the LEDs will be the highest cost in this project, it pays to procure one of each type, wire both in series and, with your camera, determine which one appears the brightest.

Assembling the Circuit

Due to the fast risetime of the switching waveforms, it is almost mandatory to use a printed circuit board for this project, with wide traces and good ground planes. A double-sided sample board used by the author is shown in Figure 3.

With the exception of the LEDs, all the components go on the top side of the board, as shown in the silkscreen. Most of the devices employed in this project are surface mount technology (SMT) components for several good reasons: not only do they allow a more compact layout, but for a high frequency switching circuit, they have far fewer parasitics.

A few thru-hole components are also employed. A view of the board's top side is shown in Photo 3. The LEDs are mounted on the bottom side of the board, as close as possible to the board itself without actually touching it. The reason being that at the high operating current, the LED themselves will become fairly warm, and the board's copper lands act as a small heatsink, see Photo 4. However, do not solder the LEDs flush to the board, leave about 1/16-inch spacing between the board and the LEDs themselves.

First, it will allow some play such that you can slightly aim the beams. Second and most important, the LED anode is electrically connected to the metallic case, and if the case touches the cathode pad, no damage will occur, but that LED will not light up. And since it emits invisible light, you will not notice!!

The specified LEDs have a built-in lens, which solves one of the more vexing problems facing the assembler of the circuit; namely how to focus a beam of infrared light. The lens focuses each individual beam in a fairly narrow angle, and thus the complete LED array will illuminate an area similar to what a three-inch reflector flashlight would do. As mentioned previously, the LED spacing will allow some alignment of the beam.

One word of caution: To maximize efficiency, the circuit does not include reverse-battery protection. Connecting it to the wrong polarity will certainly damage the circuit. If you require reverse polarity protection, include a Schottky diode such as a 1N5817 in series with the (+) input lead. **NV**

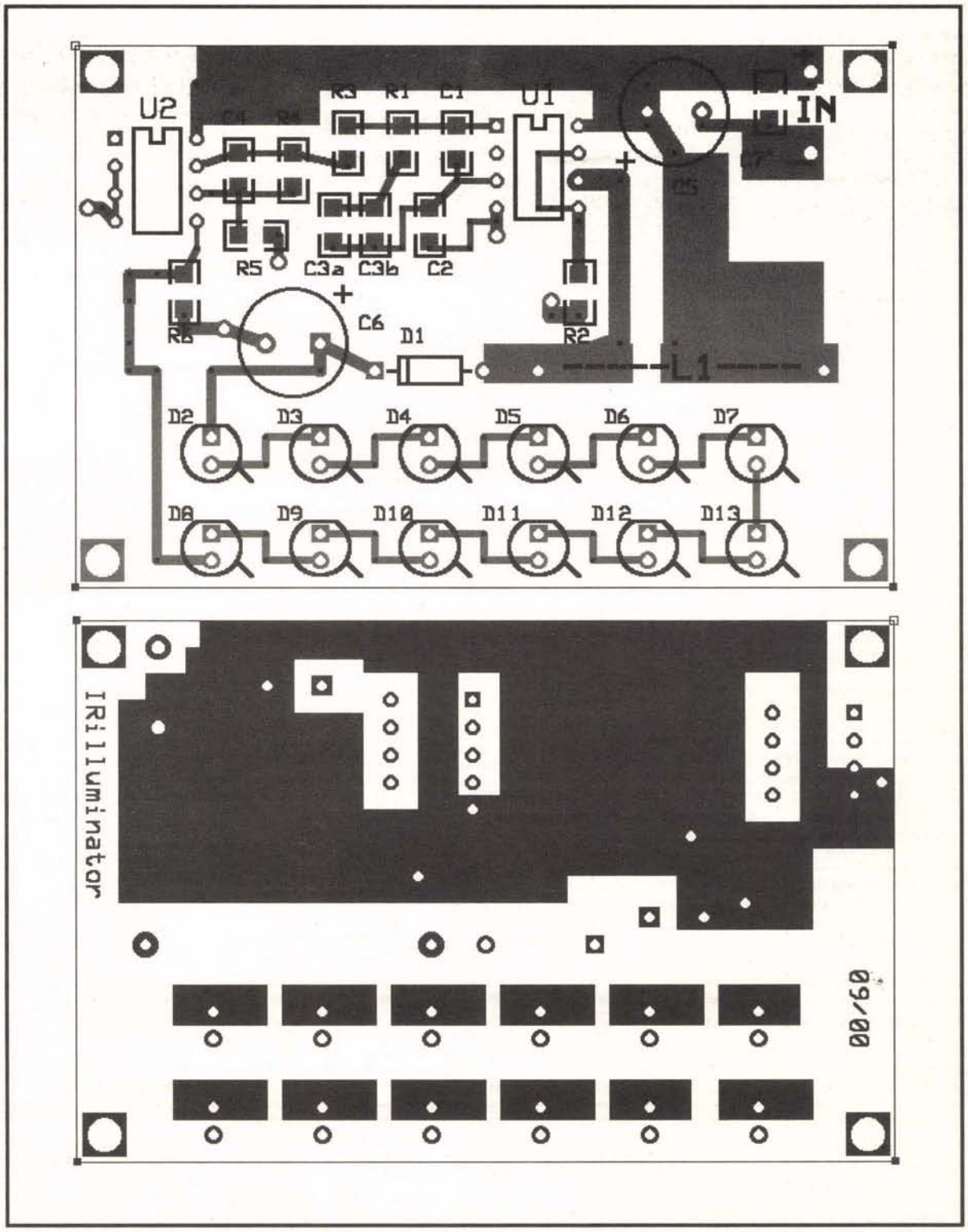


Figure 3: Double-sided board layout. Component side (top), and solder side (bottom). The IR LEDs are placed on the solder side, see Photo 4.

Parts List

Semiconductors:

U1	LM3578N switchmode regulator
U2	LM358 op amp
D1	1N5819 Schottky diode
D2 - D13	1N6266 or F5D1 Infrared LED (see text)

Resistors (1206 size SMT, 1%)

R1	220k ohm
R2	0.39 ohm
R3, R5	4.87k ohm
R4	19.6k ohm
R6	2.2 ohm

Capacitors

C1	20 pF, 5% ceramic 1206 size SMT
C2, C3a, C3b, C4	1 nF, 5% ceramic 1206 size SMT
C5	100 uF, 16V electrolytic
C6	220 uF, 25V low-Z electrolytic
C7	0.1 uF 20% ceramic

Miscellaneous

L1	2700 uH, 500 mA inductor

Wire, PC board, 12-volt (nominal) battery

Continued from page 42

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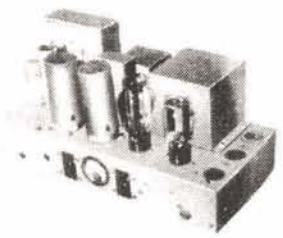

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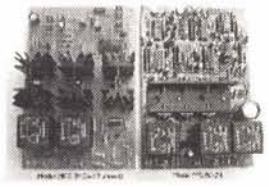

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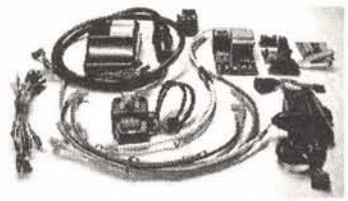

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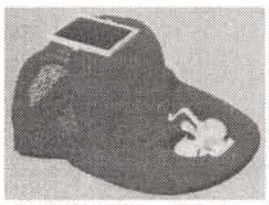

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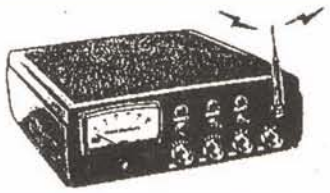

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Continued from page 24

need this function though, since our Stamp programs designed for Stamp Plot Lite will probably send binary data.

If we go back to **ProcessBuffe,r** we see that if the first character of our buffer is "%" then the data is extracted and converted to a numeric value with the function **Bin2Dec**. For this program, we could probably get away without the conversion, but by doing it, we give ourselves the opportunity to process and manipulate the data before sending it to the display.

To see the VB program in action, we need to load our Stamp with the demo program that comes with Stamp Plot Lite (you'll find it in the Help file). Run the Stamp, then start the VB program. If you have a newer BSAC or used the circuit in Figure 1, the VB program can reset the Stamp when the comm port is opened. To do this, we need to leave the "Reset Stamp on Connection" option of the Port menu checked.

If the Stamp's ATN is opened after programming (by removing a jumper), then we'll have to manually reset the Stamp after the VB program is started and the comm port opened. Once this happens, we'll see the analog graph parameters set-up (span is set from 0 to 600) and data will start coming in. Figure 5 shows the VB program in action.

This Is Cool – Let's Do More!

Okay, we will. Next month, we'll extend our Stamp program by allowing it to receive requests for information. This will allow us to "ask" for the information with a simple terminal program or a custom program that we'll write in VB, which will give us more precise control over when we get information and what we actually get. Finally, we'll update our Stamp program to receive data with a command. Again, this program will be compatible with a text terminal or a custom program and opens up all kinds of possibilities.

Until then, Happy Stamping. **NV**

```
' Nuts & Volts - Stamp Applications
' July 2000 (Listing 2)

'
'================================================================
' Program... StampToPC.vbp
' Author.... Jon Williams
' Started... 26 MAY 2000
' Updated... 26 MAY 2000
'
'================================================================

Option Explicit

Dim showData As Boolean                 ' okay to show incoming data
Dim rxBuffer As String                  ' buffer for incoming characters
Dim multiplier As Single                ' analog multiplier

Private Sub Form_Load()

  ' center form
  Me.Left = (Screen.Width - Me.Width) / 2
  Me.Top = (Screen.Height - Me.Height) / 2
  Me.Caption = App.Title

  ' setup comm object
  With MSComm1
    .CommPort = 1
    .Settings = "9600,N,8,1"            ' setup for DEBUG
    .DTREnable = mnuPortResetStamp.Checked
    .RThreshold = 1                     ' process one char at a time
    .InputLen = 1
    .InputMode = comInputModeText       ' input will be strings
  End With

  multiplier = 1#                       ' analog multiplier
  SetSpan ("0,100")                     ' set span of progress bar
  ClearForm
  showData = False                      ' wait for reset

End Sub

Private Sub Form_Unload(Cancel As Integer)

  If MSComm1.PortOpen Then MSComm1.PortOpen = False

End Sub

Private Sub mnuFileExt_Click()

  Unload Me

End Sub

Private Sub mnuPortComX_Click(Index As Integer)

  ' deselect last port
  mnuPortComX(MSComm1.CommPort).Checked = False
  ' select new
  MSComm1.CommPort = Index
  mnuPortComX(Index).Checked = True

End Sub

Private Sub mnuPortConnect_Click()

  Dim x As Byte

  If Not (MSComm1.PortOpen) Then
    ' open the port
    On Error GoTo PortError
    MSComm1.PortOpen = True
    ' update the title bar
    Me.Caption = App.Title & " [Connected]"
    ' update port menu
    For x = 1 To 4
      mnuPortComX(x).Enabled = False
    Next
    mnuPortConnect.Caption = "&Disconnect"
  Else
    ' close the port
    MSComm1.PortOpen = False
    ' update the title bar
    Me.Caption = App.Title
    ' update port menu
    For x = 1 To 4
      mnuPortComX(x).Enabled = True
    Next
    mnuPortConnect.Caption = "&Connect"
  End If
  Exit Sub

PortError:
  MsgBox "Could not open Com" & Trim(Str(MSComm1.CommPort)) & ". " & _
         vbCr & "Please select another port.", _
         vbExclamation + vbOKOnly, App.Title

  On Error GoTo 0

End Sub

Private Sub mnuPortResetStamp_Click()

  mnuPortResetStamp.Checked = Not (mnuPortResetStamp.Checked)
  MSComm1.DTREnable = mnuPortResetStamp.Checked

End Sub

Private Sub MSComm1_OnComm()

  Dim newChar As String

  Select Case MSComm1.CommEvent
    Case comEvReceive
      newChar = MSComm1.Input
      If newChar = Chr(13) Then
        ProcessBuffer (rxBuffer)
        rxBuffer = ""
      Else
        rxBuffer = rxBuffer & newChar
      End If

    ' process other events here

  End Select

End Sub

Private Sub ProcessBuffer(ByVal strBuffer As String)

  Dim leadChar As String
  Dim param As String

  ' get leading character
  leadChar = Mid(strBuffer, 1, 1)

  Select Case leadChar
    Case "!"
      ' command string
      DoCommand (strBuffer)
    Case "%"
      ' binary data
      param = Trim(Mid(strBuffer, 2))
      If showData Then ShowDigital (Bin2Dec(param))
    Case Else
      If IsNumeric(strBuffer) Then
        ' buffer has analog data
        If showData Then ShowAnalog (CLng(strBuffer))
      Else
        ' buffer contains message
        sbarMessage.SimpleText = Trim(strBuffer)
      End If
  End Select

End Sub

Private Function DoCommand(ByVal theCommand As String)

  Dim delimPos As Integer
  Dim cmd As String
  Dim param As String

  ' remove any leading or trailing spaces
  theCommand = Trim(theCommand)

  delimPos = InStr(1, theCommand, " ")
  If delimPos = 0 Then
    ' no parameter(s)
```

Continued on page73

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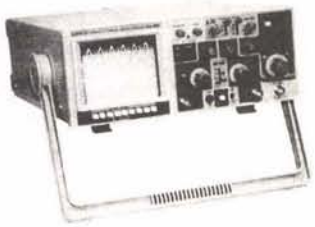

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Questions & Answers
TECH FORUM

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Want to get a jump on things before the magazine arrives? The Tech Forum questions are posted on our website on or before the first of each month. Unanswered questions from recent issues are there also.

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

QUESTIONS

I am trying to control a standard IDE CD-ROM drive with a Xilinx XC4000XL FPGA.

I would like to run the digital output of the drive to an outboard DAC and build an interface through the FPGA as a project for a digital design class at school. I'm having problems finding audio-specific specifications for communicating with the drive.

I'm sure that there are specific commands to download the table of contents, play tracks, stop, eject, etc.

7011 **Mike Lowey**
San Pablo, CA

I have a PIC programmer, an Epic Plus from microEngineering Labs that's attached to my computer's LPT1 port. When the machine boots up, the BIOS sends data to the base address (presumably as a test to see if the port is really there).

The bits turn on my programmer in the worst way: The drivers are enabled and, if I forget to unplug the "wall-wart" supply, the regulators get very hot after awhile. I want to turn off the programmer automatically.

I need a way to write $0C to the base address ($0378) at bootup. I tried sending out the data using the ECHO command in the Autoexec.bat file, but because the programmer does not respond with the ACK bit, all I get is a Write Fault Error for LPT1. There's no intelligence on this programmer at all; it just sits there and does its thing.

Short of writing a BASIC program and compiling it into .exe code, I don't know how to send $0C to the base address. Any ideas?

7012 **Jeff Kerner**
via Internet

I am trying to repair a guitar amplifier by Gorilla Musical and need to find a company that carries the TDA2030 amp circuit, that also has a reasonal minimal order. Or does someone know of a substitute part?

7013 **Verl Wooters**
Centralia, IL

ANSWERS

ANSWER TO #6019 - JUNE 2001

I'm using a 120 VAC screwjack drawing 2.1 amps no load to open and close a large heavy door.

I need a circuit that will monitor the motor's current draw, so if someone or something gets in the path of the moving door, it will give me a high output so I can have the door reverse direction.

Your approach must be to guard the path of the door and not to monitor the motor current. Your door can crush a child or injure an adult long before you can sense the motor current, interpret it, and reverse the direction of the moving door. As a matter of fact, today all garage door openers must have — in addition to the automatic reverse direction mechanism — some sort of optical sensor.

The optical sensor consists of an infrared emitter and detector mounted a couple of inches above the ground across the opening of the door. Any object blocking the path of the infrared beam will prevent the door from operating or reversing it, once it has already started moving.

Most good hardware and home center stores sell these sensor kits, which are specifically designed to retrofit old garage door openers without the sensor.

Haim Sandel
Phoenix, AZ

ANSWER TO #6011 - JUNE 2001

I'm interested in purchasing a device which can be connected to a phone socket (U.K. frequency). I will block the pulses to the telephone exchanges computer (and enable me to make outgoing calls).

For incoming calls that you want to "block," about all you can do on your end is disconnect the ringer in your phone.

There really is no way to block incoming calls without some kind of cooperation by the central office.

On the other hand, if it's outgoing calls that you want to inhibit, the device you need is called a "call restrictor," and is available in kit form from *Nuts & Volts* advertiser, **Weeder Technologies** at **(850) 863-5723** or **www.weedtech.com**.

This device is designed for US standard touchtone frequencies, but since all the tone decoding is handled by a MC145436 tone decoder chip, the circuit could be adapted to some other tone dialing system provided that uses no more than 16 dial buttons.

Jack Dennon
Warrenton, OR

ANSWER TO #4013 - APR. 2001

I have an Arrick Robotics stepper motor (two motor) controller for #23 steppers. I would like to adapt it for use with steppers of different voltage and current. Can an outboard circuit be devised to do this with minimal complexity? I would appreciate any help. I have found NO INFO in any source for this.

Just use each output of your controller to control an outboard transistor selected to handle the voltage, current, and switching speed you want to use. Of course, the transistors will have to be tied to an appropriate power supply and the outputs of the transistors will have connected to the new motor.

It might be necessary for you to use opto couplers between the controller outputs and the transistors in order to isolate and protect the controller from the higher voltages applied to the transistors.

The optocouplers should also be selected for fast switching speed. Slower switching speeds in the transistors or the optos may lead to excess heating and/or operating the transistors outside their safe operating range.

Tom Tillander
Bay Village, OH

ANSWER TO #6017 - JUNE 2001

What is the proper operating voltage of my Uniden BC2500XLT scanner. The charge voltage is 12

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail or we can not send payment.
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- The question number and a short summary of the original question will be printed above the answer.
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QUESTION INFO

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All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and email. Only your name, city, and state will be published with the question, but we may need to contact you.

TECH FORUM

ANSWERS TO #6018 - JUNE 2001

I have about 600 stereo LP records many of which I love and would like to keep. Because I like them, I used them a lot and they have dust "clicks and pops" on them, most of which won't clean out.

About 1978 or 1980, a friend who was an audio freak had a "black box" that would take out the clicks and pops from dirt and scratches. It seemed to be able to "hear" a "pop" coming and replace that fraction of a second with the previous good note by extending it for a fraction of a second. That was way before digital buffers and other delay type circuits that are common place now.

Have you heard of any program or black box that I could play my LPs through to clean up the sound before (or while) I transfer them to CDs. Perhaps, I could just play them through the device to listen to them without having to transfer to a CD.

#1 The program Spin Doctor does exactly what you want, and it does an excellent job! It used to be sold by Adaptec, but is now sold by **Roxio (www.roxio.com, 866-280-7694)**.

Spin Doctor is available only as part of the program Easy CD Creator, currently $100.00 less a $20.00 rebate.

Although the purpose of Easy CD Creator is to burn CDs, Spin Doctor can clean up your disc recordings even if your PC doesn't have a CD-R or CD-RW drive.

Connect the output of your stereo turntable to the stereo line input of your sound card. If your turntable has a magnetic cartridge, you'll probably need a preamplifier; RadioShack can special order #970-1018 for you for $25.00.

In that case, connect the output of your turntable to the input of the preamp, and the output of the preamp to the line input of your sound card. If your turntable has a piezoelectric cartridge or a built-in preamp, you won't need to order a preamp.

You run Spin Doctor in three easy steps. First, select the source: "LP through sound card." Second, click Options and click on the bathtub icon to remove clicks and pops from your recordings. Finally, select the directory where you want your WAV files to appear, and click "Record to Disk."

You can then enjoy the music on your computer, minus the clicks and pops. Of course, if you have a CD-R drive, you can transfer the music to CDs with Easy CD Creator.

Spin Doctor can also remove most of the hiss from tape recordings, and I've even used it to improve very old 78-RPM recordings!

You'll really enjoy using the power of your computer to give new life to your entire music collection!

John J. Herro
Palm Bay, FL

#2 There is an excellent program for transferring LP and taped audio collections to digital format — removing pops, clicks, and other undesirable transients — called Wave Corrector from Ganymede Test & Measurement.

Support can be obtained via their website at: **www.ganymede.hemscott.net**.

Here you will find the latest version of Wave Corrector together with FAQs, bug reports, and information regarding future releases.

Wave Corrector is developed by: **Ganymede Test & Measurement**, 8 Hillman Close., Uxbridge, Middlesex, UB8 1QA, United Kingdom.

Email: **ganymede@hemscott.net**.

I have used this software with excellent results.

Mike Sheridan
Manitowoc, WI

TO #6018 - JUNE 2001

#3 The black box you are referring to is probably a Garrard Model MRM101, music recovery module. It shuts off the signal during the noise spikes, however, it will not remove the frying sounds from dirty or worn recordings.

I'd use software from "DART" for what you are doing, and the results can be spectacular. The software is somewhat pricey, but well worth the initial outlay.

David M. DeAlba
Chin Valley, AZ

#4 Check out **www.steinberg.net**. They have a product called Clean that will do what you require. In fact, there are two versions, one software-based, which is good, and one hardware-based, called Clean plus! which is excellent.

The hardware in Clean plus! is actually a phono preamp, specially designed to boost phono output signals to the higher digital sound card input levels.

Chris Edstrom
via Internet

#5 One answer to Robert Gardner's requirement to remove pops and clicks from LP records is the program Cooledit 2000 supplied on line from **www.syntrillium.com** for $69.00.

I recently acquired this program for the very reason of converting LP records to store on CD. The program contains a plug-in devoted to removing clicks and pops and it really works.

The Cooledit 2000 program provides a visual display of program material so you can see the before and after effect of any filtering, noise reduction, or special effects, after they have been applied. The options are very impressive and work smoothly and I find the program easy and intuitive.

There are suggestions on the web site for a "black box" as suggested. Most sound cards have some control over input level and output level and it's just a matter of obtaining the correct connector/adaptor plugs to take the output of the turntable and adapting it to the input of the sound card. There is usually a pair of RCA phono plug females at one end and a 2.5mm or 3.5mm stereo plug to connect to the sound card input.

Of course, a computer is required, and the LP record may be stored as a wav file then converted to MP3 where the compressed format is 10:1 and storage reduced markedly.

Syntrillium has more advanced software if this is needed.

Ralph Cameron
via Internet

#6 The program you want is Easy CD Creator. This is now sold by **Roxio www.roxio.com/en/products/ecdc/**. Note that your results will be limited by the quality of your computer's sound card, so while the software will do what you want, you still need to take care of the analog part of the system.

Don't forget that the cables from your preamp to your computer sound card are part of the analog system, so shorter is better. Also, be sure your computer is fast enough to support the sound card you are planning to buy.

Mike Beaver
Los Altos, CA

#7 One product that did that was made by a company named SAE, and was called the SAE 5000 Impulse Noise Reduction System. IIRC, it used a "bucket-brigade" device to "patch in" a bit of the sound before the pop or click. I did a quick net search and found a few for sale, including two on Ebay. I have one that I could part with as well, as I don't listen to LPs any more. As I recall, it worked fairly well.

If you want to go the CD route, I'd suggest a good sound card. The one that comes with the PC is *not* a good sound card, the line-level inputs tend to be particularly bad. I've had good luck with a Turtle Beach Montego II. You'll also want some editing software; I used Gold Wave **www.goldwave.com** for some editing I did awhile back, and it worked very well. They claim to have noise reduction and pop and click filtering, but I've never used that feature. You'd also need a CD burner.

Frankly, I think you're better off with the SAE box. My guess is that you're talking about at least an hour of work per LP to get it onto a CD (depending on how much editing you do), and my guess is you aren't looking for a 600 hour project. It would, however, allow you to preserve the recordings.

Eric Gunnerson
via Internet

VDC, either from a car battery or a 12-volt wall wart. There are five 1.2 VDC batteries contained in the battery pack that add up to 6 VDC. I'm not sure if the radio operates on 6 or 12 volts.

I don't know the purpose of the small circuit card inside the battery pack. Is it a voltage requlator or does it convert 12 VDC into 6 VDC for battery charging or radio operation?

Your scanner definitely operates on 6 VDC, which is also your battery voltage. To charge a battery, the charger output voltage has to always be higher than the battery voltage. In your case, the charger output voltage is 12 VDC, which is for charging your battery and not for operating your scanner.

The small circuit board inside the battery pack you are talking about is the battery charging circuit.

Haim Sandel
Phoenix, AZ

ANSWER TO #4012 - APR. 2001

I'm looking for some Visual Basic codes which would allow me to use a computer's sound card to decode DTMF for incorporation in a computer-based amateur radio repeater controller program.

I'm looking to do the decoding with the computer itself rather than an outboard decoder such as a Stamp.

One way to determine the frequency components of an analog signal, such as a DTMF code, is to sample the signal and apply an algorithm called a Fast Fourier Transform (FFT) to the sampled data.

The FFT algorithm output contains a series of numbers. The numbers are representative of the amplitude of the frequency components of the signal.

For a DTMF signal, two of the numbers will be larger than the others, numbers representative of the beat frequencies of tones will be somewhat smaller.

The amount of numbers in the series is dependent on the number of samples analyzed. The frequen-

TECH FORUM

ANSWERS TO #6012 - JUNE 2001

I'm in need of the pinout of an MM58167AN microprocessor real-time clock.

#1 The MM58167AN application data sheet (18 pages) can be found at the National Semi web site. The URL to the data sheet is www.national.com/an/AN/AN-353.pdf. This document shows the IC's pinout and provides extensive information on how to use the chip.

T. Black
Folsom, CA

#2 From the National Semiconductor data sheet: "The MM58167 is a low threshold metal-gate CMOS circuit that functions as a real-time clock calendar in bus-oriented microprocessor systems."

Here is the pinout:

CS* chip select	1	24	Vdd = 4.0 to 5.5 Vdc
RD* read	2	23	PowerDown*
WR* write	3	22	D7
RDY ready	4	21	D6
A0	5	20	D5
A1	6	19	D4
A2	7	18	D3
A3	8	17	D2
A4	9	16	D1
Osc in	10	15	D0
Osc out	11	14	Standby Interrupt output*
Vss	12	13	Interrupt output

* active low

Oscillator is designed for 32.768 KHz crystal with each side by-passed to ground through 20pf.

Address codes and functions

A4	A3	A2	A1	A0		
0	0	0	0	0	counter	- thousandths of seconds
0	0	0	0	1		- hundredths and tenths of seconds
0	0	0	1	0		- seconds
0	0	0	1	1		- minutes
0	0	1	0	0		- hours
0	0	1	0	1		- day of the week
0	0	1	1	0		- day of the month
0	0	1	1	1		- month
0	1	0	0	0	latch	- thousandths of seconds
0	1	0	0	1		- hundredths and tenths of seconds
0	1	0	1	0		- seconds
0	1	0	1	1		- minutes
0	1	1	0	0		- hours
0	1	1	0	1		- day of the week
0	1	1	1	0		- day of the month
0	1	1	1	1		- month
1	0	0	0	0	interrupt status register	
1	0	0	0	1	interrupt control register	
1	0	0	1	0	counter reset	
1	0	0	1	1	latch reset	
1	0	1	0	0	status bit	
1	0	1	0	1	"go" command	
1	0	1	1	0	standby interrupt	
1	1	1	1	1	test mode	

all others unused

Jack Dennon
Warrenton, OR

cies that the numbers in the series represent are dependent on the sampling rate.

Anyway, by running the FFT on your audio data and then scanning the FFT output, you should be able to determine which DTMF code is present at the audio input.

These pages that deal with Visual Basic FFT source code are **http://cdeagle.cnchost.com/** and **www.fullspectrum.com/deeth/programming/vb.html**.

Tom Tillander
Bay Village, OH

ANSWER TO #60112 - JUNE 2001

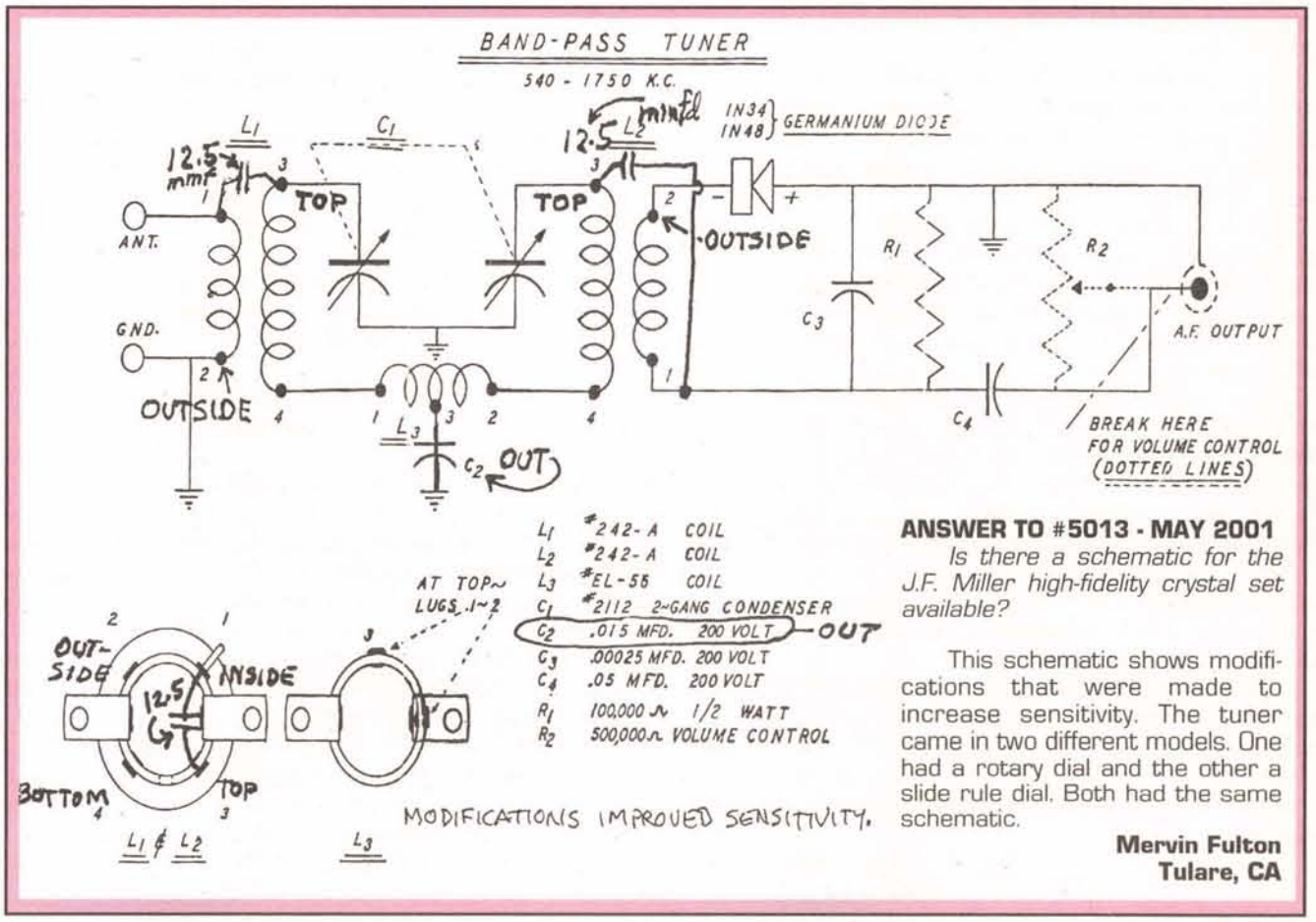
Does anyone have information on how to build a device that will take an alarm input and emit an IR signal that can start and stop the recording features of any standard home VCR? It would also have to be programmable to most any of the consumer VCRs on the market.

I thought I had seen something in a past issue of Nuts & Volts, but some of my Y2K issues are missing.

While tackling a similar problem, I found the easiest way to approach it was to just buy or use an old universal remote control. They can be had for as little as $10.00 and, as the name implies, they can be used with any VCR.

You can just open it up and solder directly to the button pads (where the button makes contact on the remote PC board) for the record button, run some leads out, and use it like a normal SPST switch. Then just run the alarm output to the control coil of a suitable relay, and you're good to go.

Andy Cleary
via Internet



ANSWER TO #5013 - MAY 2001

Is there a schematic for the J.F. Miller high-fidelity crystal set available?

This schematic shows modifications that were made to increase sensitivity. The tuner came in two different models. One had a rotary dial and the other a slide rule dial. Both had the same schematic.

Mervin Fulton
Tulare, CA

ANSWERS TO #6016 - JUNE 2001

How can I convert a three-phase electric motor to single phase 220?

#1 The short answer is, you can't, but that's not the whole story. You have options. The best solution probably is to trade the motor you have for a motor that matches your power source. If you must use the three-phase motor, then the device that you need is called an inverter, or sometimes a "static phase converter."

Quite a range of these devices are available from **Tower Electric Motor Company** at **(510)770-0851** or **www.phaseconverter.com**.

They range in price from $95.00 up, depending on the power rating.

Jack Dennon
Warrenton, OR

#2 You basically have to send it to an electric shop to rewind the motor to single phase 220, unless you have the knowledge and the tools to do it yourself, which includes taking all the copper out and installing enough for 220 single phase, of course. I have sent in several motors from wind turbines that ran at 480 three-phase and had them rewired to 220. They have worked just fine, and it's relatively inexpensive.

Alfredo Yttesen
Tehachapi, CA

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Laser Insight

NEW COLUMN!!!

by Stanley York

Last month, we took a brief look at the Helium-Neon laser, and examined in some depth, just how it worked. I also mentioned briefly about how the laser beam is constructed, the spatial profile, and various operating modes internal to the laser. I told you then that I would give you more information about some of these aspects of the laser in the future, and here it is. This month, we're going to take a closer look at how the laser beam is constructed, some of the characteristics of a laser beam, and how the various operating modes influence the 'goodness' of the beam.

Transverse Electromagnetic Modes

In a perfect world, we would like to see a Gaussian distribution for just about any statistic we care to look at. It's the same when looking at laser beams. The ideal laser beam would have a Gaussian distribution of energy as we cut across the face of the beam.

We discussed very briefly the Gaussian curve last month. If you're not familiar with the Gaussian curve (sometimes called a 'bell' curve because of its shape), it is shown again in Figure 2-1.

The Gaussian curve describes statistically, how certain features are distributed within a sample. In the case of a laser beam, we are interested in how the laser energy is distributed within the beam.

Typically, and for most laser applications, we would like to see the center of the laser beam to be the 'hottest' part of the beam, where most of the energy lies, with a gradual fall-off in power toward the outside of the beam.

The different operating modes I spoke of earlier tend to favor certain distribution modes, and thus give different beam profiles. This requires a lot of explaining, and the introduction of a new concept: TEM modes (for Transverse Electromagnetic Modes).

TEM modes describe how a laser beam is put together in the spatial (cross section) plane. TEM modes allow us to describe the beam in terms of energy distribution, and also allow us to predict how the laser beam will behave under a given set of conditions.

We learned last month that if we slice into a laser beam and measure the energy at each slice, we would see that the energy (or power) level will change as we slice further into the beam. If we were to see a uniformly growing energy level toward the center of the beam, and then see a gradual decay as we exit the beam, then we can say that the beam is operating in a near single (or fundamental) mode. I say nearly single, because there is math involved before we can honestly say that it truly is single mode.

A laser beam with a perfectly Gaussian distribution is said to be operating in a single mode, fundamental mode, or TEM00. All three terms are used interchangeably to describe this mode of operation. If we were to take some film and expose it to the incident laser beam, we would expect to see something like that shown in Figure 2-2. We would see a circular pattern of exposed film that gradually darkens (corresponding to a more intense beam) toward the center. The transition from unexposed film to the center is gradual, smooth, and uniform at all areas equidistant from the center. As I stated before, there is some math involved to describe properly the Gaussian energy profile, and is described below.

For the laser beam to be truly single mode, the decrease in the energy field intensity with distance from the center of the pattern with distance r from the axis is:

Eq 2-1

$$E(r) = E0 \exp(-r2/w2)$$

where **E(r)** = energy level
E0 = starting value
r = distance from the axis
w = radial distance at which the field amplitude drops to 1/e of its value on the axis (e = 2.71828...)

In laser circles, the parameter w is often called the beam radius or spot size of the beam, but we'll get into that a bit more soon. Needless to say, many lasers offered for sale boasting TEM00 output do come very close to this ideal, usually close enough that the differences are very minor and can be disregarded for all but the most exacting requirements.

As I said before, TEM modes give us a way of describing the quality of a laser beam. It also describes how the laser beam is constructed. The profile shown in Figure 2-2 is that of a single mode, or TEM00 beam.

Figure 2-3 shows other beam profiles that are frequently seen, labeled with their TEM mode numbers. As more and more modes become operative, beam quality changes, usually for the worse in terms of beam structure, but in some cases for the better, depending on the application. The laser beam usually grows in size and laser output power usually increases (because more of the higher-order modes are operating).

The operating modes shown in Figure 2-3 are spatial modes that would be seen if film were to be exposed as suggested earlier.

Another series of operating modes, closely related to these spatial modes, are the longitudinal modes, and are the result of intracavity interference and self-modulation effects of the laser beam internal to the resonator. In some ways, they also influence how the beam appears on film in the spatial plane, but for most applications, they are not of any great concern. In holography, or in interferometry, longitudinal modes can destroy an otherwise perfectly good experiment, but we'll discuss this a little more in a later article.

TEM classification describes the operating modes in a cylindrical or rectangular spatial field.

Again referring to Figure 2-3, in the cylindrical field, the first subscript gives the number of dark rings, while the second subscript gives the number of dark bars.

In the rectangular patterns, the

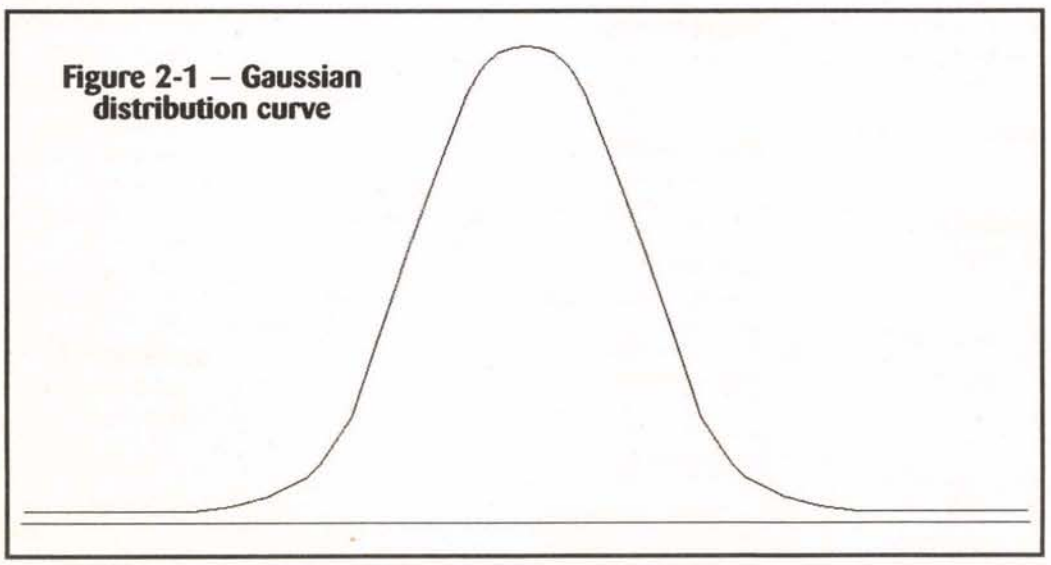


Figure 2-1 – Gaussian distribution curve

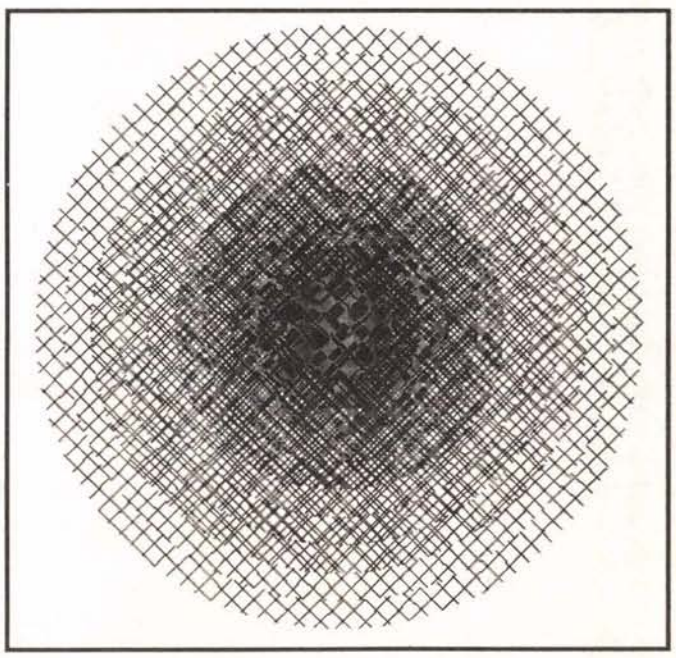


Figure 2-2 – TEM00 distribution

subscripts indicate the number of dark bars in the x and y directions.

In all cases, operating modes above TEM00 are referred to as multimode, and is a word heard often in laser circles. Multimode in itself does not describe the purity of the laser beam, only that it is not operating in TEM00.

If we take our thin knife as before, and slice through a typical multimode beam, we would find that instead of seeing the central peak that we saw in the Gaussian distribution, we would see a number of peaks, corresponding to the patterns discussed/described (Figure 2-3).

Figure 2-4 shows us the energy curve corresponding to a beam distribution of TEM01*. In this case, the peaks represent the power output of the laser beam, corresponding to the dark ring in Figure 2-3. The low power output in the central region of the laser gives a cold spot in the center of the exposed film.

Divergence

When a laser beam leaves the output coupler (sometimes called output window), there is a natural tendency for the beam to spread out. In the case of a flashlight, the beam spreading is more a function of imperfections in the reflector and/or the position of the bulb than the light beam itself. But in the case of the laser, using essentially flat mirrors, it would be expected that the light beam should travel in a straight line without diverging, that is, without this innate tendency to spread out.

Generally speaking, lasers operating in multimode show a higher divergence than lasers operating in single mode. The number of transverse modes operating primarily governs beam divergence. The higher the number, the greater the divergence.

Beam divergence is usually measured by one of two methods. In the first method, a piece of film is exposed to the laser beam at a distance d1 (nearfield) from the end of the laser. A second piece of film is then exposed at a distance d2 (farfield) from the end of the laser. The divergence is then calculated in radians as follows:

Eq 2-2

$$D = s2 - s1/d2 - d1$$

where **D** is full angle divergence in radians
S2 is farfield spot size (inches)
S1 is the nearfield spot size (inches)
d1, d2 nearfield, farfield distance (inches)

The second method is more accurate, but is a little more complicated, and requires the use of other instrumentation. Essentially, the test consists of setting up a power meter close to the laser head, and maximizing the power output from the laser. A note is made of the laser power operating in this manner, and a variable aperture is installed at a distance d1 between the laser and the power meter.

The aperture position is adjusted so that it is centrally aligned with the incoming laser beam. The aperture opening is then reduced so that approximately 86.5% of the incident energy is impinging on the power meter. A recording is made of the aperture opening. At a distance d2 from the laser, the process is repeated, and a second measurement made of the aperture opening. The divergence is then calculated using the same method as before in Equation 2-2.

Why 86.5% you may ask? Well, of course, there is a reason. And for the reason we have to return to the Gaussian curve (don't fret, it will all make sense soon).

The parameter w referred to in the description of the Gaussian curve corresponds to the point in the laser field intensity where the power drops off to the 1/e point. Since we are talking about a two-dimensional field, and not of a single point in space, parameter e should be squared (area of a circle = (r2). The power level then becomes proportional to 1/e2. This number, 0.1353, is approximately 13.5% down from the full area value (100%) and corresponds to 86.5%.

As mentioned before, the parameter w is sometimes known as the spot radius or 1/e point, and the spot area thus becomes the 1/e2 point on the Gaussian curve. This point is universally known, and has become the world standard when describing the laser beam diameter in any research papers or trades journals.

So the second method of beam divergence measurement actually gives us a lot more information than just divergence, it also gives us the 1/e2 spot size. The beam diameter (spot size) defined by this method thus contains 86.5% of the total laser beam energy, and is the figure usually quoted when talking of laser output power.

As an example, let's say we have a laser and we wish to measure the beam divergence. We'll use the first method. The laser is brought up to power, and a piece of exposed photographic film is placed in the beam path two feet from the end of the laser. The shutter is opened briefly to expose the film. A second piece of film is set up, this time six feet from the end of the laser. Again the shutter is opened and the film exposed. Examining the film, we see that the two laser spots are about the same shape, but one spot (the second one) is a little larger than the first. We measure the two spots and see that the first spot (nearfield) is 0.125 in diameter. The second spot (farfield) is 0.350 in diameter. Now we have enough information to determine the divergence.

Using the formula:

$$D = s2 - s1/d2 - d1$$

We get $D = (0.350 - 0.125)/(72 - 24)$

D = 0.225/48 = 0.0046 radian (or as is usually stated, 4.6 millradians)

Coherence

Another thing that sets laser light apart from any other light source is coherence. Coherence is a way of saying that all the light waves leaving the laser are locked in phase with their neighboring waves. Put another way, coherence is the measurement of radiation in which the phase relationship between any two points in the radiation field has a constant difference, or is exactly the same in either the spatial or temporal (timewise) mode throughout the duration of the radiation.

Ordinary white light from an incandescent bulb is totally incoherent. The light emitted scatters in all directions from the source, and because the light consists of many different wavelengths, there cannot be two points in space that have the same wavefront relationship.

Because the exiting light waves from a laser reinforce each other in this manner, the laser beam has a natural affinity for itself. That is to say, the beam will travel a long way before it diverges to a point where it is not detectable. So-called low-order mode beams (single mode) diverge much less than higher-order mode beams. In many applications, laser beam divergence is critical to proper operation of external optical devices. For example, many lasers have applications where frequency doubling (discussed in a later article) is a requirement. Frequency doubling crystals work more efficiently when a single mode beam of low diver-

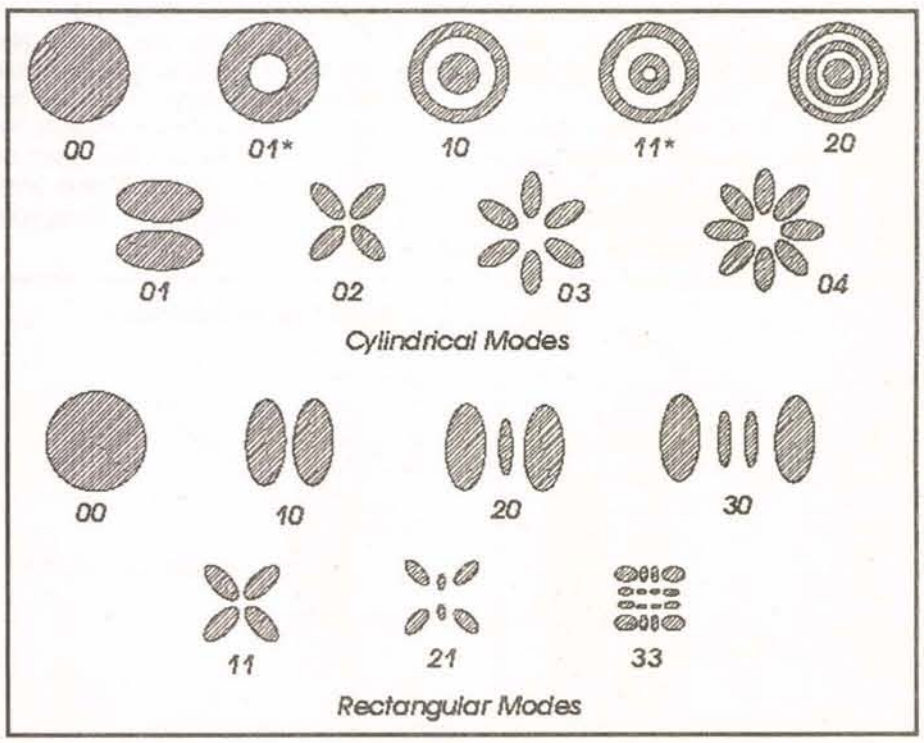


Figure 2-3 – Examples of multimode beam configurations

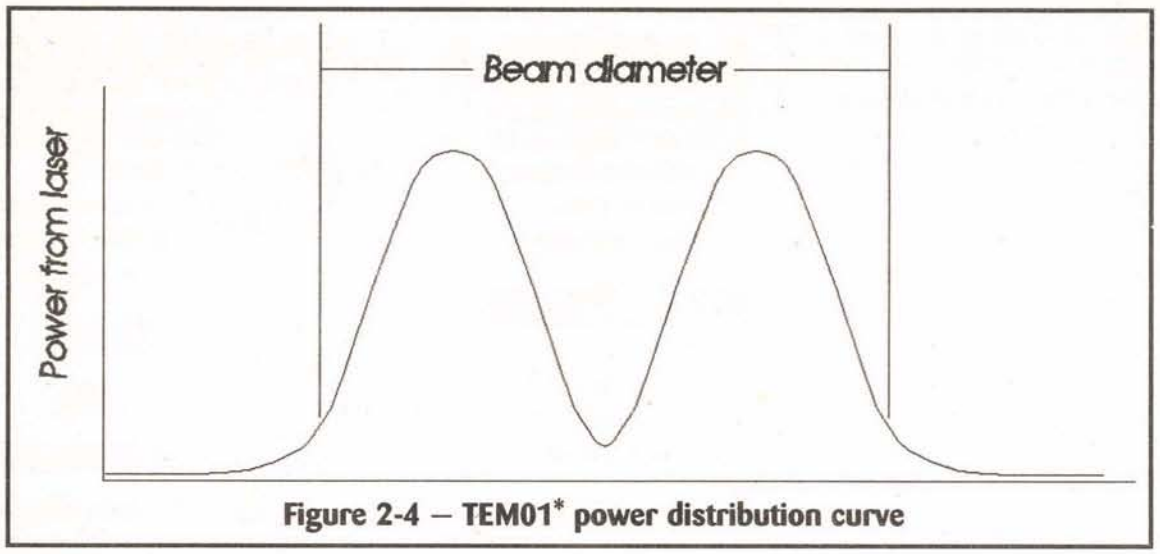


Figure 2-4 – TEM01* power distribution curve

gence is incident on the crystal. Holography requires a single mode beam for other reasons (again a subject for future discussion).

Many years ago, scientists at the Jet Propulsion Labs in Pasadena first made contact with the moon (average distance = 238,000 miles) using a laser shot from earth. By the time the beam reached the moon, it was about 22 miles in diameter!

Polarization and Birefringence

A polarized light beam – whether it is from a laser or a white light source – has some unusual properties. Some simple experiments with sheet polarizer will illustrate some of these properties and help clear the way for the explanation that follows.

Edmund Scientific, Inc. (Barrington, NJ), sells sheet polarizing material in small squares (a 2" x 2" sheet costs about $6.00 for two sheets). With this material, some very interesting effects can be observed. Put two of these sheets together and rotate one of them as you look through the combination. You will notice that at every 90° of rotation, the combination will go from transparent to opaque, and back to transparent again.

Crumple a piece of cellophane wrap, and place it between two polarizer sheets. Look through the combination again and see how the polarization effects of the crumpled cellophane change the appearance of the wrap. Again rotate one of the polarizer sheets and notice the effects on the cellophane.

Hold a piece of polarizer material in front of your eye and look at a horizontal reflecting surface (i.e., pool of water, shiny floor, or table), and rotate the polarizer. Note the effects.

If you have fish in your home, try this. Dim the lights in the room, and position a light behind the fish tank. Place a piece of the polarizer film close to the lamp, so that the light impinging on the tank is mostly being transmitted through the polarizer sheet. In other words, you need to flood the tank with polarized light (don't worry, the fish won't notice it). Hold another piece of polarizer in front of your eye and watch as the fish swim in and out of your field of view and through the polarized light field. I won't tell you what happens, you'll have to see for yourself.

You can imagine polarized light like this: Think of a fine-toothed comb with thousands of teeth on it. Imagine now, a light source shining through the comb. The output light field, if you like, consists of thousands of light streaks all angled in the same direction. If you had a second comb, and you looked through this comb at the light field generated by the first comb, you would see light, dim, light as you rotated the comb in front of your eye.

Real polarized light works in a similar way. But here we don't break the light beam into light streaks, but rather into orthogonal electric fields. We know that light consists of electromagnetic fields. We also know that the electric and magnetic parts of these fields are perpendicular to each other in a normally transmitted light ray. We know further, that the electric and magnetic fields are perpendicular to the direction in which the light ray is traveling. When a light ray becomes polarized, what we are doing is limiting the direction in which the electric field is allowed to vibrate.

In normal white light, the rays are said to be unpolarized, and the electric and magnetic fields are allowed to vibrate in all directions randomly. When talking about polarized light beams – either from a laser or some other source – it is normally meant that the electric field is the polarized field referred to.

Certain crystals, and some liquids, exhibit a phenomenon called birefringence. Birefringence is a peculiar property of a medium that is characterized by two orthogonal axes, called the "fast" and "slow" axes. These two axes have a different refractive index, dependent on the polarization of the incident beam.

If an unpolarized laser beam strikes a block of birefringent crystal (Figure 2-5), the beam will become linearly polarized, and the "fast" and "slow" axes will divide the beam into two. Because the two axes are orthogonal, there will be a displacement of one of the two resulting beams (the "slow" or "E" axis). The displacement, of course, depends on the difference in refractive index of the two axes.

In these mediums, the path of the light beam is split at the crystal/air interface and forms two distinct and separate beams traveling through the medium. Upon emerging from the medium, the beams may be close enough together as to be indistinguishable from a single beam. It will, however, have some unusual properties.

Where the two beams overlap, the polarization vector will be unpolarized, but the parts of the beams that do not overlap will have polarization vectors that are perpendicular to each other.

If an unpolarized HeNe laser is aimed through a crystal such as this, the exiting beam will become two beams. If a polarizing sheet is held up to the eye, and the sheet is rotated while observing the HeNe beam, it will be found that there is an apparent shift in the position of the exiting beam. Of course, the beam doesn't really shift. What you are seeing is the apparent change in position bought about by the difference in polarization vectors of the two exiting beams. This phenomenon gives rise to some very misleading results when performing experiments using a polarized beam.

Going back to the experiments with the polarizing sheet at the start of this column, we saw that in one experiment, we were to hold up a sheet of polarizer in front of our eye, and look at a horizontal surface. While looking through the polarizer, rotate the sheet and see what happens. When a horizontal reflecting surface is viewed through the sheet polarizer, at some points during the rotation, the surface will appear to go from bright to dull, and back to bright again.

What you are witnessing here is the filtering effects of a polarizing sheet on polarized light. The light reflecting off the horizontal surface is plane-polarized by reflection. And because the reflecting surface is horizontal, the light coming from the surface is horizontally polarized. When the polarizer sheet is in the same plane as the light from the surface, then maximum transmission can occur through the polarizer sheet.

If the polarizer sheet is rotated through 90°, the polarization planes will not be the same, and minimum transmission will result. Popular brands of anti-glare sunglasses work in this manner, by using vertically-aligned polarizer sheets to block horizontally polarized glare from the sea, lakes, wet roads, etc.

Polarization is tricky to understand, and takes a while to see all the vagaries and implications it embodies.

Think about some of the other experiments with the sheet polarizer discussed earlier and see if you can figure out the results you saw.

That's all for this month. Next month, we'll be looking at fundamental optical principles. We'll see how mirrors, lenses, and prisms work, how the spatial profile of a laser beam can be improved, and we'll also briefly look at fiberoptics and holography. **NV**

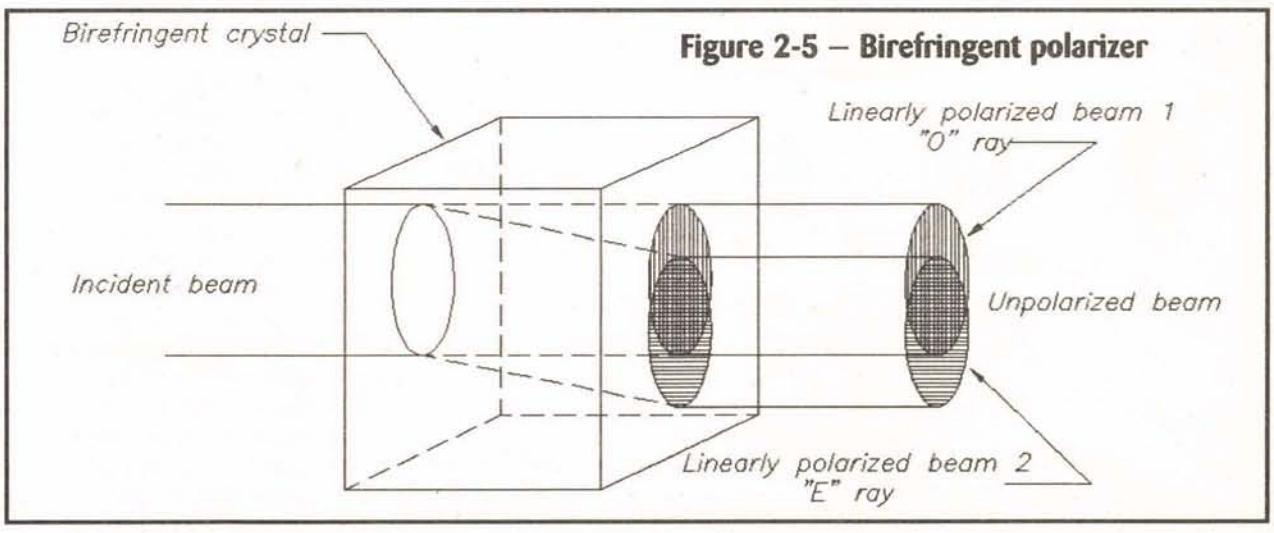


Figure 2-5 – Birefringent polarizer

Keyless Keyboard Emulator

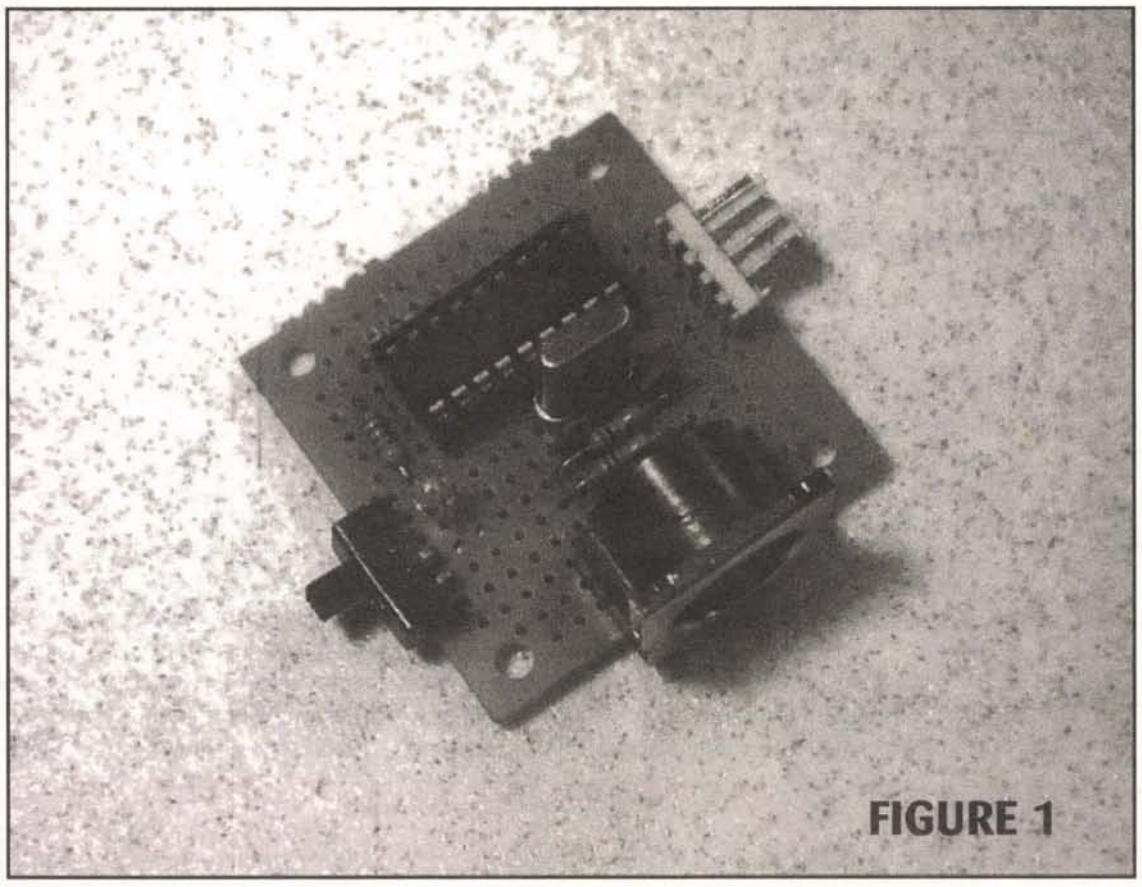


FIGURE 1

by Tim Hamel

Whether you are stashing that old PC in a closet or in the dash of a truck, chances are you don't need a bulky keyboard. Here's how to get rid of that pesky appendage while keeping the PC happy.

Tired of playing sneaker net between my upstairs and downstairs PC, I decided to install a small local area network (LAN) to link the two. I did what most nerds do and recycled an old PC to serve as a router for the network. Finding an old PC was easy, I had a collection of them gathering dust in a corner. Finding a keyboard to spare for the project was another story. No big deal, I thought. It doesn't need one, and I prefer the router didn't have a keyboard, anyway (my cat loves the closet, and I can live without paw strokes).

With the hardware fitted and the software installed, I smugly flipped the power switch, only to be greeted with, "Keyboard not connected. Press any key to continue." Not one to give up without a fight, I tried every trick I knew to make the system boot without a keyboard – all to no avail.

Then the ol' light bulb came on. Maybe there's a way to fool the computer into thinking there's a keyboard attached. Armed with a just a PIC16F84 microcontroller and plenty of enthusiasm, I set out to conquer the keyboardless PC.

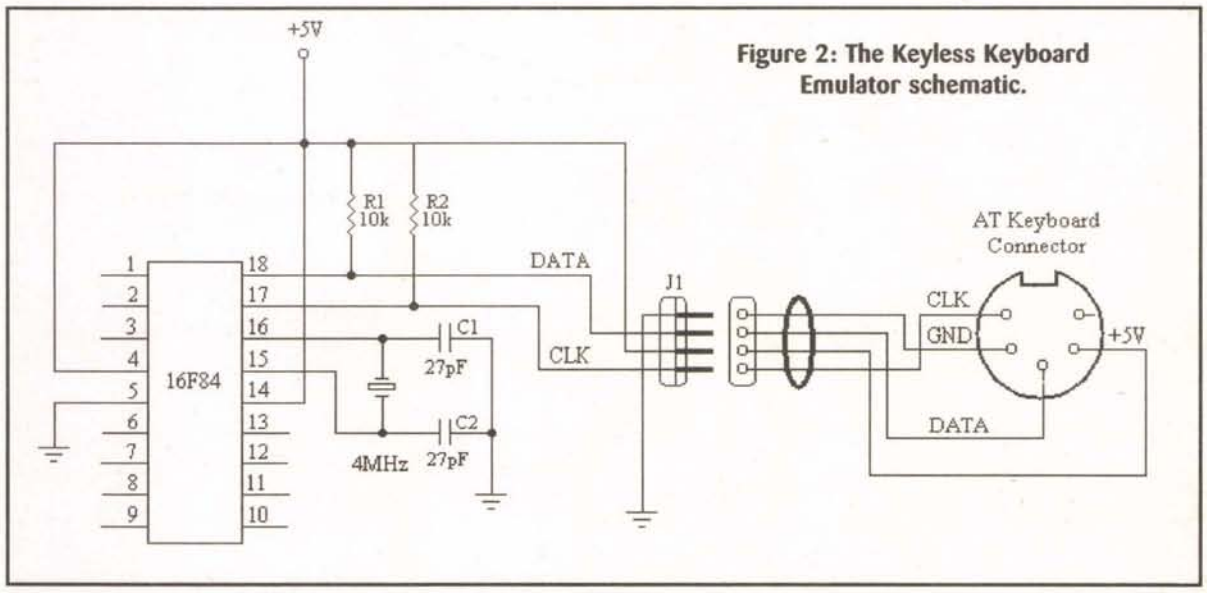


Figure 2: The Keyless Keyboard Emulator schematic.

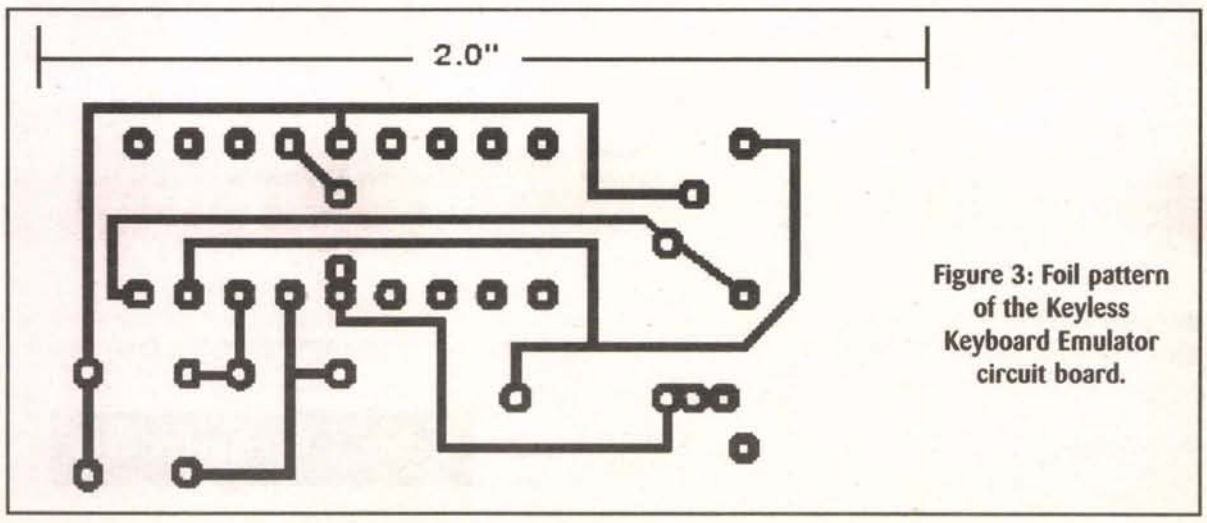


Figure 3: Foil pattern of the Keyless Keyboard Emulator circuit board.

Is Anyone Out There?

When you turn on your PC, it goes through a routine affectionately known as POST (Power-On Self-Test). During this test, the PC looks for installed hardware, initializes the video ... and attempts to talk to the keyboard. Inside the keyboard is a microcontroller. This chip is responsible for all communications between the PC and itself.

Like the PC, the keyboard goes through a self-checking routine, called Basic Assurance Test (BAT). If the keyboard finds itself healthy, it transmits an "AAh" (h denotes hex) message to the PC via the keyboard cable. If the PC doesn't receive this acknowledgment, it assumes the keyboard is missing in action or mortally wounded. (During my research, I noticed that the PC polls the keyboard about every 10 seconds to verify that the keyboard

Keyless Keyboard

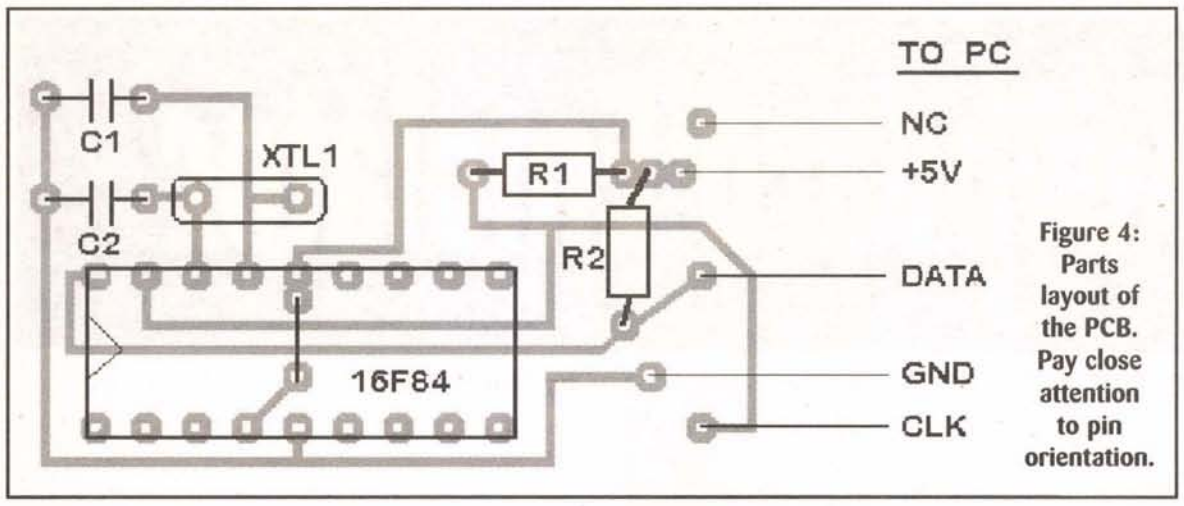


Figure 4: Parts layout of the PCB. Pay close attention to pin orientation.

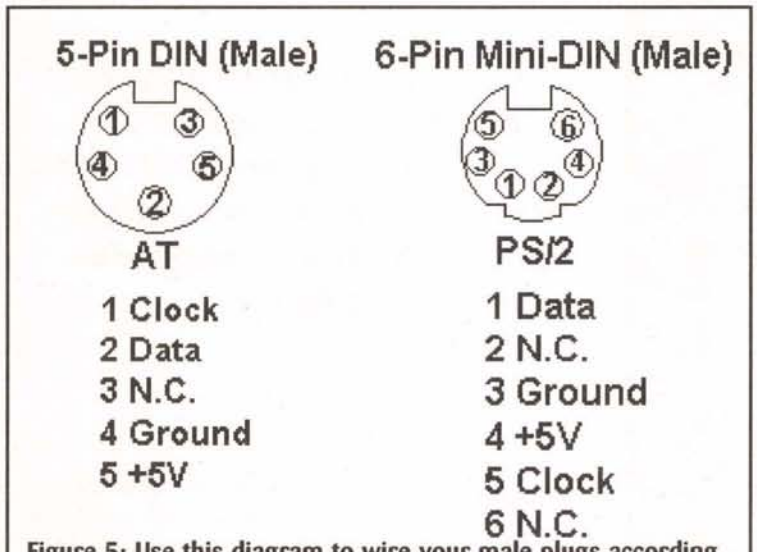


Figure 5: Use this diagram to wire your male plugs according to your PC's keyboard port.

is still alive and well.)

Proper Protocol

Now that I knew what the PC was looking for, the next step was to duplicate the keyboard's response in the PIC. Unfortunately, I wasn't out of the woods, yet. Just knowing what the keyboard sends isn't the same thing as sending it. There's a small item called protocol. That is the scheme by which the encoded information sent by the keyboard is understood by the PC and vise versa.

"How am I going to figure this out?" I thought. I turned to my most valuable resource, that thing we call the Internet. After a while of dead-end surfing, I came across a "Keyboard FAQ" site – with more in-depth details about keyboards than I wanted to know.

I quickly discovered that the keyboard uses a bi-directional synchronous serial protocol for its communications. What this means is that the keyboard sends two signals over the connecting cable: a clock pulse train and the data stream. What the PC does is match the clock pulses to the data stream to decode the "secret" messages. (See "Synchronous Savvy.")

Firmware

With these protocol details duly noted, it was time to start writing the PIC program and load it into the flash EEPROM of the PIC controller. For this leg of the project, I made a keyboard "spy" that sits between the PC and the keyboard and passively listens to the data zipping by. As it turns out, the "handshaking" actions are fairly simple. The PC sends an FFh reset command, and the keyboard responds with the correct answers.

My plan of attack was to have the PIC sit in a constant loop waiting for an FFh code, and respond appropriately with FAh and then AAh. Sounded straightforward enough. It wasn't until later, though, that I realized that some PCs turn on the Num Lock function when they power up. Unfortunately, this set-up routine expects a differ-

```
        include "P16c84.inc"
;PIC-Based Keyboard Emulator
;Author: Tim Hamel
;Date: June 27th, 2k


dta     equ     H'0001'
clk     equ     H'0000'
dela    equ     12
pass    equ     13
count   equ     14
parity  equ     15
send    equ     16
delb    equ     17

        org     0
        goto    main

;****Delay routine for 25kHz Clock****

delay   movlw   .13
        movwf   dela

delay1
        decfsz dela
        goto    delay1
        return

;******

;****Routine to Receive data from PC****


PC_rx   movlw   9               ; Read in 8 bits + parity
        movwf   count
        movlw   0x02
        tris    PORTA

PC_rx1  call    delay
        bcf     PORTA,clk

        bcf   STATUS, C         ; What is the bit coming in?
        btfsc  PORTA, dta
        bsf   STATUS, C         ; High Bit
        rrf   pass              ; Shift in the Bit

        call    delay           ; Wait for Bit to Go High
        bsf     PORTA,clk
        decfsz  count           ; Are we done with 9 bits?
        goto    PC_rx1          ; No, decrement 'count' and receive
next bit

        bcf     PORTA,clk       ; Yes, clock out stop bit
        call    delay
        bsf     PORTA,clk

wait    bcf     PORTA,clk
        call    delay
        bsf     PORTA,clk
        btfss   PORTA,dta       ; Wait for PC to take DATA line low.
        goto    wait

        movlw   0
        tris    PORTA
        bcf     PORTA,dta       ; send ACK
        call    delay
        bcf     PORTA,clk
        call    delay
        bsf     PORTA,clk
        bsf     PORTA,dta

        return

;******

;****Transmit Routine****

KB_tx
        movwf   send
        movlw   0
        tris    PORTA
        call    delay
        bcf     PORTA,dta
        bcf     PORTA,clk       ; Send a 0 start bit.
        call    delay
        bsf     PORTA,clk

        movlw   .8
        movwf   count
        clrf    parity
sendnext                        ; Start sending response byte
        btfss   send,0
        goto    shiftright
        incf    parity,f
        bsf     PORTA,dta
        goto    sendzero
```

Listing 1. KBE Source Code

Keyless Keyboard

ent response pattern.

When the PC wants to turn on the keyboard LEDs, it first sends EDh, waits for an acknowledgment from the keyboard, and then sends another eight bits of data signifying which keyboard LEDs to turn on and off. I have no need for the EDh command, but if the keyboard doesn't respond, the PC will generate an error. To overcome this, I read in EDh, send an acknowledgment (FAh), and then read in the LED byte (which I promptly discard). The PC is happy, the PIC is happy, and I'm elated that it doesn't involve more than a shrug of the shoulder.

The program is shown in Listing 1, and can be downloaded from the *Nuts & Volts* website (www.nutsvolts.com) under the name KBE.TXT. Much of the program is made up of little programs – called routines or modules – that do specific tasks. For instance, there's a delay routine that generates a 39-uS delay and another that deciphers PC commands.

The actual program starts at Main: (original, huh?). When the PIC is powered up, it waits for approximately 6mS (about 154 ticks of the 39-uS delay clock) to simulate the keyboard BAT routine. After the delay, the PIC sends AAh to tell the PC that it has passed its check-up successfully. From then on, the PIC has a boring life waiting for FFh or EDh from the PC. The branching Convert routine is responsible for deciphering the command sent by the PC and choosing the appropriate action to take.

Construction

Building this project is a no-brainer – even for a newbie hobbyist. With but six parts total – the PIC chip included (Figure 2) – this project lends itself to a variety of construction methods, including breadboard, point-to-point, wire-wrap, perfboard, and etched printed circuit board.

I built my prototype circuit on a RadioShack perfboard (276-148), but have since transferred it to an etched printed circuit board (Figure 3). The parts layout for the printed circuit board is shown in Figure 4.

When fabricating this circuit, you must take care not to short any pins together (especially to Vcc or GND). Doing so could possibly fry your motherboard, resulting in a costly repair bill.

While the construction method isn't critical, the parts layout is. It's especially important that you place the oscillator as close to the PIC's pins as you can. The bypass capacitors (C1 and C2) should also be cuddly close to the PIC. If you plan on playing around with the programming code,

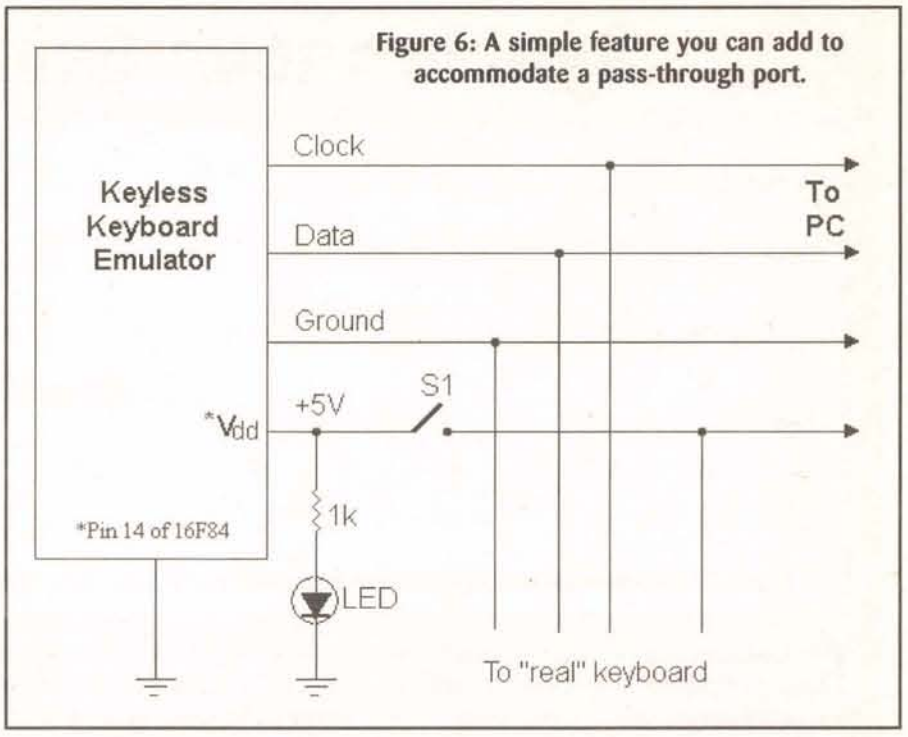


Figure 6: A simple feature you can add to accommodate a pass-through port.

```
shiftright
        bcf     PORTA,dta
sendzero
        call    delay
        rrf     send,f
        bcf     PORTA,clk
        call    delay
        bsf     PORTA,clk
        decfsz  count,f
        goto    sendnext

        bsf     PORTA,clk
        movlw   0xFF
        xorwf   parity,f
        btfss   parity,0
        goto    sendlow
        bsf     PORTA,dta
        goto    sendhigh
sendlow
        bcf     PORTA,dta
sendhigh
        call    delay
        bcf     PORTA,clk
        call    delay
        bsf     PORTA,clk

        call    delay                   ; send STOP bit (1)
        bcf     PORTA,clk
        bsf     PORTA,dta
        call    delay
        bsf     PORTA,clk
        call    delay
        movlw   0x03
        tris    PORTA
        return
;******
;****Start-up Delay****
longdly
        clrf    dela

        movlw   9
        movwf   dela
dele    movlw   0xFF
        movwf   delb
delc    decfsz  delb
        goto    delc
deld    decfsz  dela
        goto    dele
        return
;******
;****Determine what the PC Sent****
Convert movf pass,W
        xorlw 0xFF                      ; Did the PC send a reset signal?
        btfsc STATUS,Z
        retlw 0xAA                      ; Yes, send Acknowledge

        movf  pass,W
        xorlw 0xED                      ; No, maybe PC is trying to turn on
Status LEDs
        btfsc STATUS,Z
        goto  test                      ; EDh means "Set LEDs"

        retlw 0x00                      ; We don't care at this point, send
                                        ; 'Acknowledge' anyway.
test    movlw   0xFA
        call    KB_tx
        call    PC_rx
        return
;*****
main:
        movlw   0x00                    ; Make PORTA output
        tris    PORTA

        call    longdly
        movlw   0xAA                    ; Initial start-up, send AAh
        call    KB_tx                   ; Transmit it...
loopi   movwf   0x03
        tris    PORTA
        btfsc   PORTA,dta               ; Wait for DATA line to go low.
        goto    $-1                     ; Meaning PC wants to TX.

        call    PC_rx                   ; Receive PC data.

        call    Convert                 ; What is it?
        movwf   pass
        movlw   0xFA
        call    KB_tx                   ; Send 'Acknowledge'.
        movf    pass,W
        call    KB_tx

        goto    loopi                   ; Repeat all this endlessly.
        end
```

Synchronous Savvy

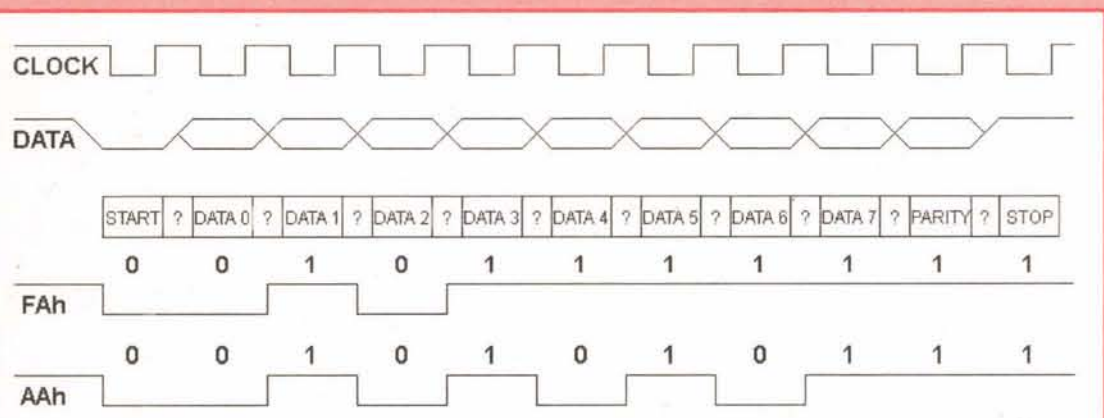


Figure 7: Communications between the keyboard and PC are done using an 11-bit packet.

The waveforms above show what it takes for the keyboard to converse with the PC. This is known as synchronous communication. Unlike asynchronous communication – the kind used by your modem to send messages over telephone wires – synchronous requires two signal lines (wires); a data line and a clock line. The clock and the data stream are in step with other, making it easier to extract the message from the encoded bit data line. The PC does this by comparing the clock pulses to the data stream. If there is a coincidence of pulses, that is, both the clock line and the data line being high (five volts) at the same time, the PC takes this to represent a logic 1 bit. On the other hand, if the clock line is high and the data line is low (0 volts), this represents a logic 0 bit. The data line is checked for pulse coincidence on the rising edge of each clock pulse.

Like human language, the keyboard and PC talk in words. A keyboard word consists of 11 bits wrapped in an envelope called a packet. Each packet begins with a logic-low Start bit (logic low) that signifies the beginning of an upcoming word. Next comes the actual data, which is eight bits long. The data is sent least-significant bit (LSB) first.

The 10th bit is called a parity bit – a pulse that's used to confirm the validity of the word just sent. Keyboard protocol uses what's called odd-parity checking. Simply put, the keyboard counts the number of logic 1 bits in the word and checks to see if the sum is odd or even. If it is even, a parity bit is appended to the end of the word; if it's odd, no parity bit is added. When the PC receives the packet, it counts the number of bits in the word and compares it to the parity bit. If the two agree, the PC assumes the word is correct and not corrupted by noise. The packet is ended with – what else – a Stop bit (logic 1).

The received word is, of course, a number that the PC now looks up in a table that cross-references the number to a letter. The response FA(h), for example, is a command, and doesn't require a lookup.

The opposite of synchronous is – you guessed it – asynchronous. Async and sync are similar except that the async clock line doesn't exist physically. Instead, the clock pulse is embedded in the data transmission. The receiver and transmitter agree on a "clock" by the length and position of the pulses on the data line – a protocol that requires frequent resetting of the two clock oscillators to keep them in step which, in turn, takes considerably more housekeeping overhead than synchronous communications.

consider adding a socket for the PIC so that you can swap it in and out during the development phase.

The emulator plugs into the PC via a short connecting cable. I found it expedient to simply cut the plug and cord off a defunct keyboard rather than build one from scratch. (Alternatively, you can buy a keyboard extension cord for about $5.00.)

But look at the plug before you snip. There are two types of keyboard connectors (Figure 5).

Older, but still popular, is the five-pin AT type connector, which is found on many of today's systems with Baby-AT form factor motherboards. Newer systems sport the PS/2 keyboard connector, which is a six-pin mini-DIN found on most Low Profile (LPX motherboard) PCs. It's physically smaller than a standard DIN, hence the "mini" prefix. Despite the difference in their sizes and pin arrangements, they have something in common in that they're both female sockets. Determine what kind of socket you'll be plugging into and wire your male plug according to Figure 5.

In the photo of the finished project, you'll notice an LED, a switch, and a keyboard socket. I added these parts as an after-thought to accommodate a pass-through port. When the switch is on, the emulator is connected to the PC's power supply (via the keyboard cable). The LED lights to let you know the emulator is in control. When the switch is off, the emulator receives no power from the PC, allowing you to connect and operate a real keyboard normally without interference. You can easily add this optional feature by referring to Figure 6.

Bye, Bye, Keyboard

After all the sweat and tears, I was finally able to power up my LAN without an unwanted keyboard. So, whether you want to run a closet router like me, or slide a computer in your truck, with the keyless keyboard emulator, those days of "Keyboard Not Found" are gone forever! **NV**

NEWS BYTES Continued from page 13

NEW DIGITAL THERMOMETERS ASSURE COOKOUT SUCCESS AND SAFETY

For anyone who barbeques there is a new generation of hand-held digital thermometers that will assure both success and safety when grilling outdoors.

Have you ever stood over the grill, smoke billowing around you, and wondered if the steak, burger, or chicken you were cooking was done enough, yet? Or perhaps erred to the side of caution with burnt dinner as the result?

Easy-to-use, hand-held AcuRite® Sure Grip digital barbeque thermometers take the worry out of food preparation and put the fun back into grilling outdoors.

With consumer attention recently focused on bacteria-borne illnesses resulting from undercooked and mishandled foods, food preparation and safety has become of paramount importance. AcuRite's digital thermometers have large, soft handles that make them easy to grip and they instantly read the temperature of the food being cooked. Plus, the FDA recommended cooking temperatures are printed right on the product. These tools are available individually at fine retailers (for under $24.99/ea.). For availability see www.chaney instrument.com.

"Expert or neophyte, your chefs will love the comfort of the Sure Grip handles, and because the thermometers are so accurate and easy to use it means that their barbequed foods are safe, and delicious, too!" said Trish Koeppel, Chaney's product development and marketing manager.

There are several barbeque thermometers in the AcuRite line, including the Sure-Grip Burger Probe and Sure Grip Fork, which is ideal for steaks and chicken. The brand-new Burger Probe makes gauging the correct cooking temperature more precise with an exclusive angled 3/8" stainless steel probe which assures correct insertion depth every time. Both feature instant-response sensors and easy-to-read LCD displays, on/off switches, and soft-touch Sure Grip handles for easy control.

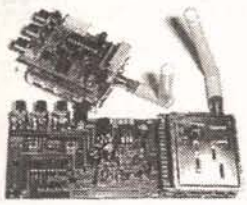
For more information on food safety, including food preparation rec-

NEWS BYTES Continued on Page 76

Continued from page 60

```
  cmd = UCase(theCommand)
Else
  ' command has parameter(s)
  ' - get command
  cmd = UCase(Mid(theCommand, 1, delimPos - 1))
  ' extract parameters from command string
  param = Mid(theCommand, delimPos + 1)
End If

' process the command
Select Case cmd
  Case "!RSET"
    ClearForm
    showData = True
  Case "!CLRM"
    If showData Then sbarMessage.SimpleText = ""
  Case "!USRS"
    If showData Then sbarMessage.SimpleText = param
  Case "!AMIN"
    pbarAnalog.Min = CLng(param)
  Case "!AMAX"
    pbarAnalog.Max = CLng(param)
  Case "!AMUL"
    multiplier = CSng(param)
  Case "!SPAN"
    SetSpan (param)
End Select

End Function

Private Function Bin2Dec(ByVal binValue As String) As Long

  Dim temp As Long
  Dim binLen As Integer
  Dim x As Integer

  temp = 0
  binLen = Len(binValue)
  For x = 1 To binLen
    ' add bit value if "1"
    If Mid(binValue, x, 1) = "1" Then
      temp = temp + 2 ^ (binLen - x)
    End If
  Next

  Bin2Dec = temp

End Function

Private Sub SetSpan(ByVal span As String)

  Dim comma As Integer

  comma = InStr(1, span, ",")
  If comma = 0 Then Exit Sub              ' improper format - exit

  ' update progress bar
  pbarAnalog.Min = CLng(Mid(span, 1, comma - 1))
  pbarAnalog.Max = CLng(Mid(span, comma + 1))

  ' update legends
  lblSpanMin.Caption = Str(pbarAnalog.Min)
  lblSpanMax.Caption = Str(pbarAnalog.Max)

End Sub

Private Sub ShowAnalog(ByVal aValue As Long)

  aValue = CLng(CSng(aValue) * multiplier)

  ' show value
  lblAnalogValue.Caption = Trim(Str(aValue))

  ' check limits and show on progress bar
  If aValue > pbarAnalog.Max Then aValue = pbarAnalog.Max
  If aValue < pbarAnalog.Min Then aValue = pbarAnalog.Min
  pbarAnalog.Value = aValue

End Sub

Private Sub ShowDigital(ByVal digValue As Long)

  Dim mask As Long
  Dim led As Byte

  For led = 0 To 3
    If (digValue And (2 ^ led)) > 0 Then
      ' channel off - extinguish
      lblDigitalInput(led).BackColor = &H8000000F
    Else
      ' channel on - light
      lblDigitalInput(led).BackColor = vbGreen
    End If
  Next

End Sub

Private Sub ClearForm()

  ShowAnalog (0)
  ShowDigital (&HFFFF)                    ' all off (active low)
  sbarMessage.SimpleText = ""

End Sub
```

2.4 GHz Wireless Transmitter & Receiver



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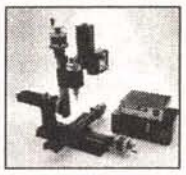

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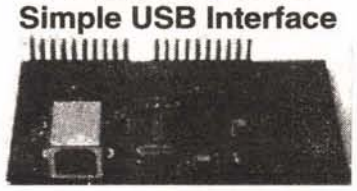

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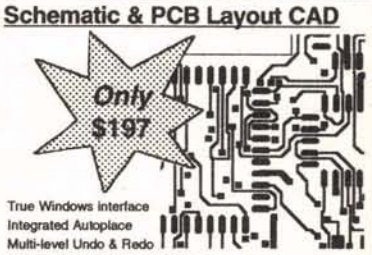

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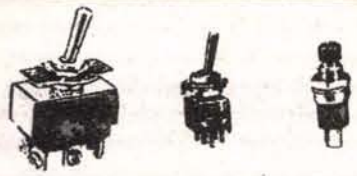

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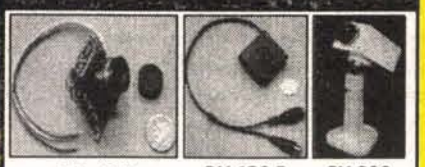

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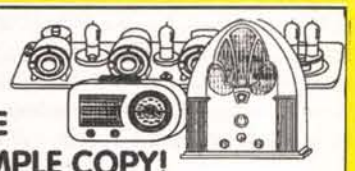

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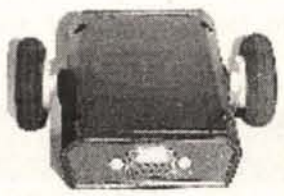

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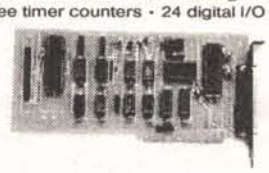

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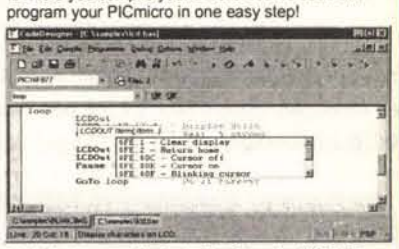

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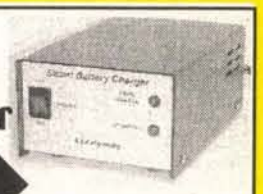

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WEBCAM WATCHDOG BRINGS HOME SECURITY TO THE WEB

Webcam Corp. has released Webcam Watchdog, a Windows application that provides around-the-clock surveillance for your home or business. When Webcam Watchdog detects motion in the area being monitored by your web camera, it can sound an alarm, email you the captured image, and increase the recording frame-rate speed to capture more high-quality images.

Because Webcam Watchdog uses the Internet along with its built-in Java capability, there is no need to buy and install any software to view the images being captured. All surveillance images can be viewed using Internet Explorer 4 or 5, or Netscape 4 or 5.

Capturing 320-by-240 images at one per second, a 40 GB hard drive will hold 10 days of video. Webcam Watchdog can automatically delete the oldest video files, allowing you to capture data forever in a maintenance-free mode.

The program's built-in web server makes it easy to retrieve your video archives securely and remotely. There is even a log that keeps track of who accessed Webcam Watchdog remotely. In addition to using the program as a web server, it can also be used to upload webcam images to your web site. Other features include the ability to add text captions to the images, to place a date/time stamp on each video frame, and to adjust the frame rate, picture size, and quality settings.

Webcam Watchdog requires Windows 98/Me/NT4/2000 and a Video for Windows compatible camera. The program costs $69.95, and may be purchased securely online at http://www.webcam123.com/. You can download a free, fully-functional trial version from the same web address. For more information, contact Webcam Corp., 2 Primrose Lane, #3C, Fords, NJ 08863. Email: service@webcam123.com

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The Windows and Macintosh software features a Quiz Editor for creating multiple-choice quizzes on any topic. Quizzes can then be instantly presented to an audience as a TV-style game show with an animated host and supermodel, flashy sets, catchy music, fun sound effects, automatic scoring, and comic relief. Up to four people or teams can play the quiz simultaneously. The program can automatically sort and present the quiz "Millionaire-style" with the questions getting tougher in higher rounds of play.

Customizing options for the game show include giving the show a title, selecting a background set for the show, choosing the duration of the show and the question timer, adding your name to credits, and adding an optional "Prize Presentation Scene."

The program features high quality sound and supports 800 x 600 and 1024 x 768 screen resolutions, so the output is suitable for many multimedia projection systems. The Presentation Edition is around $79.00 for a single user license. Version 1.3 is available now as a downloadable product from http://www.gameshowpresenter.com.

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An attention getter and conversation piece, the scrolling LED clock accurately shows hours and minutes by presenting each digit in a dot-matrix format moving from right to left in a ticker-tape format.

It can be built from a very complete $49.00 kit, or from scratch using the information in this article.

The Scrolling LED Clock Kit includes front and back panels allowing it to stand unaided. The base shown is not needed.

Starting when digital clock kits became generally available in the mid-1970s, I've built at least three-dozen digital clock kits of almost every description for the home and the car.

One digital clock displays giant 3.5-inch-high numbers formed from many red light-emitting diodes (LEDs).

One looks like a large grandfather clock with three concentric circular paths along which LEDs march clockwise to indicate hours, minutes, and seconds.

Another multi-function clock uses a blue fluorescent display with 14 switches to set various functions.

One clock uses three different colored sets of seven-segment displays to advance biorhythm counts daily.

Three others display the time — to the second — in binary coded decimal notation, using different layouts.

But the scrolling LED clock — available as a kit from LNS Technologies — is one of the most unique of my clocks. It is fascinating to watch as the numbers scroll mysteriously across the blank red front panel, like the famous scrolling news sign on top of the New York Times building.

Each digit is formed from a four-across by seven-high matrix. Starting at the right side, the tens-of-hours digit moves to the left, followed by the hours digit, then a colon to separate the hours from the minutes, then the tens-of-minutes digit, and finally the minutes digit. The display then goes blank for a short period, then starts again, with a full hours/minutes scroll about every four seconds.

Circuit Description

Figure 1 is a schematic of the scrolling LED clock. At the heart of the circuit is an Atmel AT89C2051 microcontoller integrated circuit, U1. This must be programmed to perform the desired functions, and it is available from LNS Technologies already programmed in the kit, or available separately as a special item.

When programmed, U1 handles a variety of functions, including time-setting, time-keeping, LED dot-pattern display encoding, and scrolling. An 11.0592 MHz crystal provides internal oscillator timing for U1.

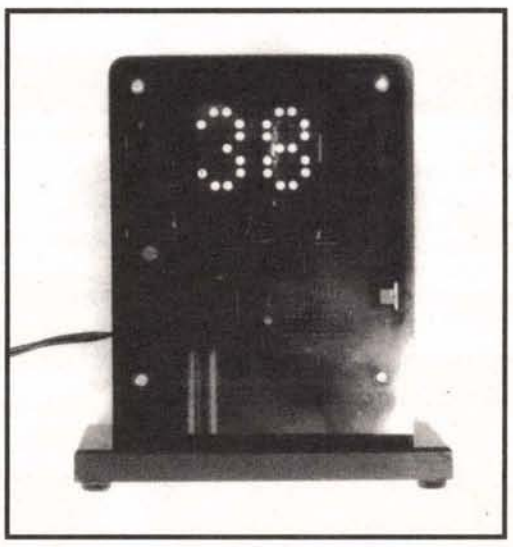
Even though the microcontroller is doing most of the work in the scrolling clock, some additional circuitry is required. The entire circuit receives power from a 9VAC wall-mount transformer. The 9VAC power is rectified by the full-wave bridge DB1, filtered by electrolytic capacitor C9, and then regulated to five-volts DC by U5. Electrolytic capacitor C8, and ceramic capacitors C4, C5, and C6 provide further filtering to produce a very stable five-volts DC.

In most localities, there is hardly a more accurate timing function than the 60Hz power line. (Oh, sure, there are atomic clocks if you want split-second accuracy — but that's hardly necessary for a home clock!) The 60Hz power line frequency is constantly monitored and adjusted to maintain an average of 60 cycles per second. For this reason, it makes an excellent source for time-keeping.

In the scrolling LED clock design (and for most digital clocks plugged into home AC power), the AC waveform is used to assure time-keeping accuracy. Looking at Figure 1, the nine-volt AC positive half-cycles pass from bridge rectifier DB1 through current-limiting resistor R15 to pin 1, the input to the internal LED of opto-isolator U6. The negative half-cycles bypass U6 through diode D1. The NPN transistor built into U6 isolates and squares the signal, which then leaves pin 6 of U6 and goes to pin 6 of U1, the external interrupt. This is, in effect, a clocking pulse 60 times per second.

Next look at the displays,

First the hours (shown here) move across the screen, followed by a colon (:), then the minutes.



Minutes follow the hours as the numbers march across the screen from right to left.

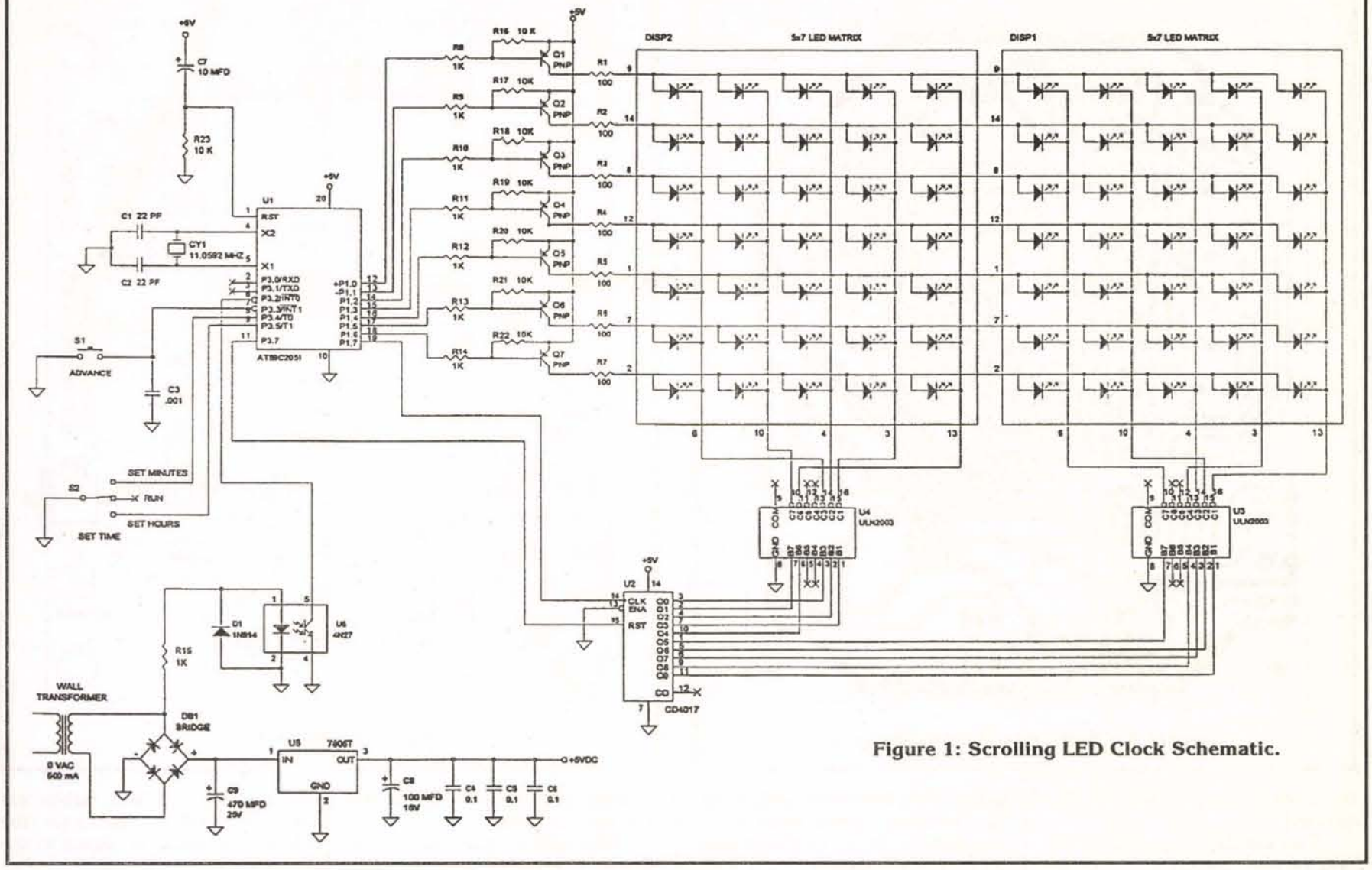


Figure 1: Scrolling LED Clock Schematic.

DISP1 and DISP2, in Figure 1. Each has 35 LEDs arranged in a matrix of five vertical "columns" and seven horizontal "rows." (If you have trouble remembering which are columns and which are rows, recall that columns in architecture are vertical.) The LED anodes of each of the seven rows are connected together, and the LED cathodes of each of the 10 columns are connected together.

In the scrolling LED clock, the rows of both displays are bussed together to form a larger array of 70 LEDs, now with 10 columns, but still with just seven rows. This configuration allows any of the individual 70 LEDs to be lighted with only 17 connections by properly powering any of seven anode rows, or grounding any of 10 cathode columns.

It is the combination of lighted LEDs that forms a number. In this design, each number — from 0 to 9 — is composed in a 4 x 7 grid, as shown in Figure 2.

Now comes the tricky part. How do you form the numbers and make them seem to move across the matrix? The programmed microcontroller, U1, does this by apparently turning on the appropriate LEDs at the right-hand column for a short time, then moving these to the next-left column and introducing a new column of lighted LEDs at the right, and so on. Each set of four columns displays a single number, apparently moving from right to left. But all this is not as simple as it may seem.

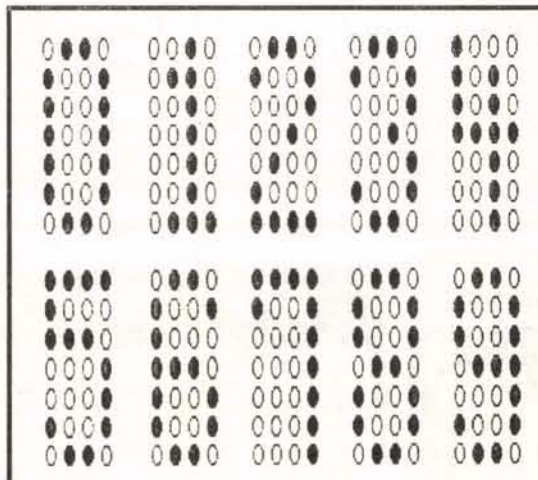
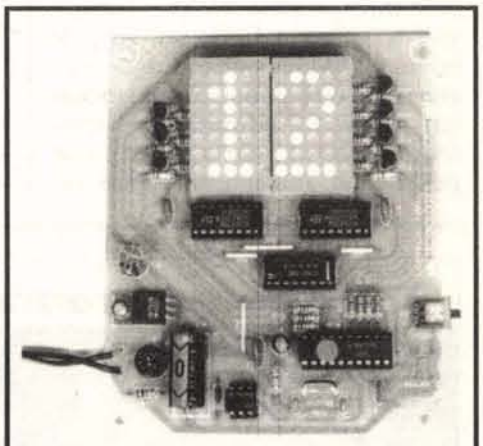


Figure 2: Each number is formed in a four-column seven-row pattern.



All the parts, including the two side-by-side displays, fit on a single printed circuit board.

Exactly how is this accomplished? The seven rows are controlled by seven outputs of U1 (pins 12 through 18). Whenever a pin goes LO, the associated PNP transistor and resistors provide a negative bias, throwing the transistor into conduction. The regulated five volts now appear at the anodes of all 10 LEDs in that row. But none of the LEDs can light unless the cathode is also grounded.

That's where the CMOS decade counter, U2, comes into play. It provides a way to turn on each of the 10 columns in sequence. But U2 can't carry the required current directly, so U3 and U4 — NPN Darlington arrays — are used for LED current sinking.

Two additional output lines from U1's internal oscillator — pins 11 and 19 — go from U1 to U2. Pin 11 is used to reset the U2 counter so the data presented to the display rows can be synchronized with the proper column. Pin 19 goes to U2's clock input to increment the counter. Each time the counter is incremented, the next column is enabled.

Confused? Follow this closely, referring to Figure 1. First, pin 11 of the programmed microcontroller, U1, resets counter U2 at pin 15 to enable (ground) the left-most column (pin 6 of DISP2) through pins 3 of U2 and pins 3 and 14 of U4. Next, data is output from pins 12 through 18 of U1 to the seven rows to turn on the appropriate LEDs in that column. The LEDs in that column are left on for only one millisecond!

Next, a clocking pulse is generated internally by U1 at pin 19 to increment U2 at pin 14. As U2 increments, the first column is turned off and the next-right column (pin 10 of DISP2) is enabled. At the same time, the raw data is changed to turn on the LEDs in this column. This strobing sequence continues for each of the 10 columns before the entire process is repeated.

The entire display is strobed in 10 milliseconds, or 100 times per second. The microcontroller sequencing is programmed to make the numbers appear to be moving from right to left, even though the 10 millisecond strobing is from left to right. At that speed, the human eye cannot perceive the strobing and the display appears to

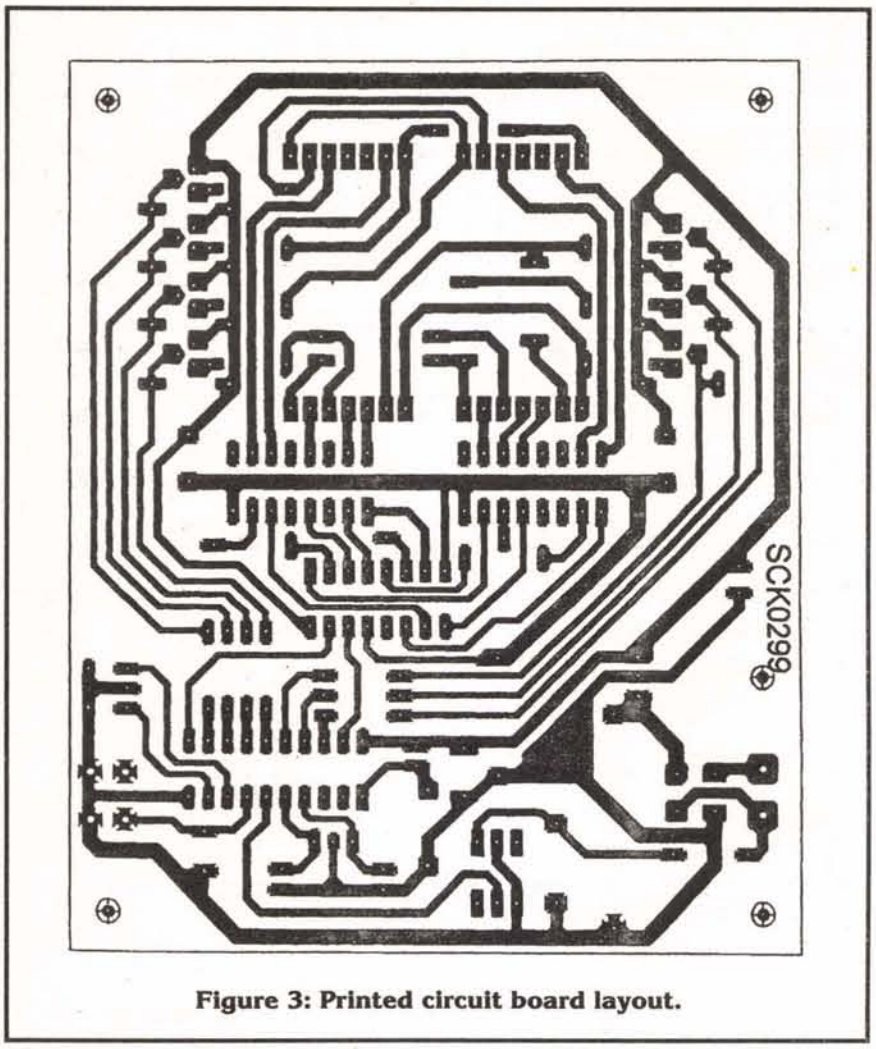


Figure 3: Printed circuit board layout.

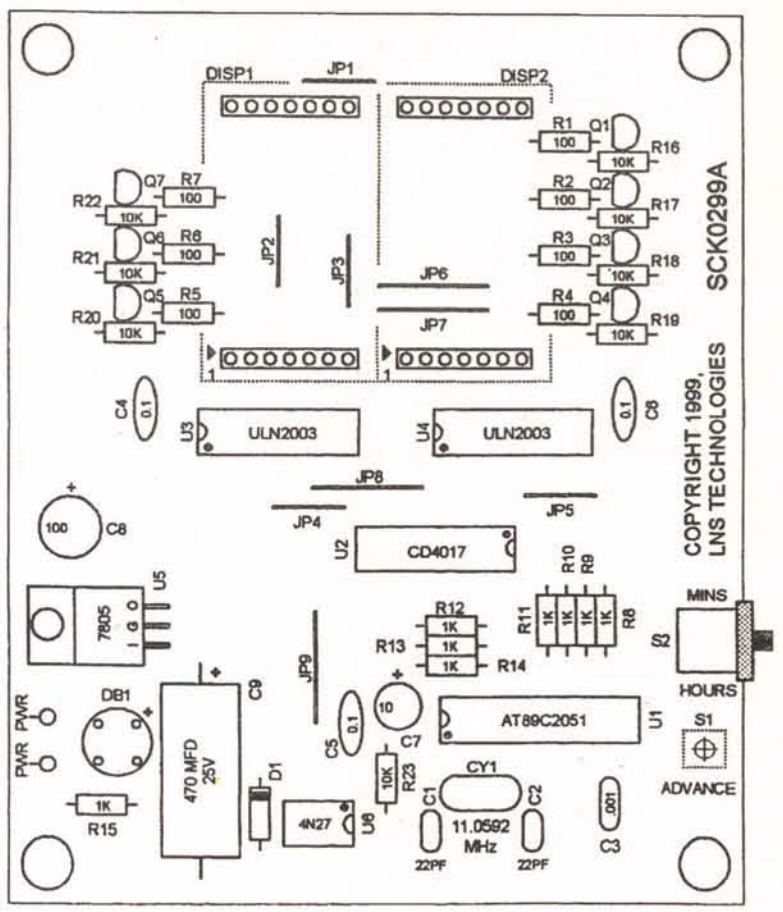


Figure 4: Parts layout.

be continuously, quickly scrolling leftward.

Two switches are used for setting the time. Switch S2 — a single-pole three-position switch — allows you to select minutes-set, run, or hours-set. When setting the time — either minutes or hours — push-button switch S1 advances the non-moving flashing digits about twice per second. You simply release the switch when you see the proper digits. The clock counts hours to 12, and there is no AM or PM designator or alarm function.

The Kit

I've built many, many (many!) kits in the over-40 years I've been an electronic hobbyist. The kit provided by LNS Technologies for this scrolling LED clock is one of the best kits I've built.

Why such a strong statement? The kit is not only very complete regarding some hard-to-find parts (lacking only solder), but the parts are poly-bagged by type, with a slip in each bag describing each included item. The microcontroller is pre-programmed. The required wall-plug transformer and pre-drilled plastic front and back panels are also provided to "package" the completed clock, as shown in the photos.

The 21-page step-by-step assembly instructions include the schematic and circuit description, the printed circuit board layout, the parts layout, and many clear illustrations.

Of course, a detailed parts list, and operating instructions are included, as well as soldering and troubleshooting suggestions. Even nine required insulated wire jumpers, all cut to length, bent, and with insulation trimmed off the ends are supplied! Finally, the printed circuit board is not only etched and properly drilled, but it is clearly silkscreened to show component locations. All in all, an outstanding kit.

If you decide to build this project from scratch, most parts you don't already have are available from Jameco, 1355 Shoreway Road, Belmont, CA 94002-4100, (650)592-8097, www.jameco.com. This does not include the programmed microcontroller or the displays, which are available from LNS Technologies. See the Parts List.

Assembly

Figure 3 shows the printed circuit board layout, and Figure 4 is the parts layout using this printed circuit board. Although you probably could build this clock on a perforated board with a different physical layout, you might run into trou-

Parts List

Resistors: 1/4-watt, 5% carbon film or equivalent
R1-R7..... 100 ohm
R8-R15..... 1,000 ohm
R16-R23..... 10,000 ohm

Capacitors:
C1,C2 ..... 22 pF 50V, ceramic or monolithic
C3..... .001 uF, 50V, ceramic or monolithic
C4-C6..... 0.1 uF, 50V, ceramic or monolithic
C7..... 10 uF, 16V, electrolytic
C8..... 100 uF, 16V, electrolytic
C9..... 470 uF, 16V, electrolytic

Semiconductors:
U1..... AT89C2051 microcontroller IC, programmed (see text)
U2..... CD4017 decade counter IC
U3,U4..... ULN2003A NPN Darlington driver IC
U5..... LM7805T 5VDC voltage regulator IC
U6..... 4N27 or 4N28 opto-isolator
Q1-Q7..... 2N2907 PNP transistor
DISP1, DISP2, LTP1157AE 5x7 LED matrix display, cathode columns, anode rows (see text)
D1..... 1N914 or 1N4148 signal diode
DB1..... Diode bridge rectifier, 200PRV, 1A

Miscellaneous:
PCB..... Etched, drilled and silkscreened printed circuit board
CY1..... 11.0592MHz or 12MHz crystal
S1..... Momentary push-button switch
S2..... Single-pole three-position slide switch
TXFMR..... 9VAC 500mA wall transformer
20-pin IC socket; (three) 16-pin IC sockets; six-pin IC socket; (four) seven-pin strip sockets; black plastic back panel, red transparent plastic front panel, panel mounting hardware, nine jumper wires.

The following items are available from **LNS Technologies**, P.O.Box 67243, Scotts Valley, CA 95067, (831) 438-2028 or http://www.techkits.com

Complete Scrolling Clock Kit including all parts listed above: $49.00; programmed U1 microcontroller IC: $12.00; DISP1 and DISP2: $3.50 each; etched, drilled, and silkscreened printed circuit board: $10.00. Add $5.00 USA shipping and handling per order. CA residents add 8% sales tax. VISA/MC accepted. No COD.

ble with stray radio-frequency interference.

Assembly is straightforward, but you have to be very careful about parts orientation of the electrolytic capacitors, the diode, the bridge rectifier, the integrated circuits, the transistors, and the displays.

Start by first installing the nine jumpers, then the resistors, diode, crystal, bridge, and regulator, being careful about polarity. Four seven-pin strip sockets are used for the displays, and standard IC sockets are used for the integrated circuits. Next, install the transistors, capacitors (polarity for the electrolytics!), and switches, then the power leads from the wall-plug transformer.

There are over 200 solder joints, so solder very carefully to avoid poor joints or unwanted solder bridges. Putting the entire kit together took me just under two hours, working slowly and carefully.

Finally, plug in the displays and ICs (careful about the orientation!) and you're ready to test the clock.

Testing

Testing the clock is simple enough. Put switch S2 in the center RUN position and plug the wall transformer into 117 VAC. The display should light up, blinking "12" (without the quotes). If some of the LEDs are not lighting, you'll need to do some troubleshooting, as I had to do later.

Assuming you have a blinking 12, move switch S2 upward to the "set minutes" position. Pressing and holding push-button switch S1 will advance the number of minutes until you release the switch. Now put S2 in the "set hours" position and set the hours with S1. When you have the hours and minutes set, move S1 to the center "run" position and watch the scrolling digits!

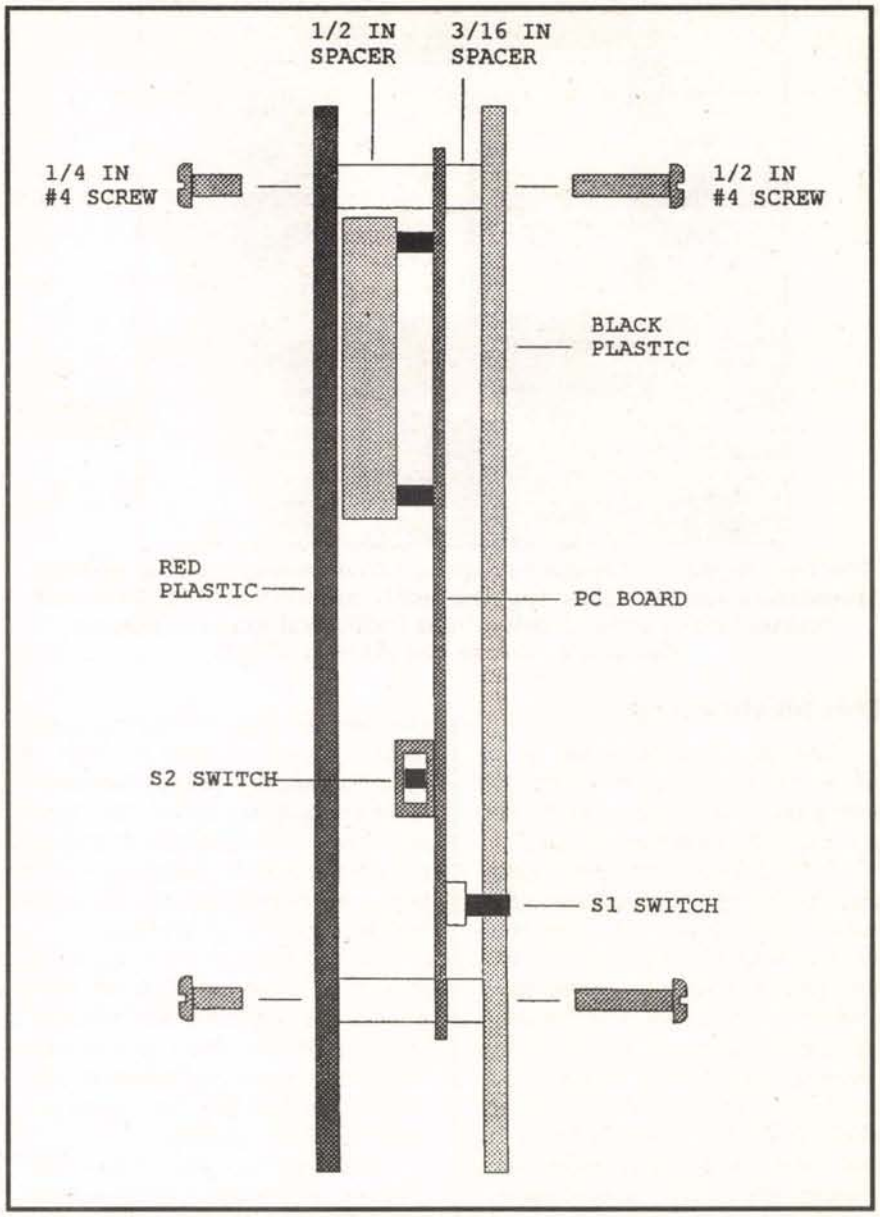
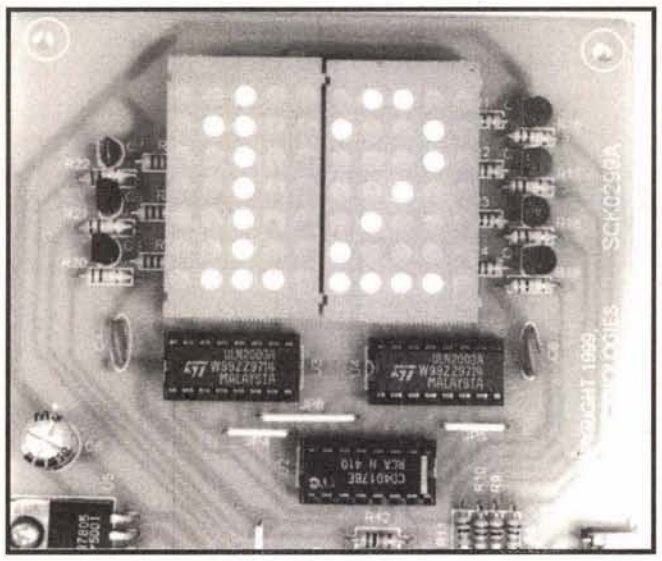
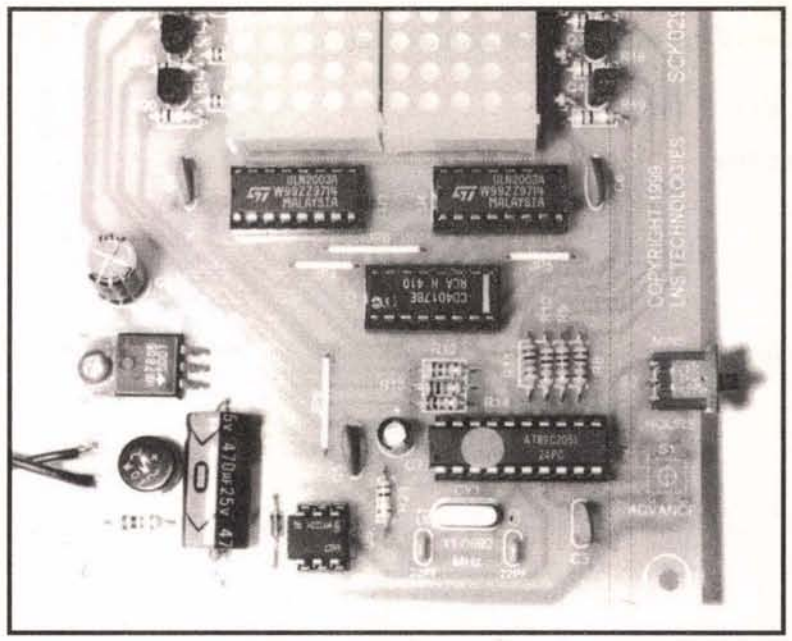


Figure 5: Final assembly of the kit sandwiches the clock assembly board between the red front and black back panels, using the supplied spacers and screws.



The two displays combine to form a 10-column seven-row matrix. Transistors and resistors, together with counting and LED current-booster integrated circuits, light individual matrix LEDs in sequence to create the moving effect.



Standard 60Hz 117VAC is used both to power and time-keep the scrolling LED clock. An opto-isolator driven by 60Hz provides precise clock-timing pulses to a programmed microcontroller.

Troubleshooting

Normal troubleshooting is to check for proper part orientation and good solder joints. But let me tell you what happened to me.

I'm 73 years old, and legally blind in one eye. This makes building electronic kits a bit more challenging, since I've lost stereo vision, and getting the component lead, soldering iron, solder, and the printed circuit board all in the same place at one time is a chore.

It is tricky to know exactly where each of these elements is, since there is no depth perception — especially at this close distance — with one eye.

So, I was very careful in assembling the scrolling LED clock. Yet, when I plugged it in, I did not get a "12." LED rows two and seven were not lighting! Hmmmm. Because all 10 columns were not used, I could not even be sure all the columns were working! However, placing S2 in the "run" position allowed scrolling, and all the columns were operating. Now it became a question of why rows two and seven were not lighting.

Looking at the parts layout in Figure 4, I verified that all parts were properly placed and oriented. That left solder joints as the next suspects, since experience has taught me that defective parts are usually not the problem.

Looking at the schematic (Figure 1), I decided to trace from pins 14 and 2 of DISP2 back to pins 13 and 18 of U1, respectively, checking each solder joint along the way. Using a strong magnifying glass, I found two solder joints that looked like they were not properly holding the leads. I re-soldered them — and everything worked perfectly! Or so I thought ... I set the minutes, then the hours, and the clock scrolled the time.

Packaging — and More Trouble!

Thinking everything was now perfect, I assembled the board between the red front and black back panels, using the hardware supplied, as shown in Figure 5. I decided to put it by my front door, together with two other digital clocks and an odd device called "The Eye of the Storm." This odd unit has streaks of orange-colored "lightning" dancing inside a clear glass globe. This is fascinating to watch, and when you put your fingers on the outside, the lightning goes right to your fingertips, making them appear to glow.

I set the scrolling LED clock to the same time as the two other clocks and went about my business, having completed another successful project.

But about eight hours later, the scrolling LED clock was about 50 minutes fast! Yoiks! Something was wrong! Did I have a microcontroller chip programmed for 50 cycles of power, rather than 60 cycles? That would make it count a minute in 50 seconds rather than 60 seconds, or gain 12 minutes in an hour, or 96 minutes in eight hours, not just 50 minutes. Hmmmm.

I plugged the clock several other places around the house, and it kept time perfectly! This meant something in the original location was causing this clock to run fast, though not affecting the other two digital clocks. Simple troubleshooting involved unplugging one of the other three items — and since the Eye of the Storm might be causing radio frequency interference (RFI) and causing random clocking signals, I unplugged it first.

Problem solved! It seems the scrolling LED clock is somewhat sensitive to nearby strong radio frequencies, although the other two nearby digital clocks were not affected. Subsequent investigation with a digital counter and portable AM radio verified that The Eye of the Storm was generating a goodly amount of RFI at about 38MHz.

Summary

Everything considered, this is one terrific project. If assembled carefully — and kept away from strong radio frequency interference — you'll have a real accurate and unique time-keeper, and a great conversation piece! **NV**

by Robert Nansel

Amateur Robotics

In the time warp that is paper publishing, I'm writing this column in spring, but y'all will be reading it along about midsummer. One of two recurrent, maddening events associated with spring here at the Robot Ranch is the arrival of carpenter ants inside our house (the other is the onslaught of pollen, which makes both Shoshana and me wish we could uninstall our sinuses and send them to Arizona for the duration).

Ants have always fascinated me. They are tiny biological robots that, viewed individually, aren't too bright, but viewed as an extended superorganism are brilliant. In fact, they seem to have the upper hand at the moment.

All this combat with the ants gave me plenty of opportunity to watch ants in action. Carpenter ants are fairly big, up to a half-inch long in these parts. They are thus easy to observe (man, are they agile). I've filed a few ideas away for Tall Grass, you bet, and I'm doubly eager to get my Heavy Iron CNC machine finished so I can mass produce robots based on ant locomotion. Now, if I could just convince one of the ants to stand still while I make measurements with my calipers ...

This month, therefore, I'm getting back into the thick of the Heavy Iron project. I've got a passel of old-time tips, tools, and techniques on how to improve the action of the X-Y tables, and then I finish with a trio of book recommendations.

Here we go.

Preparing the X-Y Tables

You can use kerosene, paint thinner, TSP, or even good old soap and water and elbow grease to remove the waxy cosmoline gunk coating the Enco X-Y tables. It's a good idea to take your tables completely apart to familiarize yourself with how they are put together and to get rid of any molding sand trapped in odd crevices. Once cleaned, be sure to dry everything and coat all bare metal surfaces with light oil to prevent rust.

As long as you use the right tools and don't use too much force, you shouldn't be afraid of breaking or misaligning anything. In order to get these tables into shape, you'll need to do a fair amount of tinkering – adjusting the gibs and smoothing any rough spots on the ways at a minimum – so become comfortable with all the pieces.

Depending on what your goals are for your Heavy Iron CNC machine, you may need to make more than just adjustments. For simple PC board drilling and routing, you likely won't have to do much more than adjust the gibs, but to use Heavy Iron to machine metal, you might have to do some more work. You might want better precision, smoother action, and to achieve this you may need to do one or more of the following: counterbore the leadscrew brackets to accept Torrington needle thrust bearings to reduce friction and play (www.torrington.com); replace the existing 10 TPI Acme lead nuts with anti-backlash nuts (www.picdesign.com) to reduce friction and backlash; hand scrape the dovetail ways to get more accurate, smooth sliding contact between the ways' bearing surfaces.

I'll leave the Torrington bearing and the anti-backlash modifications for another time. They aren't absolutely essential to building a version of Heavy Iron capable of drilling the holes in circuit boards. Later, I will show you how to extend Heavy Iron's machining capabilities, but for now, we'll just aim for circuit boards. It's better to spend less money and effort up front and get some experience with what your CNC machine can do. Then you'll have a better idea of what changes to make in the future.

Enco Backlash

A number of readers have expressed concern with how much backlash they perceive in the cross-feeds of the Enco X-Y tables I've recommended for this project. There will always be some backlash – also known as slop – in machine tool cross-feeds; some of it can be eliminated by proper adjustment of gibs and thrust bearings, etc., but some slop will always remain. Indeed, some backlash is desirable to free operation of machine tools. By providing extra clearance in the mating of feed screws with their nuts and meshing of gears, your machine tool will be quieter, will wear longer, and will optimally use the strength engineered into its components.

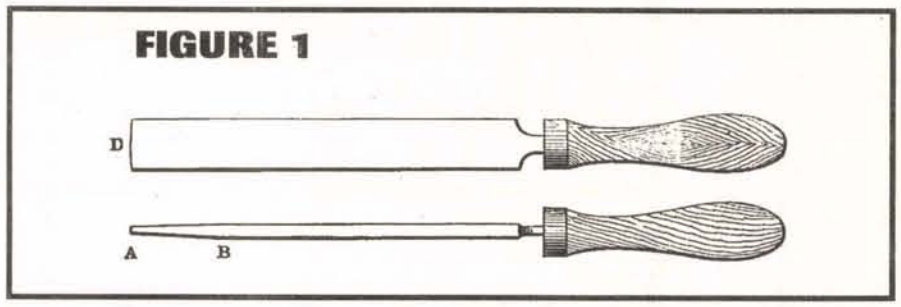


FIGURE 1

There are ways to drastically reduce backlash in cross-feeds by using special components such as ballscrews instead of plain Acme screws, but these are expensive; you really want to be sure you need them before you spend the money for them. For Heavy Iron, I'm assuming that everyone will use Acme screws. Since you can't and don't want to eliminate backlash with Acme screws, you have to learn to live with it. One of the first things you learn in machine shop is how to compensate for backlash.

I learned to run lathes and milling machines in a typical community college machine shop. The shop had a variety of machine tools, new, old, expensive, cheap, in all possible permutations. One thing they had in common after years of being abused by students was slop in their feeds. How were we expected to maintain tolerances of 0.001" when there might be as much as, say, 0.100" slop in the cross-feed?

As my shop teacher was fond of saying, anyone can get good results from a brand-new, properly adjusted machine tool, but it takes a real machinist to get good results from an old, worn-out machine. Fortunately, compensating for backlash isn't that hard.

Compensating for Slop

First of all, you must get an idea of how much backlash is in your feed screws to begin with. After you've adjusted the gibs, handwheels, and thrust collars to minimize other slop that can be mistaken for backlash, tighten up the gib screws a little more to lock the machine table in place (some tables are provided with thumb setscrews for this purpose).

Now gently turn the feed wheel counterclockwise until it meets firm resistance; note the reading on the graduated collar, then turn the wheel the other way and note what the graduated collar reads when the feed wheel stops in this direction.

The difference between these two readings is the feed's backlash. If you want to be really thorough, you can perform this backlash measurement several places along the feed screw and average the results together. (Don't forget to readjust the gibs or the setscrew for normal operation after you've measured backlash.)

The effect of backlash is that the same position of the machine table will show different readings depending from which direction you

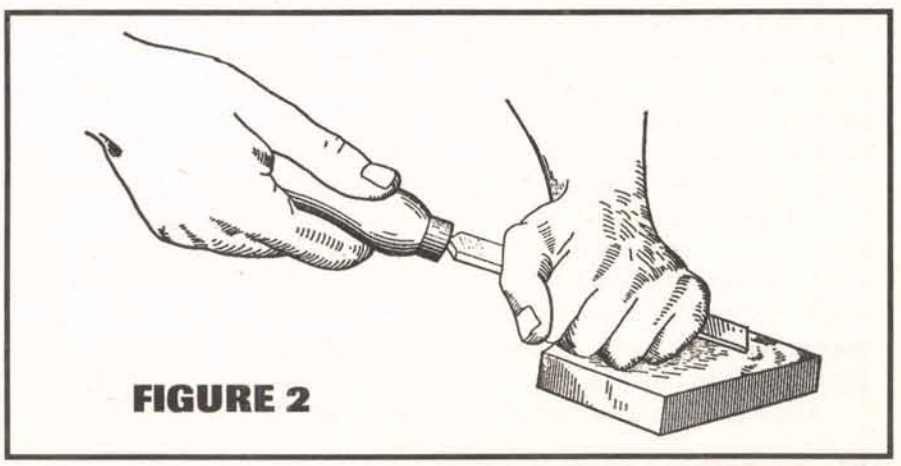


FIGURE 2

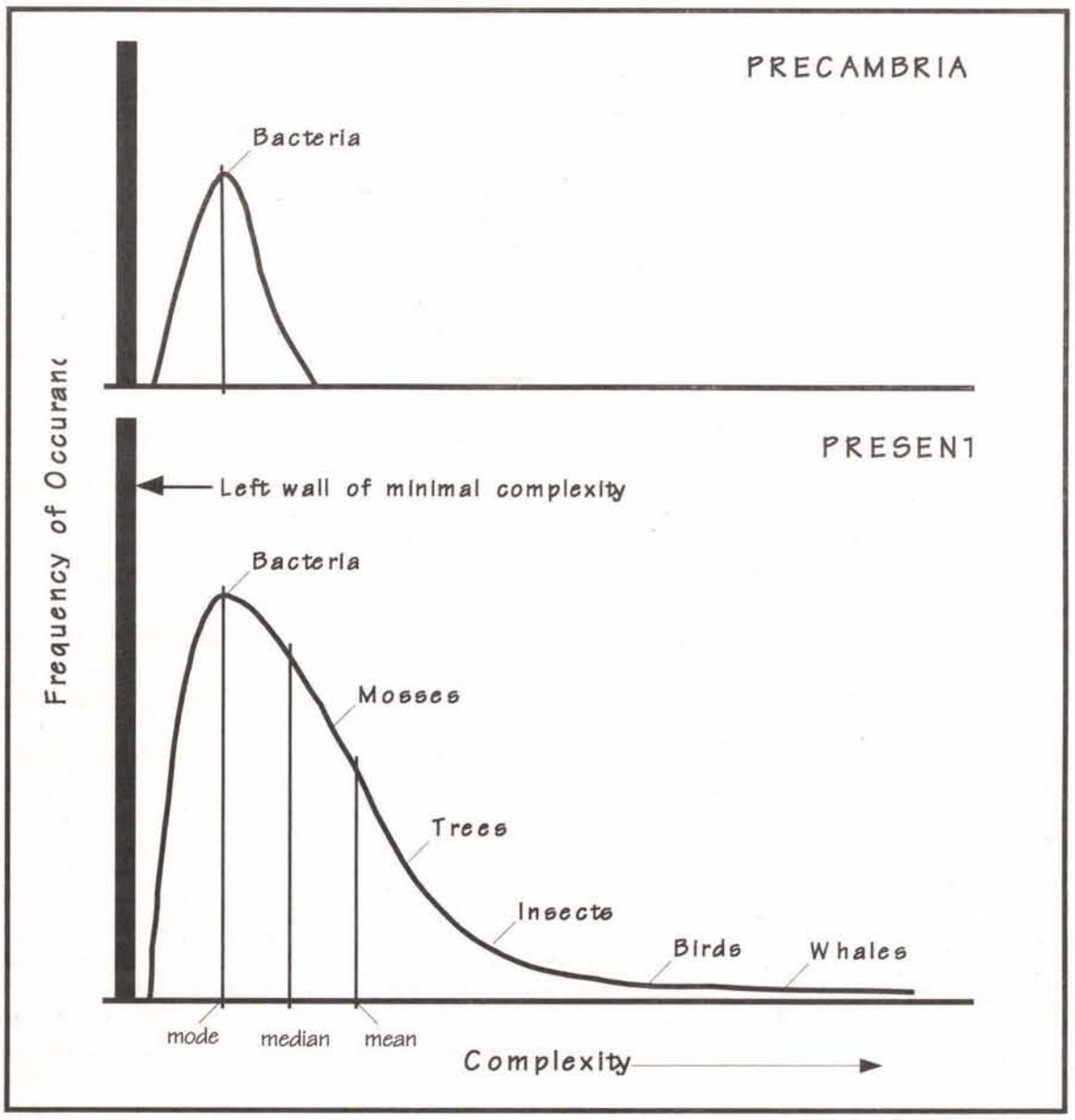


FIGURE 3: Right Skewed Distribution of Life's Complex

approach that position. To compensate for backlash during manual operation, then, you could add or subtract the appropriate amount of known backlash from what you read on the graduated collars each time you make a cut. However, that would be inefficient and error-prone.

A better way is to always bring the cross-feed graduated collar back to zero – or whatever offset you are using – from the same direction for each cut. Say you are measuring the feeds for your cuts by turning the relevant feed handwheel clockwise. Each time you want to make a new feed change from zero, you should turn the wheel counterclockwise past zero by a little more than the backlash amount, then clockwise through zero to your desired feed reading, all the time maintaining constant pressure on the feed wheel. If you should overshoot your desired position, back off to take out the slack and try again.

This is all much easier to do than to describe. Even better, the CNC software you'll be using allows you to enter backlash compensation parameters for each controlled axis. There are still a few gotchas – as well as work-arounds to deal with the gotchas – but I'll talk about those in future articles.

More Precision?

If you want more precision, one place where it really pays to spend time is truing up the dovetail ways of the X-Y tables. The surface finish of the ways leaves something to be desired with both Enco X-Y tables I bought. These are not precision ground bearing surfaces the way they come from Enco, and lacking access to a surface grinder to correct this, I resorted to hand scraping the mating surfaces to get a better fit.

Hand scraping the ways is not necessary for the PCB version of Heavy Metal, though it's certainly worth your time to remove any machining burrs and scrape down any noticeable rough spots. I outline the more rigorous precision scraping process below because the techniques and tools mentioned are generally useful for the construction of the rest of the project.

The art of hand scraping is actually quite easy to learn, and the level of precision you can reach using the technique is astonishing. It was the method used to make true surfaces for the first precision machine tools two centuries ago, before there were the tools to make the tools. It is still in use today to finish new premium machines and recondition old ones. Using hand scraping, you can produce surfaces as perfectly true and smooth as you wish, to millionths of an inch, if you have the patience.

Surface Plates

In hand scraping, one surface serves as the test standard against which one or more other surfaces are measured. Sometimes the standard will be the surface of a part meant to mate with another part, such as a shaft to run in a bearing, a tapered plug to fit in a tapered socket, or the inside angles of a dovetail.

A more general test standard is a precision surface plate – a slab of granite or cast iron with a perfectly flat surface. With either type, you apply a thin coat of indicator color to the test surface to show up high spots on the work when you rub the work against the test standard. Dykem Hi-Spot Bluing Paste (Enco #505-1387, $4.46 a tube) is a good indicator color, but Prussian blue oil paint available from art supply stores will do also.

A surface plate is used in two ways: "wet" as a test standard to which is applied an indicator color as above; "dry" as a reference surface for doing precision layout on machine parts. In a shop where I once worked, I used a surface plate exclusively for the latter purpose, and I miss having one. Surface plates are quite expensive, though; an 18x24 Starrett pink granite surface plate – .00026" unilateral tolerance – runs about $300.00 including shipping in the continental US (a good thing, since this baby weighs 165 lbs.).

You can also find cheaper import brands. For instance, Enco's #640-0140 18x24 black granite surface plate is just $49.99, and it sometimes goes on sale for less than $40.00. Depending on where you live, though, you may pay more for shipping than for the surface plate itself. It weighs 180 lbs., and truck freight from Enco's warehouse in Nevada to Pittsburgh, for instance, is about $80.00, enough to deter me from buying one just yet.

Just Scraping By

Anyway, once you've got the high spots indicated on the work, you use a hand scraper to scrape metal from high spots to gradually bring them down. You can buy 4" machinist scrapers from Enco in triangle, flat, and half round styles (Enco #380-0030, #380-0020, and #380-0025, respectively); they cost only $1.65 each, so I recommend getting a couple of each. They are a bit small for hand scraping large surfaces, but quite useful for deburring and scraping small areas.

You can also make a larger scraper from an old file by grinding it to the profile shown in Figure 1.

Robotics

The end A should be ground at right angles to the centerline of the file, and the teeth should be ground off on a flat taper about 1-1/2" long, varying in thickness from about 1/16" at A to the thickness of the file at B. The end should be very slightly rounded at D so the corners of the scraper won't dig into the work.

In grinding the file, you must grind lightly and cool the file frequently in water. You don't want to draw the temper by allowing the metal to become too hot while grinding. If this should happen, the metal won't be hard enough to cut. A half second of grinding followed immediately by several seconds cooling in cold water should do the trick. Once the proper profile is ground, finish the scraper by honing it on an oil stone until sharp and smooth.

To use the scraper, hold it as shown in Figure 2. Hold the scraper at a shallow angle with respect to the surface to be scraped and push smoothly along the work to remove thin shavings of metal.

If the scraper chatters, you are probably holding it at too high an angle; the higher the angle, the deeper you cut. Chatter can also occur if the edge isn't uniformly sharp.

Move the scraper in one constant direction for each pass over the work using short strokes about 1/2" to 1" long, all in the same direction. Reapply the work to the surface plate to indicate the new high spots, and go over the entire work again with the scraper using strokes at right angles to the previous direction.

The third pass you may stroke the same direction as the first or half way between the directions of the first and second. The fourth pass should be at right angles to the third.

Continue this process of rubbing the work on the test surface and scraping the high spots until the high spots are all small and evenly distributed. When you begin, there may be only a few high spots representing a small percentage of area contact between the surfaces.

The contact points become more numerous and closer together as you scrape the surface true. A dead-flat surface would have 100% contact, but it's better to shoot for 75% contact; this is a good compromise between enough precision for the job and good friction and wear characteristics.

Alternatives to Surface Plates

A good quality bench level with milled surfaces will work in place of a surface plate, as will any precision machined surface such as a drill press table. Plate glass — because of the way it is manufactured — also possesses the necessary smoothness and flatness, provided you support the glass so it won't flex. Ordinary window glass won't do (it's not precise enough).

If you can find plate glass 1/2" thick or more, that is ideal, though in my area anything thicker than 1/4" is a special order item. I have heard of laminating thinner blanks of plate glass together, but you would have to be very careful about how you perform the lamination — the adhesive used must be a close thermal match for the expansion rate of plate glass.

In our case, we're interested in the bearing surfaces of dovetail slides. A surface plate would only be able to help indicate the trueness of the accessible flat bearing surfaces of the slide (it's of no use, directly, on the inside angles).

On disassembling the larger X-Y table (Enco #201-2536), the accessible bearing surfaces are the top and bottom of the saddle. For the smaller table (Enco #201-2826), the accessible bearing surfaces are the top of the saddle and the top of the base.

To sum up, if you have — or can improvise — a surface plate, feel free to try your hand at hand scraping. For very little money, you can turn a mediocre machined surface into a thing of precision beauty.

Full House

What do a drunkard's walk, the disappearance of 0.400 hitting in baseball, the Boston Marathon, and the dominance of bacterial life on Earth have to do with each other? For Stephen Jay Gould, they are all systems — natural and artificial — that illuminate the nature of evolutionary trends. In *Full House: the Spread of Excellence from Plato to Darwin*, Gould uses these systems and more to shine daylight on some commonly held — but erroneous — beliefs about trends and progress in nature.

Why should a book about evolution — even one as entertaining as this one — be of interest to robot builders? First, all engineering design is evolutionary; there are no truly blank paper designs, all engineering depends on what has gone before. When we design a new robot, we add incremental changes to previous robots, we combine elements from other robots in some new way, or — more often — we do a bit of both. Successful robots tend to be the ones that get copied. Variation with differential descent: that, dear reader, is evolution in a nutshell.

Second, in the last 20 years, we've used evolutionary techniques to create software — so-called genetic algorithms. Moreover, in the past year, we've begun to use these same techniques to evolve and manufacture complete mechanical designs for robots with minimal human intervention. Within the next 20 years, I expect it to become the norm for new robots to be evolved in computers rather than designed by hand.

Both of these are good reasons for amateur robot builders to learn the subtleties of evolutionary processes, and Gould, in this and other books, is extraordinarily lucid in explaining how it all works. *Full House* is particularly important because it shows how to tell the difference between evolutionary change brought about by random variation versus trends being "driven" by biases.

Bias Bugs

For genetic algorithms and robot evolution, it's crucial to distinguish normal random variation from bias-driven trends; the former is desired for the efficient search of the solution space and the latter may indicate bugs in the simulation. Evolutionary robots depend on faithful simulation to evaluate the "fitness" of each design, so if there are biases, we want to know about them.

Gould's arguments can be summarized by the following:

1) Life must necessarily have begun at a "left wall," the minimal complexity for organized matter to be considered alive. As Gould says, you can't precipitate a lion out of the primordial soup.

2) These minimal-complexity forms are very close to the dominant form of life on earth — bacteria. Bacteria are the "mode" on the distribution curve of life's complexity, and they have been for 3.5 billion years. There is no driving tendency to "progress" to higher forms. While it is true that the mean complexity

of organisms has increased through time, the mode has stayed the same. If there were a bias toward more complex life in evolution, you would expect the mode of the curve to move rightward as well, but the mode has remained the same for billions of years – bacteria rule.

3) The successful expansion of life over time forms an increasingly right-skewed frequency distribution. Life began at the left wall, so the only direction to expand was to the right. Purely on a random basis, some lineages will wander away from the left wall and form a right tail of the curve. One such lineage is ourselves, but remember we are vanishingly rare compared to bacteria.

4) It's a distortion to characterize a distribution by its outliers. Suppose you sampled through time the extreme right edge of complexity, what sequence would you see? Gould suggests it might be: bacterium, eukaryotic cell, marine algae, jellyfish, trilobite, nautiloid, placoderm fish, dinosaur, saber-toothed cat, and Homo Sapiens. Except for the transition from bacterium to eukaryotic cell, not one of these organisms would be an ancestor of the next. Each arrived on the right extreme by chance via less complex ancestors on the left. The tail does not wag the dog.

5) The cause of the increase in numbers and kinds of life resides at the left wall and in the spread of variation. The right tail of the curve is a consequence, not a cause.

6) Away from the wall there appears to be no bias for a given lineage to move closer or farther from the wall.

7) Over time many different organisms have been the extreme outlier. If we could replay the game of life again and again, always starting at the left wall and expanding from there, we would always get a right tail to the distribution. What organisms inhabited this region of greatest complexity would be wildly unpredictable for each run.

We are not the apex of evolution, but the extreme tail of a very old, very skewed distribution. If there is anything unique about us, it might be that we may be the first species that will have the chance to design our own posterity. Which brings me to the next two books.

Darwin Among the Machines

George B. Dyson wonders if trees think and whether machines might have souls. He comes to these questions not through foggy mysticism but through crisp knowledge of computation in its many guises. *Darwin among the Machine's: the Evolution of Global Intelligence* is foremost a book about the computational processes evident in markets, ecologies, evolutionary adaptations, brains, and, of course, computers. It is also a book about what computers have been and may become, a history of the ideas and thinkers who imagined, theorized, and eventually built computing machines.

Dyson deftly weaves together the stories of these thinkers, some well-known, some obscure, and some surprising: André-Marie Ampère, Charles Babbage, George Boole, Samuel Butler, Charles Darwin and his grandfather Erasmus Darwin, Thomas Hobbes, Gottfried Wilhelm von Leibniz, Warren McCulloch, John von Neumann, Isaac Newton, Nobert Wiener, Alan Turning, and many others. I'm reminded of James Burke's *Connections* series, but Dyson's connections are less whimsical and more thoughtful and deep, making for fascinating history and great stories.

I suggest reading this book only after getting a good grounding in evolution (Gould's *Full House* above is perfect for this), but do read this book, read it and soar. It will surprise and delight you with its gardens of the mind, and its digital ecologies of the machine.

Emergence

John H. Holland, the "father of genetic algorithms" has written a wonderful, ambitious book that attempts – and largely succeeds – to unify such seemingly disparate things as board games and neuroscience, economics and literature, and physics and evolutionary biology. It is a broad exploration of emergence, the simple idea that the whole can be more than the sum of its parts.

Holland says in *Emergence*: "We are everywhere confronted with emergence in complex systems – ant colonies, networks of neurons, the immune system, the Internet, and the global economy – where the behavior of the whole is much more complex than the behavior of the parts." He is fascinated with a vine emerging from a seed, life emerging from physics and chemistry. Much coming from little.

Cybernetics and Evolution

Braitenberg, Valentino; *Vehicles, Experiments in Synthetic Psychology* (MIT Press, Cambridge, 1984)
ISBN 0-262-02208-7 (hard), 0-262-52112-1 (paper)

Dyson, George B., *Darwin Among the Machines: the Evolution of Global Intelligence* (Perseus Books, Cambridge, 1997)
ISBN 0-7382-0030-1 (paper)

Gould, Stephen J., *Full House: the Spread of Excellence from Plato to Darwin* (Three Rivers Press, New York, 1996)
ISBN 0-609-80140-6 (paper)

Holland, John H., *Emergence: from Chaos to Order* (Perseus Books, Cambridge, 1998)
ISBN 0-201-14943-5 (hard), 0-7382-0142-1 (paper)

Levy, Steven, *Artificial Life: a Report from the Frontier where Computers Meet Biology* (1st Vintage Books ed., New York, 1993)
ISBN 0-679-74389-8 (paper)

Wiener, Norbert, *Cybernetics: or Control and Communication in the Animal and the Machine, 2nd Ed.* (MIT Press, Cambridge, 1961)
ISBN 0-262-23007-0 (hard), 0-262-73009-X (paper)

How can this happen and why is it at once both so common and so rare? In any attempt to answer these questions, you run smack into the paradox that much does indeed come from little – much, much too much. The complex behavior of emergent systems blinds us to the underlying simplicity that drives them.

A good way to deal with complexity is with a model. Models – Holland conceives – include maps, games, paintings, and even metaphors and poetry. A good model exhibits the same complexity and emergent phenomena of the system it models, but with confusing details sheared away. Models capture the regularities of emergence.

Another way to attack complexity is with well-understood building blocks. The building blocks themselves can be quite complicated, but as any software designer knows, once you can reduce something to predictable inputs and outputs and put it in a black box, you've gone a long way to conquering a larger problem.

Holland's agenda is to find and formalize regularities in how complexity emerges in all kinds of systems obeying simple rules. There's a good deal of mathematics in this book, but all the hairy stuff is set off in boxes; the text itself is written so you can skip the math if you want and still get most of the meaning.

I particularly enjoyed Chapter 4 on Arthur Samuel's checkers player program (which taught itself in the 1950s how to play checkers better than Samuel), and Chapter 5 is the best introduction to the behavior of real neurons and neural networks I've ever read, bar none. (Be aware, though, there is an error in Figure 5.5c and repeated in Figure 5.6).

I would recommend the book on the strength of those two chapters alone, and there's lots more great stuff in the other 10 chapters. Definitely read this book. Combined with *Full House* and *Darwin Among the Machines* (and the other books in the sidebar), it's a super way to triangulate on the broad field of evolutionary robotics and computation. Think of it as re-tooling your mind for the revolutions to come.

Journey to the Ants

That's all the space I have this month. Reading the books I recommended has helped me understand how an anthill can be so smart when individual ants are so dumb. The carpenter ant colony I've been battling with the past couple weeks showed all the signs of being smarter than me, but I finally got their number: they have a collective sweet tooth. The poisoned ant baits from the super market work much better now with a tiny bit of maple syrup rubbed in the poison. The tide has turned. See you next month.
NV

If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

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Raiders of the Lost Mainframes

Silicon Valley's Computer Museum History Center

by Ed Driscoll, Jr.

Photography by Art Puliafico

At the end of *Raiders of the Lost Ark*, the mystical and treasured Ark of the Covenant, which Indiana Jones had spent the entire movie risking life, limb, and fedora to rescue, is placed inside a warehouse that seems to stretch on towards infinity and beyond. (Oh wait, that's the slogan from Toy Story. Sorry — wrong movie!)

It's placed along side a vast number of other priceless artifacts. (Sure the shot is a rip-off from the end of Citizen Kane, but every film borrows something from Kane or 2001.) Well, the computer lover's equivalent of one of Indy's archaeological digs is Silicon Valley's Computer Museum History Center in Mountain View, CA.

While it plans to open a proper, more museum-like facility in 2005, currently, the Computer Museum History Center (or CMHC for short) is housed in Building #126, a World War II-era storage facility on the grounds of NASA's Moffett Federal Airfield.

Behind it, creating an ominous, overpowering feeling, simply by its sheer size, is the enormous Hangar One, 200 feet wide and 1,000 feet long. (One thousand feet! In other words, it's bigger than TV's original starship Enterprise, which was supposed to be 'only' 947 feet long.)

Hangar One was built in the early 1930s for the Navy's rigid Hindenburg-sized dirigibles. It totally overwhelms the museum's facilities, and graphically illustrates a theme of miniaturization, which has benefited both aircraft and computers.

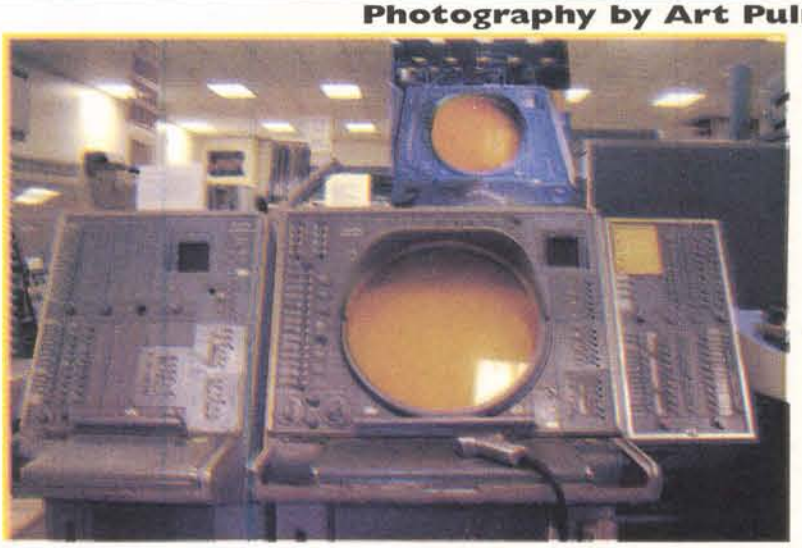
The CMHC's current home is divided into two rooms, 'T' style, with one large room filled cheek to jowl with mainframes and supercomputers, and the other filled with PCs, robots, even a computer-equipped bicycle, along with other oddities, rarities, and peculiarities of the computer world. The museum's web site at http://www.computerhistory.org/ highlights both the scope of the collection and its history.

Let's look at the museum's collection of mainframes and supercomputers; they're the history, the bedrock, the foundation that today's PCs are built on.

Heeeeeeeeere's Johnniac!

One of the first computers visible when walking through the CMHC's front door is Johnniac, a hugely influential — and just plain huge — beast of a computer from the early 1950s.

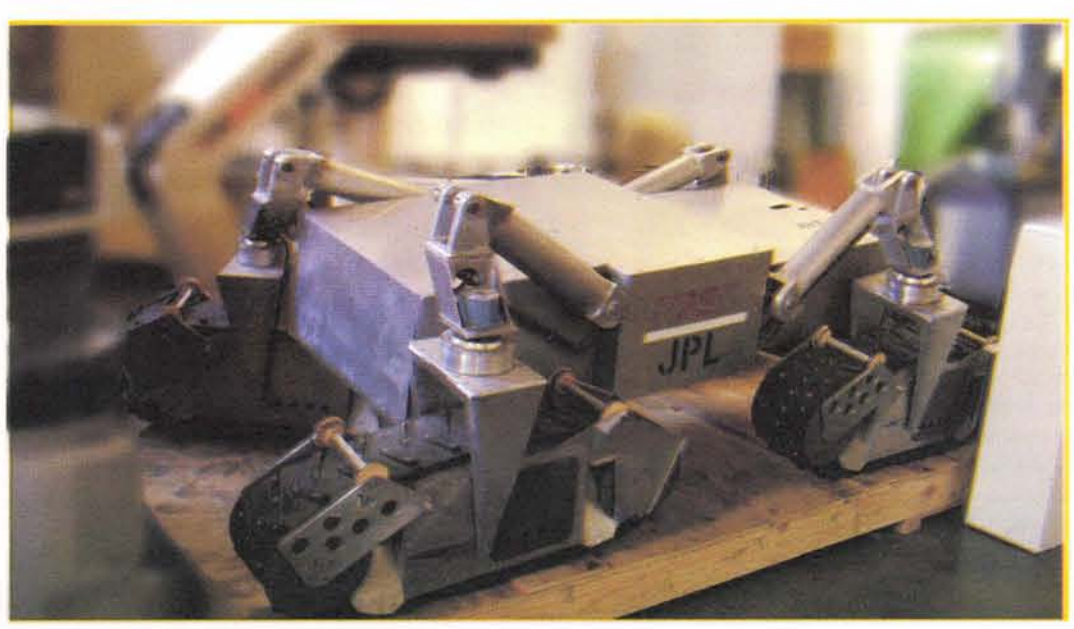
Built by the RAND Corporation, Johnniac's exterior features styling perfectly in tune with the early 50s — all rounded edges and bakelite finishes, sort of like a giant, 10 foot square refrigerator. (Which it was. Air-conditioning equipment installed on the



SAGE screen and light gun

SAGE panel

CRAY-1



Mars Rover

floor below Johnniac pumped in cool air over the machine's over 2,000 vacuum tubes to keep them from overheating.)

Turning the old cliché of 'form follows function' on its head, Chris Garcia, the Museum's historical collections coordinator, says that it's quite possible that the case came before the guts of the computer. "I've seen an early painting of Johnniac that is dated 1951," he says, "and that precedes the machine by almost three years, so I don't know. It's a very interesting question, and I've tried to get a more solid guarantee on that, but I don't know if it will ever come — most of those guys are either gone, or are slowly going away."

While Johnniac's massive exterior case is all sober 1950's design, its name must rank as a high point of silliness in the otherwise staid, tweed jacket, and briar pipe world of mid-century computer engineers. The Johnny in Johnniac comes from John von Neumann, one of the early computer pioneers, who cut his teeth designing ENIAC.

Von Neumann was actually none too happy at RAND's choice of a nom de mainframe. In a benign forecast of the rather more virulent Gates/Jobs wars of the early 1980s, Garcia says that Von Neumann wrote off a very nasty letter, saying, "How dare you name this machine after me!" No one is sure what prompted the slight, but Garcia speculates that it was Von Neumann's ego getting in the way, since he had little or no input on his namesake other than the fact that it used his basic computer architecture.

The RAND Corporation built Johnniac to aid in the design of national defense projects at the height of the Cold War, but it also performed more mundane workday tasks like running RAND's weekly payrolls. It even had an early time-sharing system called JOSS, or the Johnniac Open Shop System. Garcia says, "It did a lot of really important work for RAND, a lot of it which only recently has been made available to the public."

Amazingly, Johnniac soldiered into 1965 as a regularly used mainframe, and it was only by 1968 that it was slowly phased out.

To put into perspective Johnniac's size, and to reduce any qualms about computer-envy, consider what Willis Ware, one of Johnniac's original designers, was asked a few years ago at a symposium at the museum. "In today's terminology, just for comparison, suppose you're building Johnniacs for sale, you want to put an ad in the *Computer News*, and sell the thing. What clock speed, how much RAM did it have, how many ports — what kind of capacity …"

Ware's response? "Zero, zero, zero, and zero," causing much laughter around the room. Ware said, "It had no clock; it had no ports, in the current meaning of that word; had very nominal memory, 4,000 words by eight bytes per word — five, rather, excuse me."

That faint sound you're hearing is your PC laughing its printed circuits off.

Raiders of the Lost Johnniac

So how did the museum get Johnniac? According to John C. Toole, the museum's Executive Director and CEO, Johnniac had been on display at a Los Angeles county museum. One day, Willis Ware was horrified to see his baby sitting in the museum's parking lot! "They were just getting rid of it," Toole says. "It was one of these things where the accession records were probably lost over a period of time, and somebody said, 'we've got to clean this out for a new exhibit, get rid of it!'"

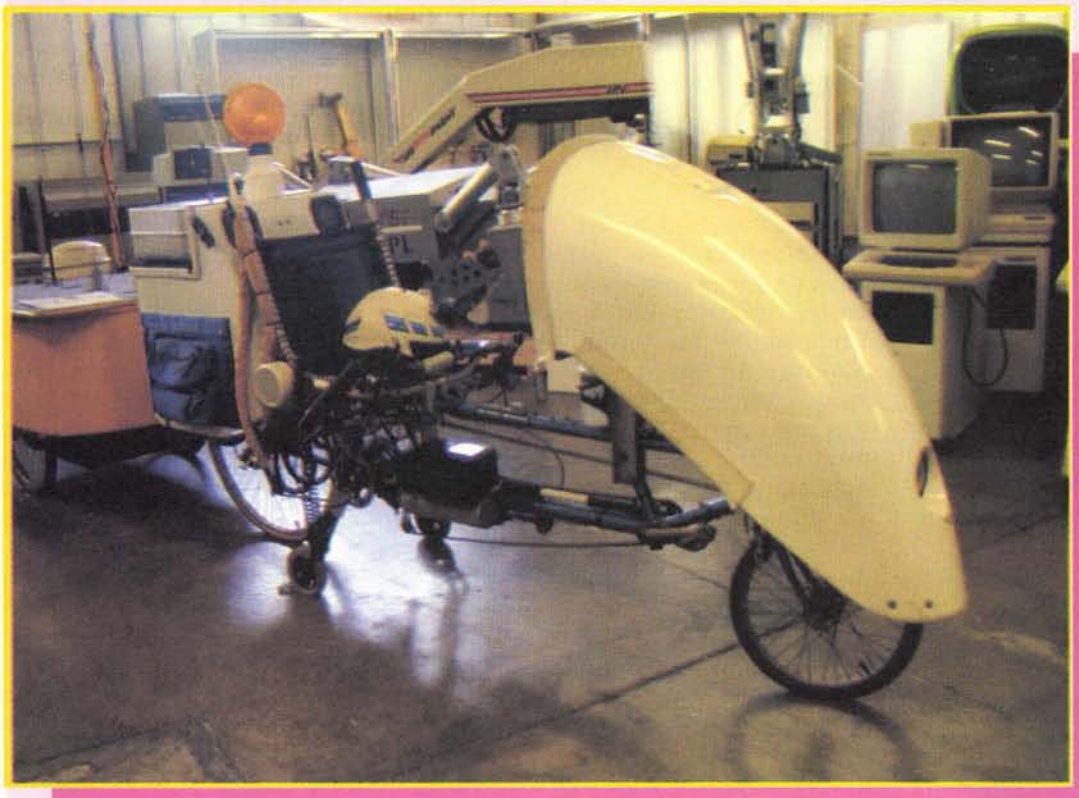
In the late 1980s, the predecessor to the Computer History Museum was located in Boston. "Ware apparently called the Computer Museum because he knew Gwen." Gwen was Gwen Bell, the wife of Gordon Bell, and the two were the cofounders of the Boston version of the current Computer Museum History Center. So having been rescued from computer oblivion, Johnniac was crated up and shipped to Boston, where it was on display until it returned west, along with the rest of the museum's contents, in the mid-1990s.

The Mother of All Air Defense Computers

Those 2,000 vacuum tubes inside Johnniac seem positively minimalist when compared with SAGE (Semi-Automatic Ground Environment), which contains a whopping 100,000 worth. The 400 square feet of SAGE hardware in the museum's collection came from one of the last survivors of a family of 28 identical computers, part of a project begun in the early 1950s and online by 1958, networked together to create an embryonic Cold War air defense system against Soviet nuclear bombers.

The museum's SAGE is particularly noteworthy, since it was the last operational SAGE to be removed from service in North Bay, Ontario, in 1983.

A Bicycle with a Trailer and Robots? In a Computer Museum??



Of course, Dr. Strangelove-style Cold War super computers are far from the only equipment in the Computer History Museum's collection. In the visible storage facility, there is a room filled with robots, many of the most historically significant personal computers of the 1970s and 80s, and a bicycle with a trailer.

Yes, I was curious about that last one, too. So I asked Chris Garcia just what is the deal with the damn bicycle stuck in the middle of a room otherwise filled with robots, video games and PCs. He explained that it's called BEHEMOTH, or the "Big Electronic Human-Energized Machine, Only Too Heavy."

In 1983, Steve Roberts, a computer consultant and ham radio experimenter was getting bored with the humdrum of suburbia, and was overtaken with a sense of wanderlust (these things happen in suburbia — even otherwise sedate Ohio suburbia — from time to time). So Roberts decided to take to the open road on a cross-country bicycle trip. He built a couple of first-generation super-bikes, one of which he dubbed the Winnebiko, until he finally realized exactly what he wanted to do while bicycling — basically, the simple, everyday things that everybody wants to do on their bikes: word processing, sending email via Compuserve, and talking on ham radio. (Given England's environmental concerns, Q Branch is probably modifying a Schwinn for James Bond with all of these features, and an ecologically balanced laser cannon in the front fender, to boot.)

Robert's 'pneumatic research lab' cost 1.3 million dollars for all of the technologies he wanted integrated into it. Garcia says that Robert's Über-Schwinn allowed him to ride more than 16,000 miles, write a book, "write articles for every magazine known to man, give interviews for magazines and television stations, and just all sorts of other neat stuff."

After one final jaunt through the Midwest, Robert's wanderlust began to develop sea legs, and the BEHEMOTH was eventually retired to the museum. His current passion is building a 'tri-maran' (a catamaran with a hull to spare) with similar features to sail around Florida with. Perhaps that too will end up in the museum, displaying man's ability to interface technology with any vehicle imaginable.

Robots, for Earth and Beyond

The BEHEMOTH isn't the only mobile computing machine in the museum's collection. Several robots sit next to it. And what interesting robots they are! They include the early-1960s Rancho Arm, which is often referred to as 'the first real robotic arm,' and its cousin, The Stanford arm, which was the first successfully computer-controlled arm.

Then there's Shakey, a mobile robot so named because whenever it would go over doorway jams, the top portion, which "wasn't completely stable," according to Garcia, would shake very violently.

Shakey, despite's its derisive name, was very important and influential in the generations of mobile robots that followed it. It sits near a machine with four tank treads, and a Jet Propulsion Laboratory logo, which is a Mars Rover prototype from the early 1970s that never left Planet Earth. Garcia says that NASA planned to send the Mars Rover to map and explore the planet. "The project was scrapped, in favor of manned spaceflight," Garcia says, "that became NASA's real baby at that point." Although in the 1990s, a new Mars Rover was developed and successfully deployed.

But Garcia thinks that in the 1970s, NASA may not have had the technology back then to accurately send the commands to the robot from Earth to Mars, 35 million miles away.

In a way, SAGE may have been the 'Star Wars' project of its time. Just as the fear of the Space Defense Initiative was enough to cause the Soviet Union to begin to unravel in the late 1980s, in the 1960s, even if SAGE never would have worked, larger-than-life rumors of its existence made it enough of a bluff to have helped keep the peace, especially during the Cuban Missile Crisis. Which is fortunate, because by the time SAGE was active in the early 1960s, it was essentially obsolete, as it was too slow to track hypersonic ICBMs.

Whatever its flaws, Garcia says that the SAGE program had "massive innovations in its architecture. Things like modems, CRTs, a decentralized network, and the light gun interface," which would allow the operator to click on SAGE's monitor and pull up information from various databases. The knowledge derived from SAGE would later be used in another aviation computer project, American Aviation's Sabre airline reservations system.

Each complete SAGE installation, encased in hardened concrete, was huge, Garcia says. "I've never gotten a good tonnage answer, but the way I had it described to me by one of the gentleman who had worked in it, was, 'If you took Fenway Park, filled it with electronics, buried it a half mile underground, that was one SAGE installation.'"

In addition to the massive size of each SAGE installation, the project's hyperbolic style included the number of people who programmed it, which was "somewhere around half of the world's programmers in the late 1950s," Garcia says.

Cray: In the Border Between Functional and Aesthetic

While the late-1970s ushered in a new era of cheap, relatively low-cost personal computers, eventually developing into the PC or Mac that sits on your desk, there were (and are) more than a few big gargantuan computers still being produced — the most well known of which are named after their designer, Seymour Cray. He's "probably as close to a rock star as the computing industry has," Garcia says. "The museum has been very lucky to be able to document his history, dating back from even pre-Cray, when he was with Control Data, and the NTDS, which he designed for Remington-Rand-Univac."

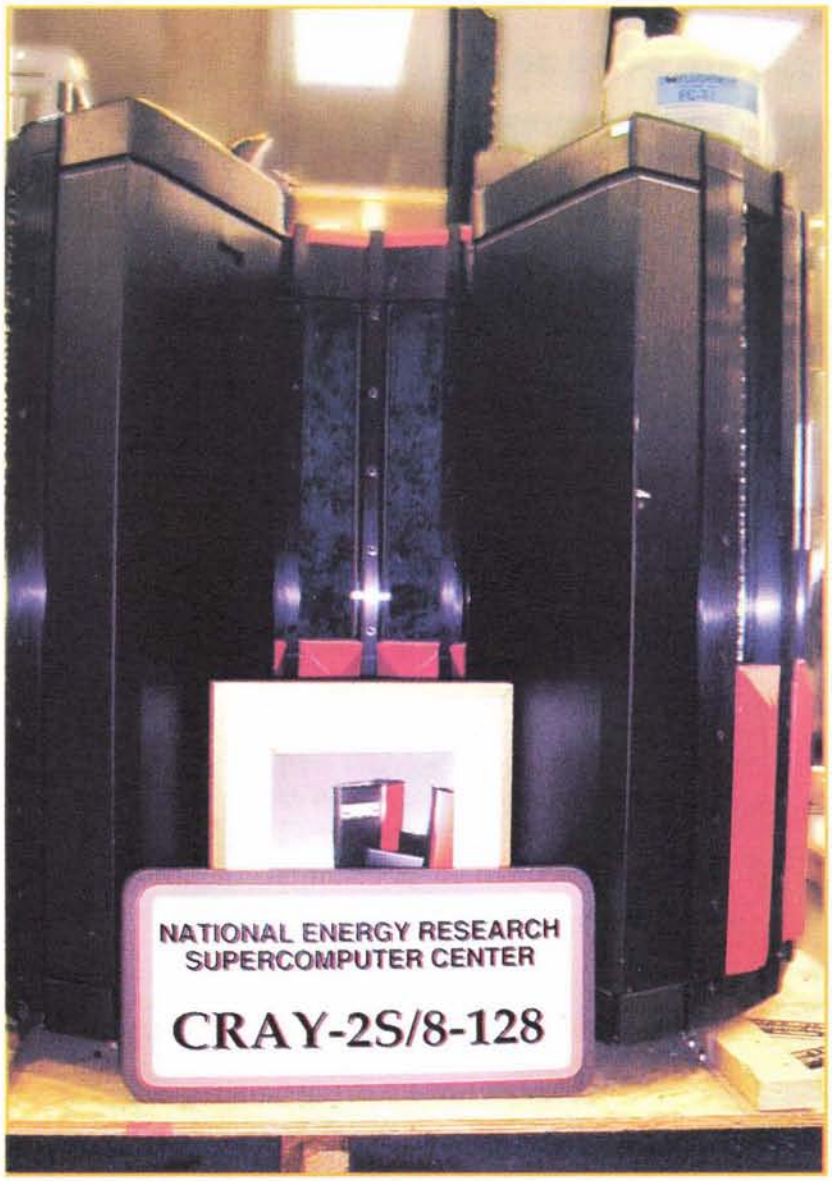
Garcia says the museum has two Cray-1s, two Cray-2s, parts of a Cray-3, and boards from Cray-4, which he says, "was never actually produced as a whole machine."

According to Garcia, Cray Research, Inc., sold about 150 of these supercomputers, evenly divided among the 1, 2, and 3 series. What made these multimillion-dollar machines so desirable was their speed, coupled with the elegance of their design, both internally and externally. Cray "really lived in the border between the functional and the aesthetic," Garcia says, and quotes him as saying, "If you're going to pay $20 million for a supercomputer, you might as well have a nice sculpture, too."

And the best of Cray's works are beautiful, functional sculptures, taking machine aesthetics to a new high, if often employing idiosyncratic, personal touches. On the Cray-1, picture a seven-foot high column curved into the shape of a C, with a padded love seat running around the base. That's the Cray-1's design.

The C shape both reduced wire lengths, and also told you immediately just who designed this hulking great sculpture, and the love seat was on top of the unit's power supplies. "So it was functional, in that it was a place for the power supplies to be, without having to run all sorts of conduit and such," Garcia says, "but also, it was a great way to have a nice little seat for people."

However, in terms of exterior



CRAY-2

styling, perhaps the most elegant of the Crays was the Cray-2, with its ingenious visible glass waterfall. This waterfall allowed its Fluorinert liquid to perform deoxygenating and cooling functions. In comparison, Garcia says that other machines using the same technology often look "like a milking machine from a cattle farm."

What's Fluorinert? It's a blood-plasma substitute that's an excellent carrier of oxygen, and non-reactive in most cases. It's such an excellent carrier of oxygen, that it was featured in the movie *The Abyss*, in the scene where a mouse is immersed in the stuff and keeps breathing — that was actual Fluorinert, not special effects trickery.

The $400.00 a Gallon Pause That Refreshes

Garcia says that the Crays' technicians "would actually cool down the Fluorinert, and pump it into the machines, and it would circulate through, and as it was circulating, it would get heated and it would bubble up. It was the equivalent to having immersed the entire machine in a cooling liquid itself."

To cool the few remaining Crays in operation, 3M still makes Fluorinert, at about $400.00 a gallon, which lasts up to six months. "That's one of the reasons why Crays sort of started to fall out, because they were very expensive to operate, and Fluorinert is harder and harder to find."

Why go to all the trouble to use a $400.00 a gallon liquid to cool a computer? Because from the late 1970s, until the mid-1990s, Crays were the fastest vector-processing computers on the market. It was only in the mid-1990s that they were finally largely replaced by even faster (and cheaper to operate) multi-processing supercomputers. Garcia believes that at least two or three Cray-3s are still operating to this day.

The Angry Wife Syndrome

How do such incredible machines wind up in the museum's collection? As we've already seen, Johnniac ended up there because of a chance discovery and a phone call from one of its original designers. Whereas the computers in the collection from Digital Equipment Corporation ended up in the museum because DEC wasn't able to support and maintain its own exhibit space.

Many of the museum's PCs come from donations, often from what Chris Garcia calls "the angry wife syndrome." He says a number of husbands have cleaned out their garages or basements as a result of gentle pressure from their wives, and come across a manual, a book, or even a whole computer.

But before you call the museum to donate your equipment, Garcia says there are certain items they have plenty of. "We get probably 50 percent of our donations for the same three or four machines: the TRS-80, the Commodore PET, the Sinclair ZX-80 or 81, and the Commodore 64. A lot of people call about those."

But beyond what Toole describes as "the more traditional kind of things on the PC side," there are a number of items that the museum wishes to add to their collection. "It could be software, it could be manuals, it could be pictures that are associated with things at that time." These items are becoming increasingly important to the museum to flesh out the collection, as it gets closer to actually being a more functional exhibit space.

The Best Bargain in Computing

Unfortunately, at the moment, the museum's 'visible storage facility' is just that. "We haven't any kind of curated exhibit space there at all. Things come in on forklifts, and we try to put them in an open way, so that you have a sense of things that are going on."

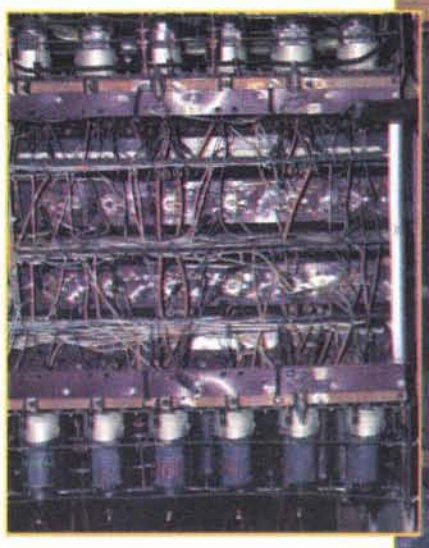
But it's not a museum, in the same way that say, New York Metropolitan Museum, or Philadelphia's Franklin Institute is. But it will be, soon. When will that occur?

Basically, there are two components to upgrading the museum. The first is that NASA is planning to convert Moffett Field from an aging Navy air facility to a 220-acre combined research and historical park, with Hangar One being turned into a giant air and space museum devoted to California's role in this field.

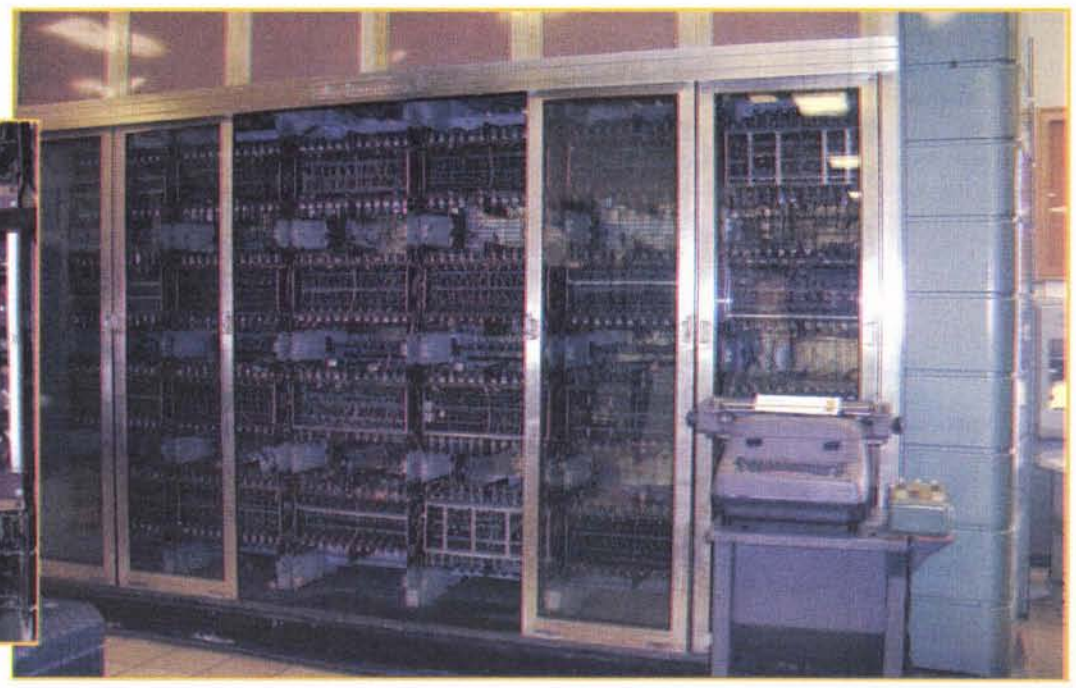
As for the Computer History Museum itself, "We expect to break ground in 2003, and be operational in 2005, on a three-acre tract of land, just in front of the big Hangar One, which isn't too far from where the current Visible Storage Area is located. We're going to build about a 114,000 square foot building on that parcel."

How much does it cost to visit the Raiders of the Lost Computers? John Toole says that until the museum's new facilities open in 2005, "Right now, it's free. You can get an up-close and personal tour of some of these things, like no place else in the world that I know of, bar none, can you see these machines side by side, and I just wish we had more space and time and energy to put more of them out, but we expect to do that in 2005, when we really become operational."

Which may just be the best bargain, bar none, in the world of computers. Give the museum a call at 650-604-2579 and stop by soon! **NV**



Johnniac tube close-up



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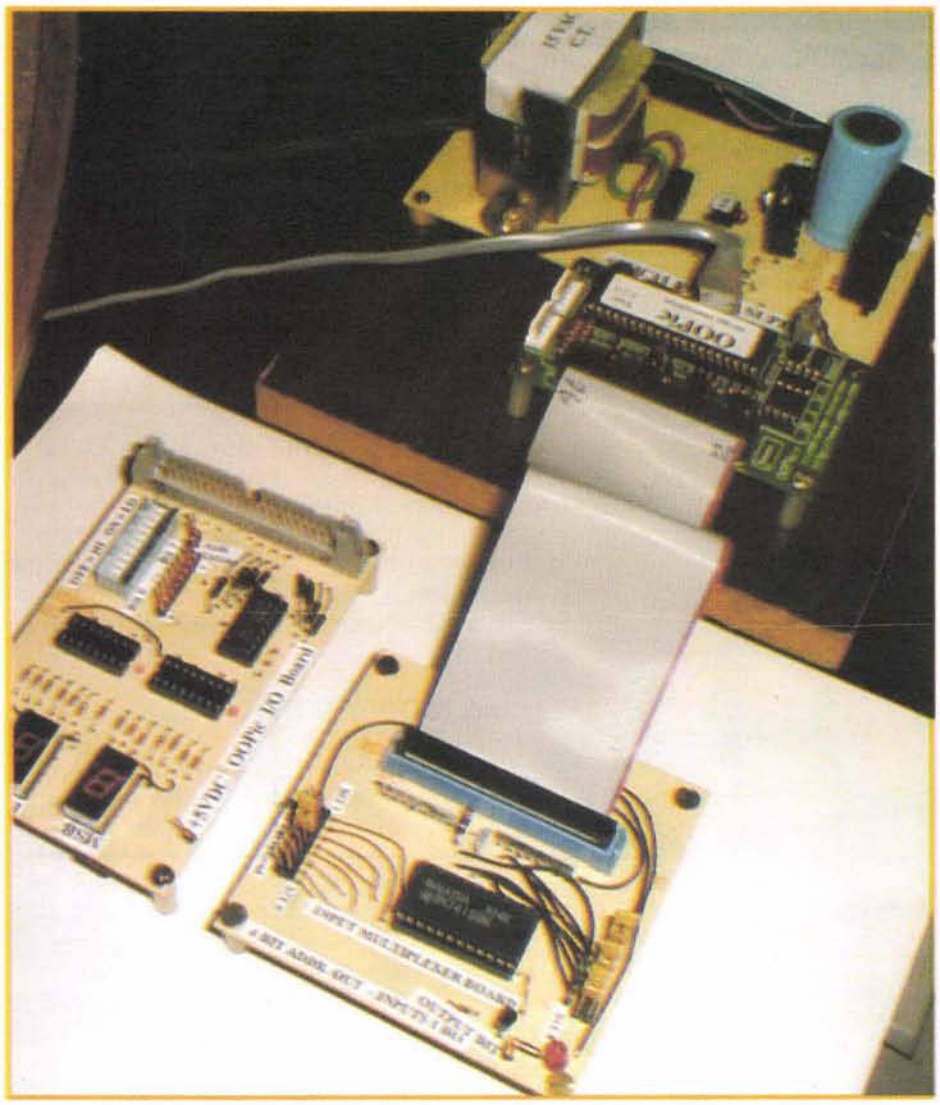


OOPics From The Ground Up

Learning to interface this versatile microprocessor by building expansion modules.

by Robert Fink

Graphics designs by Shelley Klingelsmith

Objective

I've been experimenting with SBCs since the old Cosmac Elf days. I use microprocessors for applications in the control of scale model railroads and just for having fun.

One of the neat features of the OOPic is that you can quickly program it using Visual Basic and a simple adapter cable to your PC. The compiled code is stored in EEPROM so you can disconnect the CPU from the PC and run it in a free-standing hardware set-up.

All you need is a power supply adequate for TTL and the interface you will be using. Ah, but there's the rub! Level changing and interfacing any computer seems to be the most complicated job of all.

I take the simple way out when I see a new application. I build some basic modules that will allow me to input data and have the computer run routines that verify my ideas. Then I increase the complexity and move up to more complicated, combined modules to connect. The first "boards" can be on experimenter or prototype frames, but I like to draw out and etch my own printed circuit boards (PCBs) right from the start after an idea has been tested.

Most model railroad/computer applications have exactly the same requirements as robotics or many other control outcomes.

I need to input digital data usually from many different "one bit" points, then have it processed in a logic routine. Finally, the outcome of the computer's decision must be output and converted to suitable current, voltage, or mechanical parameters to complete the loop.

Nothing new or unique here, but there are many things going on at once in the operation of trains and the track equipment and that means a lot of inputs.

The OOPic has 32 bi-directional input lines which are fine, but I wanted to be able to multiplex 16 inputs into the machine and have it seek one of these using only a four-bit address. At other times, I need all 16 lines passed in so my control module has two modes of operation.

A Dual Design I/O Module

The approach I have used is to use a single 74150 16-bit multiplexer to have any of the lines addressed by the computer input alone. There is also a "bypass" of the lines around the IC and directly into the OOPic I/O connector so I can also have program routines interpret a 16-bit "number" from the input data. I also like to have an output point that is available for any form of hardware and the old "open collector" will do just that.

To build the board shown, I used the advantage of the OOPic 40-pin IDE connector by using a standard IDE disk drive cable. Everyone seems to have these lying around or they can be purchased and cut off to yield a short cable, or even

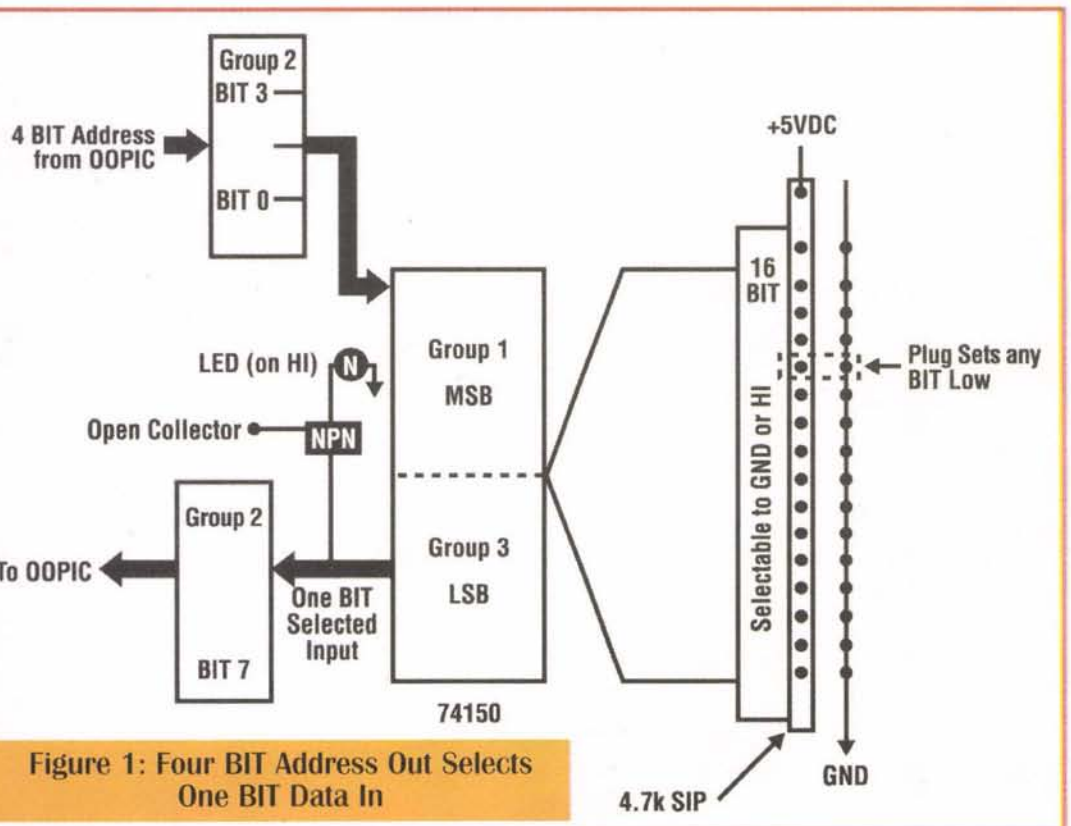
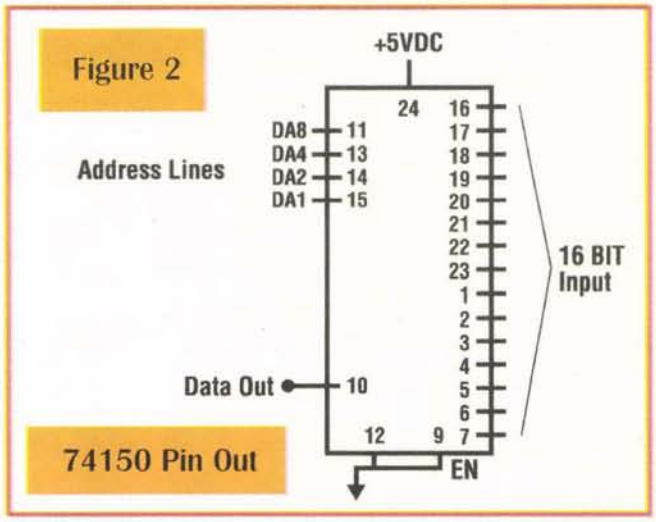


Figure 1: Four BIT Address Out Selects One BIT Data In



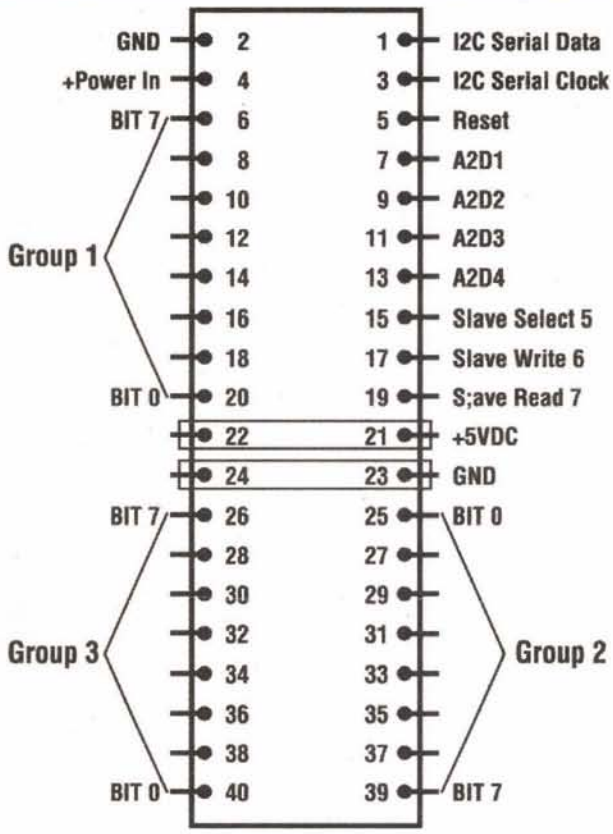


Figure 3: Underside View OOPic I/O Connector

Figure 4. Software to poll 16 input bits

```
'Software for an OOPic Multiplexer

'Using the 74150 input multiplexer
'This software polls 16 bits as
'one-bit inputs by sending a four-
'bit address and outputs their
'state on a one-bit output


Dim OUT1 As New oDio4
Dim ARN As New oByte
Dim IN1 As New oDio1


Sub Main()
  OUT1.IOGroup = 2
  OUT1.Nibble = 0
  OUT1.Direction = cvOutput
  IN1.Ioline=23
  IN1.Direction = cvInput

  Do
          For ARN = 0 TO 15
            OUT1.Value = ARN.Value
            Stall
          Next ARN
  Loop

End Sub

Sub Stall()

DIM I AS new Obyte

For I = 1 to 10
Next I

End Sub
```

all three connectors can be retained and two modules connected in "daisy change" fashion.

You must be careful if you are going to rely on the OOPic five-volt power as the onboard regulator can only supply a few hundred milliamps. I have used separate power supplies for some of my other modules, but overheating of the regulator must be checked as you test your designs.

The place to start in any interface is knowing the pinout of the 40-pin I/O connector. Figure 2 shows the underside view as you will need to view it when designing a PCB. To keep it simple, the three "groups" of eight-bit I/O lines and the power taps are about all you need.

The basic design theory of the multiplexer is shown in Figure 1. The 16 lines are all pulled high using in-line resistors and a two-pin header is provided for each line to pull it to ground if we desire. In this way, we can mechanically build any 16-bit number we need for a single application. The lines are fed to the inputs of the 74150 IC and the computer supplies a four-bit data address which "chooses" one of the 16 lines and outputs it state on a final pin which can be used for device operation or fed to the computer as one-bit information.

Software Considerations

The program I've provided as Figure 4 is as simple as it gets. We set up a loop and "poll" each line by sending the loop counter as an address to the IC. The input value is read in and also turns on the data state LED when a data line is low. Any other subroutine could be used to actually read a 16-bit data number if that were desired.

Testing It Out

After you have built the circuit and checked the wiring, fire it up. Enter the software and, if there are no mistakes during the "Make" phase, then "Make and Download" it. The nature of the clock speed of the CPU allows some delay as the polling goes on. Shunt block a line of the data to ground and notice the LED begin to blink. Shunt another and you have changed the blink rate. Does this begin to suggest counter applications to you? Or how about varying the bit pattern you pull low and notice the Morse code effect.

There are a lot of things that we can do with microprocessors, but the first step is always mastering the interfacing phase. Once you start simple and have that mastered, there's no telling what you'll be connecting your computer to. **NV**

New Product News

EVERSECURE ES-8960

Matco introduces its EverSecure ES-8960 real-time/time-lapse VCR that offers 15 selectable recording speeds ranging from 2-960 hours.

Record up to 24 hours of real-time video with audio or up to 960 hours of time-lapse video images on a standard VHS T-120 tape. Playback is also possible on conventional consumer-grade VCRs.

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Connect it directly to your security system's cash registers or Matco's IC-113 motion detection camera.

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POCKET PHOTO CJ-100 DUAL-USE DIGITAL CAMERA

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One of the special features of this camera is the built-in TFT-LCD, .44-inch color display that has a pullout magnifier. This display makes picture-taking easy while it can also be used as a playback monitor to make sure pictures are exactly what you want.

An on-screen display shows battery life, image quality mode (high or normal), the number of pictures taken and the number remaining.

Five easy-to-use buttons are mounted on the rear of the camera that allow for quick picture taking and playback. The "Snap" button will take the picture and return the camera to real-time mode. The "Erase" button allows a single image to be erased or the entire memory. In playback, the "Fwd" and "Rew" buttons lets you review pictures that have been taken.

In addition to the USB connection, is an NTSC standard video output jack so pictures may be viewed on any monitor or television equipped with a "video-in" jack.

The lens is a four-element-glass lens that also has a "macro" mode for close images. Pictures can be taken from 10 cm out to infinity with very sharp resolution.

Included in the package is a CD loaded with software to use with this camera. Photo-EZ saves the captured pictures to an album, Video Monitor automatically senses the movement of a trespasser in a room and records video in the camera and sounds an alarm, Video Games provides three easy video games to play with the camera, Video Email records a moving picture and sends it via email, Photo Magic edits your pictures, Photo Card makes various cards including Christmas cards, New Year's cards, etc., Net Meeting executes the Net Meeting program of Microsoft, and the Browser manages the saved pictures.

The camera uses two standard "AA" batteries that will take up to 1,000 pictures without replacement. System includes camera, software, video cable, USB cable, camera stand, batteries, and manual.

This unique camera system is currently priced at $179.95 with small and large quantity discounts direct from M.E.M. Electronics. Dealer inquiries invited.

For more information, contact:

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The QV306 is shipped with pre-recorded speech files. The documentation and sample source code will let you produce a talking thermometer within an hour. This requires the DS1620 Digital Thermometer (#604-00002 - $6.80), a pushbutton and a few resistors. To use the QV430P Sound Programmer Board you'll need a PC with a sound card, a speaker and two cables. These optional accessories are also available from our web site.

Download all documentation and sample source code from www.parallaxinc.com. Quadravox has hundreds of professionally-recorded speech files also available for download.

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