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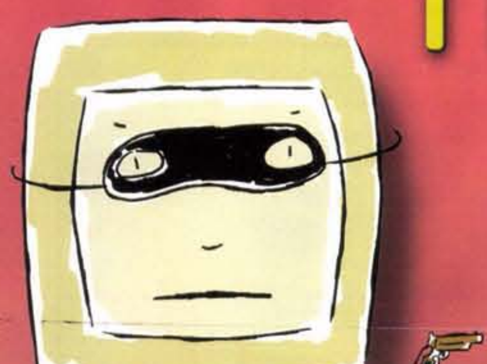

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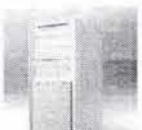

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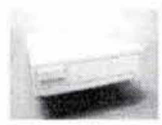

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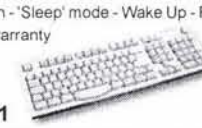

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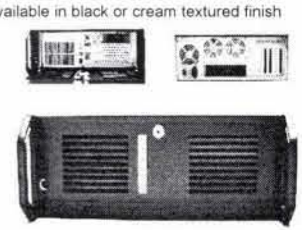

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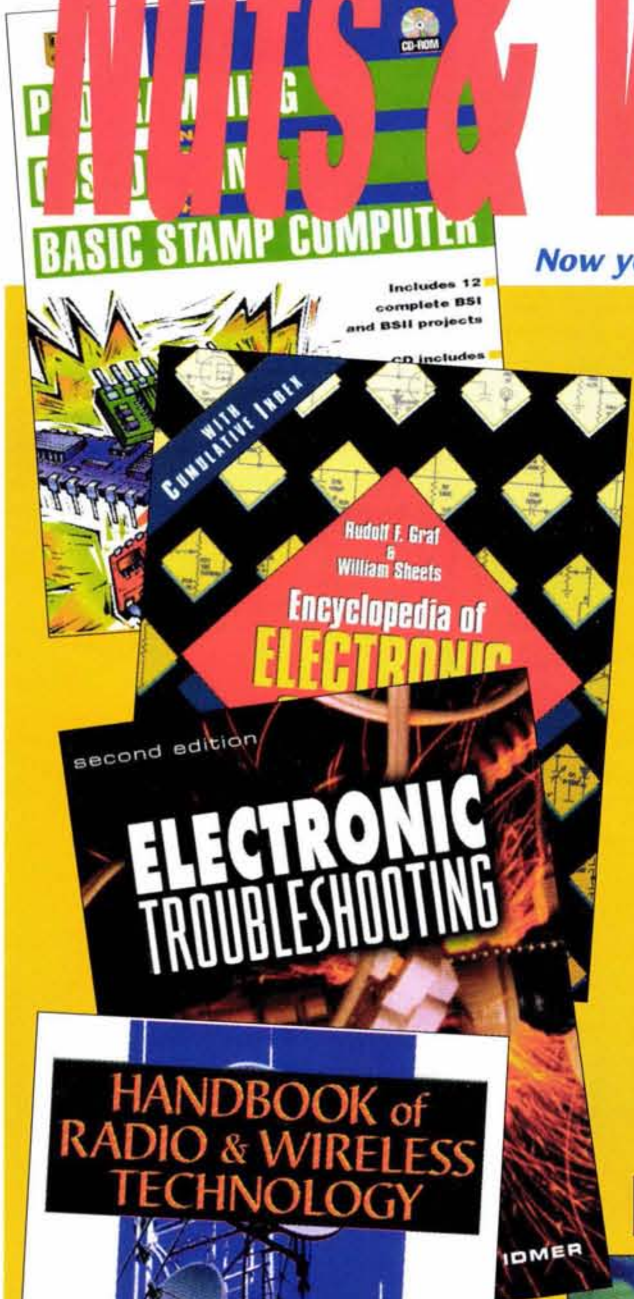

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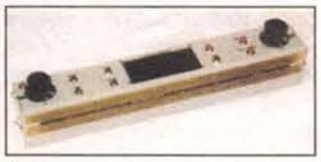

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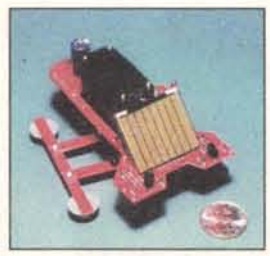

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Turn Your Home into a Robot

by Karl Lunt

Photo A. Group shot of four devices and a small computer terminal. Here is a working home robot starter set.

The computer at the top is a surplus Itronix T5000 telephone instrument, converted to a PC. Below are (clockwise from left) a TM751 RF transceiver, a standard X10 lamp module, a wall-switch module, and the black Firecracker transmitter.

Welcome to the first in what I plan as a series of home robotics projects. By that, I mean turning your home into a robot. I'm not talking about just turning on the porch lights in the evening and turning them off in the morning. I'm talking about a house that senses conditions in and around itself, then adjusts its environment accordingly.

Sensor conditions can include your daily schedule, rainfall, hockey season, or a houseful of guests. Adjusting the environment can mean turning on heaters, interior and exterior lights, changing channels on the TV, or watering the garden.

I've talked about robot design before in these pages. Those of you who followed my long-running column on amateur robotics already know about the major components in a robotics system. The sensors evaluate conditions in the robot's environment and pass that information to the processor, typically a microcontroller. The processor, in turn, changes the state of various actuators, such as motors, sirens, or dart guns, in response to its internal program.

To turn your home into a robot, you must supply all of these elements in some fashion.

Thanks to companies like X10 (**www.x10.com**), the home automation industry offers some well-engineered actuators for part of this job. The X10 units send control signals through the house wiring, removing the need to string wire back and forth. This lets you add control of existing lamps or appliances with almost no effort. The newer, RF-based X10 tools are particularly attractive, since they permit simple PC, Mac, or Linux control with minimal overhead.

Providing sensors for a home robot gets a bit stickier. Sure, you could run wires throughout your house, hooking up devices such as thermometers, PIR sensors, or door switches. But adding such wires to an existing house can be costly, and it's way more labor than I'm willing to expend. A much better solution would be an array of wireless sensors, transmitting data back to the central computer on a predefined schedule.

The central computer can be nearly anything that you're comfortable using. I prefer a small machine, since I want to leave it on all the time, and the noise from a PC's fan bothers me. But most laptops are very quiet, and could work fine. Another possibility is some type of dedicated PC-compatible computer from the surplus market. Sometimes you can find a PC-based tool that, with a little bit of rework, can be turned into a home control computer.

I decided to tackle this home robotics problem in stages. The first stage, described in this article, involves simple wireless X10 control of lights and electric heaters throughout the house. Once complete, I can then build on the software and electronics used in this stage to advance the project.

I ended up using a PC-compatible portable for this part of the project, but you'll see that other possibilities exist. For example, you could use just about any of the single-board computers from New Micros (**www.newmicros.com**) as the core for this project, though you'll, of course, have to rewrite some of the software. It would be an ambitious project, which I might well tackle myself later, but it could be done. And it's important to think of options other than the standard PC clone when designing your own home robot.

The X10 system

I built the actuator portion of my home robotic system around the X10 Firecracker module, X10 part number CM17A. The Firecracker is slightly larger than a DB9 connector, yet contains an X10-compatible RF transmitter. Using this adapter and suitable software on nearly any machine, you can transmit X10 control signals over 100 feet. This removes the need for special wiring between your computer and the X10 units in your house.

In addition to the Firecracker, you will need a suitable X10 receiver, such as the X10 TM751 RF transceiver. The TM751 is a white plastic wall-wart with an antenna on one side. Plug the TM751 into any outlet in your house and it acts as a gateway between the Firecracker and your house wiring. Signals received from the Firecracker are converted into X10 house wiring control signals and transmitted through the wiring.

Finally, you need a boxful of various X10 control modules to fit whatever electrical appliances you want to control. X10 sells a wonderful assortment of control modules, from simple appliance controllers for motors and heaters to plug-in lamp dimmers. They also sell an assortment of wall switches that you can use to replace your existing wall switches. The X10 switches include dimming capability and, of course, respond to X10 commands through the house wiring.

Each X10 module responds to a single X10 address. The addresses consist of a single letter from A to P, followed by a number from 1 to 16. Generally, a module will sport a pair of 16-position dial switches that you can change with a screwdriver blade. For example, you might set the wall switch that controls your porch light to B6. If you then send the X10 command:

b6 on

through the house wiring, this unit (and any other unit addressed as B6) will turn on.

For a great afternoon of techno-grazing, stop by the X10 web site at: **www.x10.com**. X10 is always running some type of sale or promotion, they have excellent prices on some of their assortments and kits, they take phone or web orders 24 hours a day, and their technical support desk is outstanding.

More on the Firecracker

The Firecracker plugs into any RS-232 serial connector and acts like a pass-through device. You can, for instance, insert the Firecracker between your PC and an existing modem. RS-232 signals intended for the modem pass through the Firecracker unaltered. To send X10 signals via the Firecracker, your program must toggle the RS-232 RTS and DTR lines in a specific order. The X10 signals generated by the Firecracker are emitted from

```
*
* House definition file house.def
*

SewingHtr        g6
FamilyHtr        g5
RobotHtr         g1

PorchLights      g2
XmasLights       g3
BedroomLights    g4
NightLights      g7

AllHtrs          SewingHtr FamilyHtr RobotHtr
OutdoorLights    PorchLights XmasLights
```

Figure 1. A sample house definition file

the module directly; it doesn't need an external antenna. The Firecracker gets its operating power from the RS-232 connection, so there isn't even a power cable to attach.

This design makes the Firecracker nearly ideal for home robotics. Almost any computer with an RS-232 port can use a Firecracker to control your home robot. Obvious choices are PCs and Macs, but you could just as easily use a 68hc11 BOTBoard, a homebrew PIC board, or a surplus 386 laptop. In fact, about the only limiting factor is the computer software to drive the module.

Naturally, X10 has a whole suite of software permitting PC control of the Firecracker and your houseful of X10 modules. I've never used any of it, though, so I can't comment on it. Besides X10, several people have web sites offering X10 control programs of various flavors and running on different kinds of machines. You can find lots of useful X10 tools by spending a few hours web surfing.

But my goal was very specific. I wanted a program that would run on an old DOS box, say a 386 or 486 machine, and permit batch-file control of my X10 house system. Ultimately, I would need to rewrite this code (as little as possible) to port it to a large embedded control computer, such as a 68332 machine.

Writing target-independent code means high-level language, so I started looking on the web for X10 control software written in C that I could use as a starting point. After several hours of searching, I found a program created by Adam Briggs that looked like just the ticket. His program, named cm17a.c, provided an excellent foundation. I hacked it up quite a bit to create the program x10dos.c.

x10dos

I compiled x10dos with Borland C/C++ 4.52 as a standard DOS executable. It should run on nearly any DOS box. Note, however, that x10dos takes low-level control of both the serial port and the BIOS timer interrupt, so it will not run on Windows 95. I can't speak for any of the later versions of Windows, since I don't use them.

You invoke x10dos from the command line, with a command such as:

x10dos

This entry gets you a help message explaining how to use x10dos. To control a specific X10 module, you would use a command such as:

x10dos 1 g7 on

This command tells x10dos to use the Firecracker module on COM1 to turn module G7 on. You can also string multiple X10 commands together:

x10dos 1 b2 on b5 off b8 off

Because x10dos uses the command line prompt, it works equally well from a batch file. You could collect several X10 commands into a single batch file, perhaps called dawn.bat, then type

dawn

to launch all of them at once. Since it isn't always easy to remember what X10 module code goes to

Photo B. Cable into side of computer terminal. Attaching the Firecracker couldn't be simpler! Just plug the module into a computer's serial port. If you had a cable plugged into the serial port before, just plug it into the Firecracker, and you're good to go.

Photo C. White box with antenna plugged into wall. The X10 TM751 simply plugs into any outlet in the house. Extend the antenna for best reception, then start sending RF signals from your Firecracker module.

what light or appliance, x10dos lets you rename your X10 modules, using a house definition file. This file, named house.def by default, is a simple ASCII text file giving nicknames or aliases for individual X10 modules. Refer to Figure 1 for a sample house.def file.

The format of a definition file should be obvious. Lines with an asterisk ('*') in column one are comments; x10dos ignores these comment lines and all blank lines. A line that begins with non-comment text is assumed to be a definition. Each definition consists of an alias and a collection of modules that will carry that alias. Here you can see that I've defined the sewing room heater as G6. Any subsequent reference to SewingHtr means that x10dos should send a signal to G6.

You can see towards the bottom of the file that I have used the SewingHtr in the definition of another alias, AllHtrs. Issuing an x10dos command for AllHtrs will send X10 signals to G6, G5, and G1.

Each time you invoke x10dos, it automatically opens the house.def file, if it exists, and loads the definitions into its tables. It then processes the command line to see what commands it needs to issue. The house definitions file lets you create batch files with commands such as:

x10dos 1 FamilyHtr off

Later, if you decide to recode your X10 modules for some reason, you only need to edit the house definition file to reflect the changes. All of your batch files will remain unchanged.

If you would like to play with the x10dos program, you can download a copy of the executable from my web site; just follow the links from my home page **www.seanet.com/~karllunt**. I'm also releasing the source for this program, so those of you interested in advancing the project have a good starting point.

Twiddle those lines

x10dos contains code for controlling the Firecracker module by manipulating the RTS and DTR signals on the PC's COM port. I find this method of transmitting data very useful, as it can be moved onto nearly any microcontroller, such as a small PIC or a large 68xxx system, with little effort. Here's a quick rundown on the technique used to transmit X10 commands with the Firecracker. Refer to Figure 2 for a listing of the relevant routines.

Normally, the RTS and DTR lines will be low, which keeps the Firecracker module turned off, as it derives its operating power from those lines. To turn the Firecracker module on, just bring both of those lines high. Make sure you leave the lines high for a short time, so the Firecracker can complete its power-up.

As you can see in my Cm17aReset() routine, my reset ritual involves turning the Firecracker off for one full second (though it may have already been off), then turning the unit on and waiting for two more seconds. This is likely overkill, but it does work reliably. Feel free to adjust the delay values here if you like.

The Cm17aOut() function proves that transmitting a byte of data with the Firecracker is equally simple. To send a 1 bit, your code must leave RTS high while bringing DTR low. Sending a 0 bit requires leaving DTR high while bringing RTS low. Once the two control lines are in the proper state, your code should delay a suitable amount of time; I used a bit-time delay of one msec. After the delay, your code should return both lines to the high state, then wait another bit time.

Again, these values are not well defined, and you can try experimenting with them. The technical literature from the X10 site claims that the values are really wide open, and anything from sub-millisecond range on up should work. I did notice, however, that very short bit times can make the transmissions more noise susceptible, so I stuck with the (relatively) longer delays.

I'll add a word of caution here. When changing the RTS and DTR lines during data transmission, make sure you never — *even for a moment* — have both of them low. This immediately turns off the Firecracker, and you will need to reissue the reset sequence to get the unit back on-line.

Look through the other code in my program associated with the Firecracker transmissions for more information on the technique. Note, for example, that your code must send an entire X10 transmission twice; if you send the transmission only once, the X10 devices will ignore it.

You will see a couple of large tables at the beginning of the program, which contain the bit patterns assigned to the letters and numbers that make up an X10 transmission. Also note the bit patterns used for a header and footer that must bracket each X10 transmission. This data is available, in a nearly unusable form, on the X10 site, and was condensed into the form you see here in Adam's original program.

It should be obvious that the code for X10 data transmission is trivial, and could be added easily to any microcontroller that can bang two RS-232 output lines. This opens up the possibility of building X10 control into almost anything. You could turn a PIC, a MAX232 level-shifter, and a Firecracker into a dedicated unit that could monitor sensors on the PIC input lines, then issue X10 signals to control appliances anywhere in the house. Best of all, X10 sells the Firecracker for about $10.00 each, making it a true bargain for the home robot builder.

High-resolution DOS timers

I needed to have millisecond resolution timers in my program, a feature not usually associated with a DOS box. But adding high-resolution timers to DOS has been around for many years, and I had my pick of several programs to build upon. I ended up using a program called uclock.c, adapted by Bob Stout from a program originally written by Kris Heidenstrom. The final result is a file called fasttimr.c,

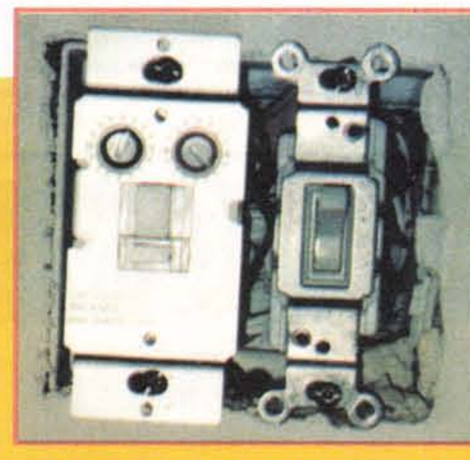


Photo D. Two switches mounted in wall. I installed an X10 wall-switch module (on the left) in place of my existing outdoor light wall switch. Here you can see the two dials on the face, used to set the house and unit codes for assigning the switch's X10 address.

which provides a library of routines for high-resolution DOS timers.

The technique used sounds complex but is actually quite simple. The process begins when your code invokes the start_fastclock() routine. This routine allows you to hook your own function into the DOS timer system. Your function is passed to start_fastclock() as a pointer to a function; this function will be "called back" on each timer interrupt. The start_fastclock() routine also changes the timer update rate to yield interrupts 64 times faster than the stock DOS timer. This gives a timer resolution of 858 usecs per tic, rather than the customary 55 msecs.

The start_fastclock() also installs its own timer interrupt service routine (ISR) to replace the ISR originally assigned by DOS on startup. This ISR, handle_timer(), will be executed on each timer interrupt. Finally, the start_fastclock() installs a companion routine, stop_fastclock(), as an exit function, to be called automatically when the x10dos program quits.

On each subsequent timer interrupt, control passes to the handle_timer() ISR. This code steps through the table of down-counting timers, decrementing any that are not yet 0. The code then checks to see if the callback function pointer is non-zero, and if so, invokes that callback function. Next, this code increments an internal counter and tests to see if that counter has reached 64. If it has, the ISR invokes the function originally connected to the timer ISR (and saved by the start_fastclock() routine above). This mechanism preserves the original behavior of the DOS timer. In fact, if this function invocation isn't performed, your DOS system will crash.

The remaining code in this module provides a high-level program with a means of setting, testing, and freeing any of the down-counting timers. I have used this library on a couple of projects now, and I'm pleasantly surprised by how smoothly the code works and how well DOS can perform high-resolution timing functions previously beyond its reach.

Now it's time ...

Running batch files to control part of your house is pretty cool, but it's more cool to have the DOS box do it for you on a scheduled basis. My choice for scheduling software on a DOS box is a program called cron, based on the Unix utility of that name. I've mentioned cron before in my *Nuts & Volts* articles; you can find a typical use of cron in an article I did for scheduled loading of files to a web site in a past issue. You can also find information on setting up cron on my web site.

Using cron to fire off batch commands at scheduled times makes a powerful home control tool for nearly nothing. Since cron and x10dos both run on 386 or later machines, you can set up the whole control system using junker PCs. In fact, my current home control system is built around an Itronix T5000 telephone test instrument that I picked up surplus from Resources Unlimited, a perennial advertiser in *Nuts & Volts*. This little gadget is a 386 PC built into a rugged case, complete with flip-up LCD screen. It runs Microsoft DOS in ROM version 5.0, and takes almost no power to do it.

I just leave the unit turned on and sitting on my workbench. When cron determines that it's time to issue an X10 command, it invokes x10dos which, in turn, transmits the required commands out the Firecracker interface. When that task is complete, control returns to cron, which waits patiently until time to issue the next command. This little box with its free software has been running my house for months now.

That's a wrap!

Note that this project does not make a home robot. This is little more than a timed scheduler; cool, I'll admit, but far from being a home robot. However, this idea of scheduled events does play a part in home robotics. After all, much of your daily life happens on a scheduled basis. Projects such as the x10dos program let your robot manage the consistent phases of its environment without much intelligence.

But a true robot requires sensors, which is the next part of the home robot project. Like the wireless Firecracker interface, the sensors must not require dragging cables through the house or climbing into the attic. To see how I solved that problem, I guess you'll just have to catch the next article ... **NV**

```
/*
 * Declare a set of macros for manipulating the RTS and DTR lines
 * of the selected port. Note that these macros use the variable
 * port, which will be modified to hold the I/O address of the
 * the selected COM port.
 */

#define MCR 4
#define RTS_ON (outportb(port+MCR, (inportb(port+MCR)
    | 0x02)))
#define RTS_OFF (outportb(port+MCR, (inportb(port+MCR)
    & 0xfd)))
#define DTR_ON (outportb(port+MCR, (inportb(port+MCR)
    | 0x01)))
#define DTR_OFF (outportb(port+MCR, (inportb(port+MCR)
    & 0xfe)))

/*
 * Define delays used in X10 communications. All delay
 * values are in usecs.
 */

#define DLY_BIT         1000L
#define DLY_RESET       1000000L
#define DLY_COMMAND     5000L


/*
 * Cm17aReset()   reset the cm17a transmitter
 */

void Cm17aReset()
{
        DTR_OFF;
        RTS_OFF;
        Delay(DLY_RESET);
        DTR_ON;
        RTS_ON;
        Delay(DLY_RESET);
        Delay(DLY_RESET);
}


/*
 * Bit-bang the modem control lines to send a byte of data
 * out the serial port to the cm17a.
 */

void Cm17aOut(unsigned char b)
{
        int
i;

        i = 0x80;
        while (i) {
                if (b & i) {
                        RTS_ON;
                        DTR_OFF;
                }
                else {
                        DTR_ON;
                        RTS_OFF;
                }
                Delay(DLY_BIT);
                DTR_ON;
                RTS_ON;
                Delay(DLY_BIT);
                i >>= 1;
        }
}
```

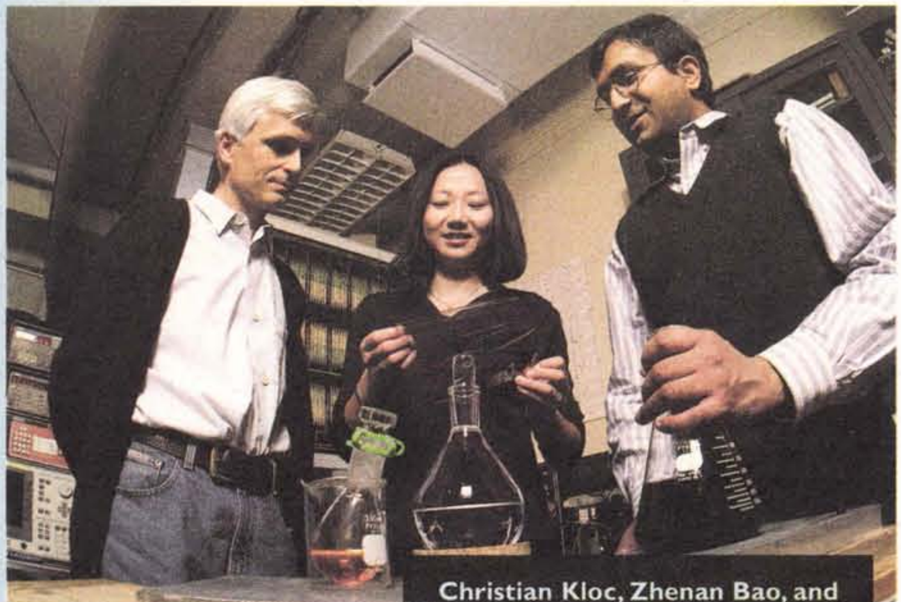
Figure 2. Listing of the Firecracker transmit routines

TechKnowledgey 2001

Events, Advances, and News From the Electronics World

by Jeff Eckert

Advanced Technologies



Christian Kloc, Zhenan Bao, and Ananth Dodabalapur were part of a Bell Labs team that produced the world's first plastic superconductor. Here they are shown with a solution of the organic polymer that exhibits superconductivity at low temperatures. Courtesy of Bell Labs.

World's First Plastic Superconductor

Scientists from Bell Labs (www.bell-labs.com) have created the world's first plastic material in which resistance to electrical flow vanishes below a certain temperature. This is said to be an inexpensive material that could be widely used in quantum computing and superconducting electronics in coming years. This comes after a 20-year search for organic polymers that act as superconductors. While polymer materials that conduct electricity have been known since the 1970s, creating one with superconducting properties was difficult. The challenge was to overcome the inherent structural randomness of polymers (similar to strands of tangled, cooked spaghetti), which prevent the interactions required for superconductivity. By depositing thin films of the material onto an underlying layer, the polymer molecules were made to stack up against each other (more like uncooked spaghetti in the box). And instead of "doping" the molecules with chemical impurities to change its electrical properties, the researchers removed electrons from the material, which is called polythiophene. As a result, the polythiophene becomes a superconductor at -455° F (-270.5°C). According to Bell Labs, using the same principle, many other organic materials can probably be made into superconductors.

Computers and Networking

Clock Rates May Become Irrelevant

At one time, computer clock rates pretty much told the story about performance. More MegaHertz meant more productivity. Today, computer systems are no longer limited to one operation per clock tick, and system performance bottlenecks result more from slow buses and peripherals, operating system overhead, and other mundane factors than from a lack of raw processing power. As a result, buying a computer based purely on clock rate is something like buying a car based purely on engine red line. It's an interesting benchmark, but it hardly tells the whole story about the system.

This complicates things for buyers and sellers, who can no longer make an intelligent purchase based on a single number (if, in fact, they ever could). And the situation is likely to get more complicated — if some of the designers at Sun Microsystems (www.sun.com) have their way. At the recent Async 2001 conference, Sun VP Ivan Sutherland suggested that the way to build the next generation of high-performance computers may be to eliminate the system clock completely. The company's FleetZero architecture, still under development, uses asynchronous chips that do not tie all their operations to the computer's internal clock, thereby eliminating the wait time between ticks. Research at Sun has shown that today's microprocessor chips are operating at perhaps as little as five percent of their potential, because transistor switching times must be slowed to remain in sync with the external clock. Reportedly, benchtop tests of a FleetZero chip have demonstrated throughput of 1.2 billion data items per second, and simulations suggest that this is just a modest beginning. Sutherland speculated that a commercial FleetZero chip is still five years away, though, so don't expect to see one in a PC anytime soon.

Pentium 4 is Disappointment

As if to underscore the point that faster clock rates don't necessarily mean better performance, Intel's 1.5 GHz Pentium 4 began shipping late last year. Although it has scored high ratings for gaming and other graphic-intensive applications, its performance when running mainstream software has been disappointing. *PC World* magazine (www.pcworld.com), for example, tested a Dell Dimension 8100, an IBM NetVista A601, and a Gateway Performance 1500, all with 256 MB of RAM and running Windows Millennium. All were beaten in office-application tests by a Micron Millennia Max XP, which is powered by a 1.2 GHz AMD Athlon chip, and by a 1 GHz Pentium III-based Gateway Performance 1000. Tests reported by CNET (cnet.com) tend to support that analysis, and 48 percent of the respondents to a CNET survey gave the Pentium 4 a "thumbs-down" rating. This may be only a temporary setback for the chip, given that it was designed to be cranked up to as high as 3 GHz in the coming months and years. But today, the Gateway, Dell, and IBM systems are selling for $3,999.00, $3,559.00, and $2,999.00, respectively, which is a pretty hefty price for a questionable performance gain.

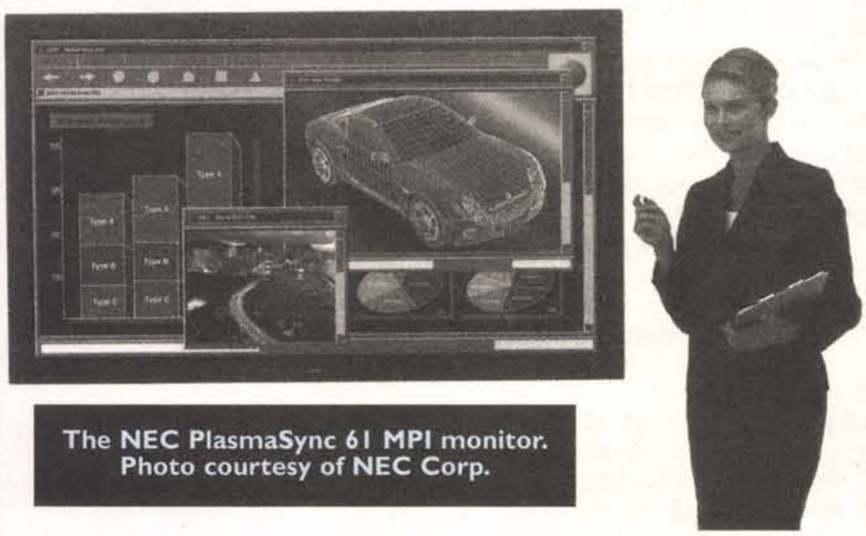
This can't be good news for Intel, which recently announced that it will cut 5,000 jobs over the next nine months and that its first-quarter revenues are expected to be down 25 percent. The company is also cutting research and development funding by 15 percent to help trim expenses.

Web Site Provides Computer Security Data

If you have serious concerns about the security of your computer system, you might want to visit the ICAT web site (icat.nist.gov/icat.taf), which is a searchable index of information about how you may be vulnerable to hacking. More than 2,300 known computer and network vulnerabilities are listed and organized according to the Common Vulnerabilities and Exposures (CVE) standards developed by Mitre Corp. Using the ICAT index, you can access information by vendor, product, version, or keywords, and your search can be narrowed according to operating system, device type, severity of the problem, and other factors. For example, a search on Microsoft Word turns up five medium- or high-severity vulnerabilities that can be exploited by attackers. ICAT is a product of the Computer Security Division at the National Institute of Standards and Technology (NIST). Take a look now, or the hackers will beat you to it.

Circuits and Devices

61-Inch Plasma Monitor Ready for Production



The NEC PlasmaSync 61 MPI monitor. Photo courtesy of NEC Corp.

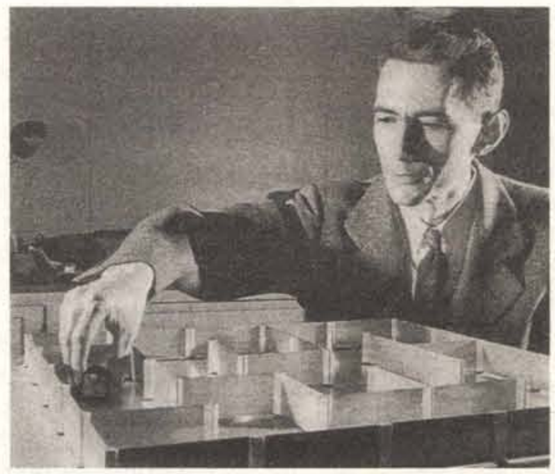
If you are tired of squinting at a small monitor, consider the new PlasmaSync 61 MPI, a 61-inch plasma display monitor from NEC (www.nec.com). Scheduled for mass production this summer, it will initially be sold in the USA and Europe. The screen features 1.05 million pixels (1,365 by 768) and a pixel pitch of 0.99 mm. The screen area is approximately 10,267 cm sq. As it is probably a little too large for your desktop, intended applications include the display of large CAD/CAM drawings, graphic presentations in mid-sized conference rooms and classrooms, and so on. Other specs include 256 RGB color steps for 16.770 million colors, an 80:1 contrast level in bright light, and a 30 percent reduction in power consumption as compared to existing plasma displays. NEC is keeping the suggested retail price under wraps for now, but the word "cheap" does not appear in any of the promotional materials.

48 GB Hard Drive is Quietest

IBM (www.ibm.com) recently unveiled what it says is the world's quietest family of hard disk drives for notebook computers. The Travelstar family of drives incorporate a proprietary noise suppression system that replaces ball-bearing designs with a fluid bearing spindle motor and motor damping techniques to reduce noise, improve shock tolerance, and provide higher reliability. At the top of the line is the Travelstar 48GH, a 48 GB unit that runs at 5,400 RPM and provides transfer rates up to 241 MB/second. The Travelstar product line includes drives with capacities starting at six GB. Shipments are scheduled to begin sometime during the second quarter of this year.

Industry and the Profession

"Father of Information Theory" Passes On



Claude Shannon's electromechanical mouse, which he called "Theseus," was one of the earliest attempts to "teach" a machine to learn, and one of the first experiments in artificial intelligence. Photo copyright 2001, courtesy of Lucent Technologies.

Claude Elwood Shannon, a mathematician who laid the foundation of modern information theory in the 1940s, died in February at the age of 84. In 1948, while a Bell Labs employee, Shannon published the now famous paper, "A Mathematical Theory of Communication," which stated that "the fundamental problem of communications is that of reproducing at one point either exactly or approximately a message selected at another point." He then proceeded to establish foundations of information theory that remain valid and practical today. The paper is widely credited with stimulating the technology that led to today's "Information Age."

According to Arun Netravali, president of Lucent Technologies, "As if assuming that inexpensive, high-speed processing would come to pass, Shannon figured out the upper limits on communication rates. First in telephone channels, then in optical communications, and now in wireless, Shannon has had the utmost value in defining the engineering limits we face."

Shannon was renowned for his eclectic interests and capabilities. A favorite story describes him juggling while riding a unicycle down the halls of Bell Labs. He designed and built chess-playing, maze-solving, juggling, and mind-reading machines. These activities bear out Shannon's claim that he was more motivated by curiosity than usefulness. In his words, "I just wondered how things were put together. **NV**

reader FeedBack

Dear Nuts & Volts:

As a subscriber to *Nuts & Volts*, I was lucky enough to be one of the winners of a 30 meg oscilloscope that Circuit Specialists generously donated.

I must say, I have been an electronic hobbyist all my life and I always wanted an oscilloscope. I just could not justify the cost for a hobby. You have actually made my dreams come true in a surprising and wonderful way.

Countless thanks. I have already been checking out every wave form in the neighborhood and I love it!

R. Douglas Hahn
Upper Black Eddy, PA

Dear Nuts & Volts:

I am neither rich, powerful, nor interested in imposing my beliefs on anyone, against their will or otherwise. Further, I take full responsibility for what my child views on the Internet and television, and don't wish to have anyone else assume or usurp that responsibility. Most importantly, I don't feel the need to malign others in a thinly veiled display of hatred for those with whom I don't agree.

Unfortunately, ML Shannon, in Part 4 of his Cyber-Street Survival series, has no qualms in doing just that. Providing his overview of the failed Senate Bill S314 with the heading "Onward Christian Soldiers", he attempts to brand an entire, diverse group of citizens as mindless, relentless drones, bent on revoking the First Amendment.

There's no question that S314 was bad legislation. Shannon's slam on Christians was no better. His cheap shot at an easy target also lacks originality. If his prejudices are in alignment with those of *Nuts & Volts*, I'll gladly exercise my freedom to not renew my subscription.

Roger Burch
Central City, KY

Dear Nuts & Volts:

There was a great article by Ray Marston on Optocoupler circuits in the Feb. 2000 issue.

One opto that was not mentioned was the LH 1191. The manufacturer is Infineon and it comes in the typical 6 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 ciruits.

Derek Casari

Dear Nuts & Volts

I have spent much time in designing and building motor controllers using BASIC Stamps. I was therefore greatly interested in John M. Baxley's article in the January issue of *Nuts & Volts* on "Closed Loop Feedback Control." It was very informative and useful. Much of my programming has been done using the BS1, which has limited memory and programming lines. I have therefore learned to be creative with my programming. Here are a few programming suggestions that I feel would be helpful.

First, a lot of "variable" memory space has been assigned to values that do not change and therefore should be assigned as constants. Secondly, by using the difference between the slave pot value and the master pot value to directly set the pulse out value not only is the motor control smoother, but many lines of programming are saved.

Ken Janzen
Edmonton, AB. Canada

Dear Nuts & Volts:

Thanks for finally including an article on the HC11 by Al Williams and please continue to print more in the future. By the way, it's a whole lot easier to deal with the HCl1 if you purchase the HC11EVBU which is the Motorola evaluation board unit. It comes with an 'E9 and is a snap to connect with other projects with the built-in header on the board, plus all the manuals are included.

Denis Casserly
Vancouver, BC Canada

Recently, we've had several subscribers ask us how to read their mailing label to be able to tell exactly when their subscription expiration is. The first set of numbers is your account number, which is typically followed by a second set of four numbers. This is the expiration date, *YEAR first*, then month. For example, if the second set of numbers reads 0105, then your subscription expires with the May 2001 issue.

Better hurry and renew!!

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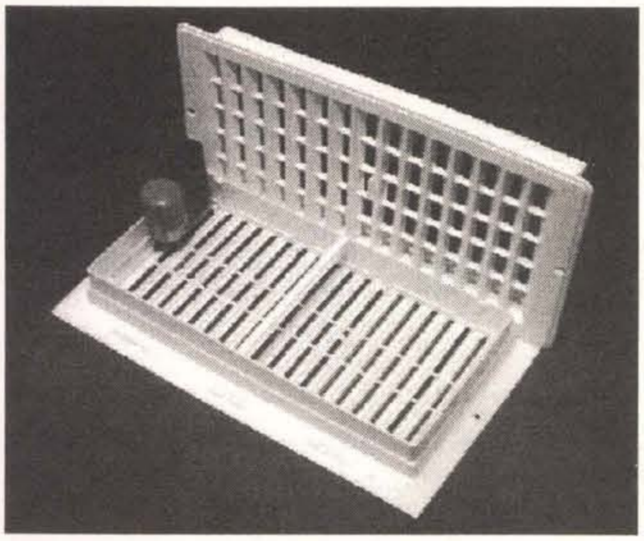

Clever Vent Solves Thermostat Tampering and Reduces Energy Costs, Too

The Clever Vent – a new, patented product of Clever Homes in Orlando, FL – is now in production and solves a myriad of air conditioning challenges, and it can save up to 50% on a heating and air conditioning bill, according to President Charlie Hafer.

The Clever Vent provides zoning to the room level and can be installed by the novice. It is battery-operated and remote-controlled with a standard flashlight. It is offered at an introductory price of $40.00 retail. One nine-volt battery can last in excess of five years – and for those that wish, a house wiring option exists at the same price.

The vent position is easily changed by shining the flashlight on the phototransistor located on the visible face of the vent. The vent will move from open to close continuously until the flashlight beam is removed. It is this concept that provides zoning to the room level and provides the do-it-yourselfer with an inexpensive, quick, and easy way to do the following:

- Provide individual room comfort
- Reduce Energy Costs
- Eliminate paddle fans
- Eliminate need for space heaters
- Help the aged and physically impaired
- Compensate for undersized air conditioners
- Provide an alternate to compressor replacement when remodeling
- Eliminate thermostat tampering
- Eliminate the hot/cold room in the home
- Provide an easy means to adjust out-of-reach vents

And, Clever Homes has an automatic time-set option in test that is presently being tooled. The introductory cost for this is $50.00. It is a simple real-time programming event that does the following:

Open the vent to expose two switches. Press the open switch real-time and the vent will go to that position every day at that time. Similarly, depress the close switch real-time and the vent will close at that time every day. Eight events a day can be programmed this way.

Clever Homes has designed the product to be quickly manufactured with OEM hardware to keep costs down and reliability up with proven concepts. The OEM vent is a slide-type vent manufactured by Witten and is made of plastic. It comes in 11 colors and nine sizes. Three expander wood frames will allow quick and easy retrofit of sizes that are no longer carried. It can also accomodate circular exit vents. If you would like to find out more about Clever Vent, or find out about distribution possibilities, contact Charlie Hafer at cleverhomes@aol.com or call 321-229-5153.

Update on "Free" Data Acquistion Starter Kit from DATAQ:

For those of you who were inquiring about the information printed in last month's TECHKNOWLEDGEY 2001 column ...

According to Roger Lockhart of DATAQ Instruments, the company does offer a starter kit as an introductory product for their WinDaq data acquisition software. Although not free — with the exception of limited, pre-qualified professionals — this starter kit may be purchased for a nominal fee of $15.00 including shipping. Should any *Nuts & Volts* readers wish to order this product, they may do so over the web at url: http://www.dataq.com/products/startkit/di194.htm.

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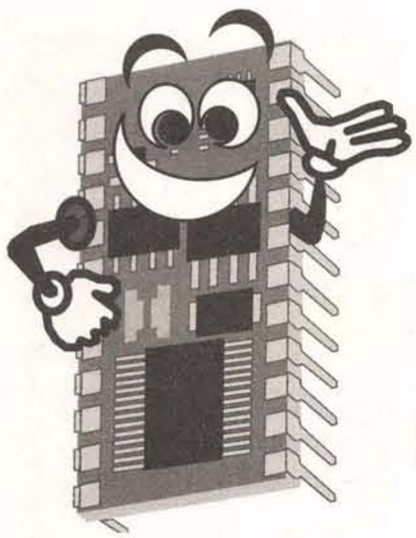

by Jon Williams

Stamp Applications

LOOKIN' FOR THE LIGHT

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

This column is geared a bit toward beginners, although you old dogs may learn a few new tricks too. To that end, you'll need very little: a BS2, a breadboard and a few common parts. There will be no long code listings to type in this month; just fragments to play with. I'll leave it to your intelligence and imagination to incorporate these sensors and code fragments into your projects. Let's rock....

The CdS Photocell

First up is the ubiquitous Cadmium Sulfide (CdS) photocell. They're very easy to get - in fact, you can buy a pack of five at Radio Shack for about two dollars. From the Stamp's point-of-view, the CdS photocell looks like a resistor that changes its value in response to light. The photocell resistance is inversely proportional to the light falling on it; as the light gets brighter the resistance gets smaller.

Okay, let's do something with it. Our first experiment will be a bright light detector that will use the CdS photocell and a 10K resistor. Figure 1 shows the schematic.

> The kinds of sensors we could connect to the BASIC Stamp are as varied and interesting as the people programming them. That said, light sensors seem to be gaining in popularity or, perhaps, I've just noticed. So this month we're going to have a bit of fun with a couple of types of light sensors. Nothing earth-shaking or human-race-saving (as if we've ever done that...), just good clean experimental fun.

Since the CdS photocell is, essentially, a resistor, we can combine it with another to create a voltage divider. The "output" of the voltage divider will depend on the amount of light striking the CdS photocell.

With my Radio Shack units, I measured the resistance at about 1 Meg when dark, about 10K in the ambient light of my office and down to about 200 ohms with bright light shining on them. Let's see how this works when we connect the circuit to the Stamp.

What we must first understand is that the Stamp is a little more flexible in its definition of zero and one than we are. For inputs, we think of zero being zero volts (ground) and one being five volts. The Stamp has a logic threshold of about 1.5 volts. This means that anything from ground to about 1.5 volts will be considered a 0; anything from about 1.5 to 5 volts will be considered a one. By applying Ohm's Law, we can see how the circuit works:

Dark	(5 volts x 1 Meg) / (1 Meg + 10K) = 4.95 volts
Ambient	(5 volts x 10K) / (10K + 10K) = 2.5 volts
Bright	(5 volts x 200 ohms) / (200 ohms + 10K) = 0.1 volts

By these calculations, we should see a one when the photocell is dark or exposed to ambient light. When a bright light is shined on the cell, we should see the input change to a zero.

Okay, then, here's a bit of code to find out:

```
CdS        VAR In0

Loop:
  DEBUG Home,BIN1 CdS
  PAUSE 100
  GOTO Loop
```

Indeed, it does work.

About now you may be thinking, "That's great, Jon, but what do I do with it?" Well, take a look around. Light/dark sensors are used everywhere: security systems, emergency lighting control, robotics. On a diet? How about building a talking refrigerator alarm that reminds you of your diet goals when the refrigerator door is opened? (This assumes that the light in your refrigerator works...)

We can "tune" this simple circuit by changing the value of the fixed resistor. By increasing the value of the fixed resistor we will reduce the amount of light needed to cause a "0" output. If we changed it to 50K, for example, ambient light would read as a zero. Finally, we could install a 50K potentiometer in place of the fixed resistor to create a tunable circuit.

Or...we could choose to create tunable software. To do this, we need to read the photocell as an analog value. Knowing that the CdS photocell behaves like a resistor, we'll use RCTIME and a couple of common parts to read its value.

To use RCTIME, we need to modify the circuit as shown in Figure 2.

The astute among you (That's everyone, right?) have probably

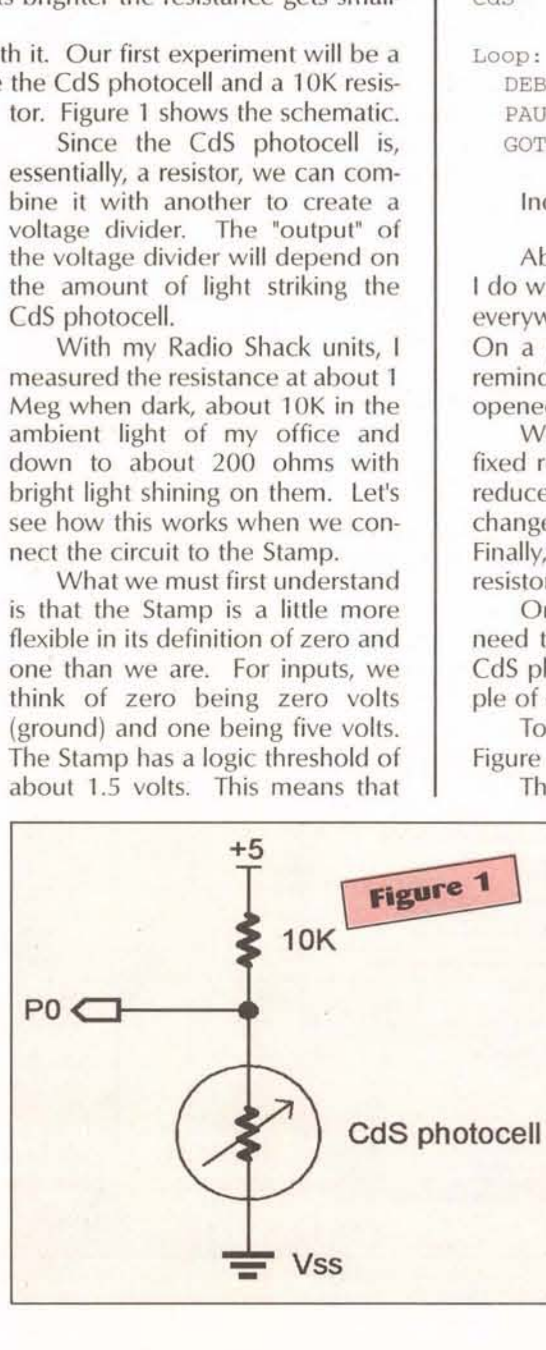

Figure 1

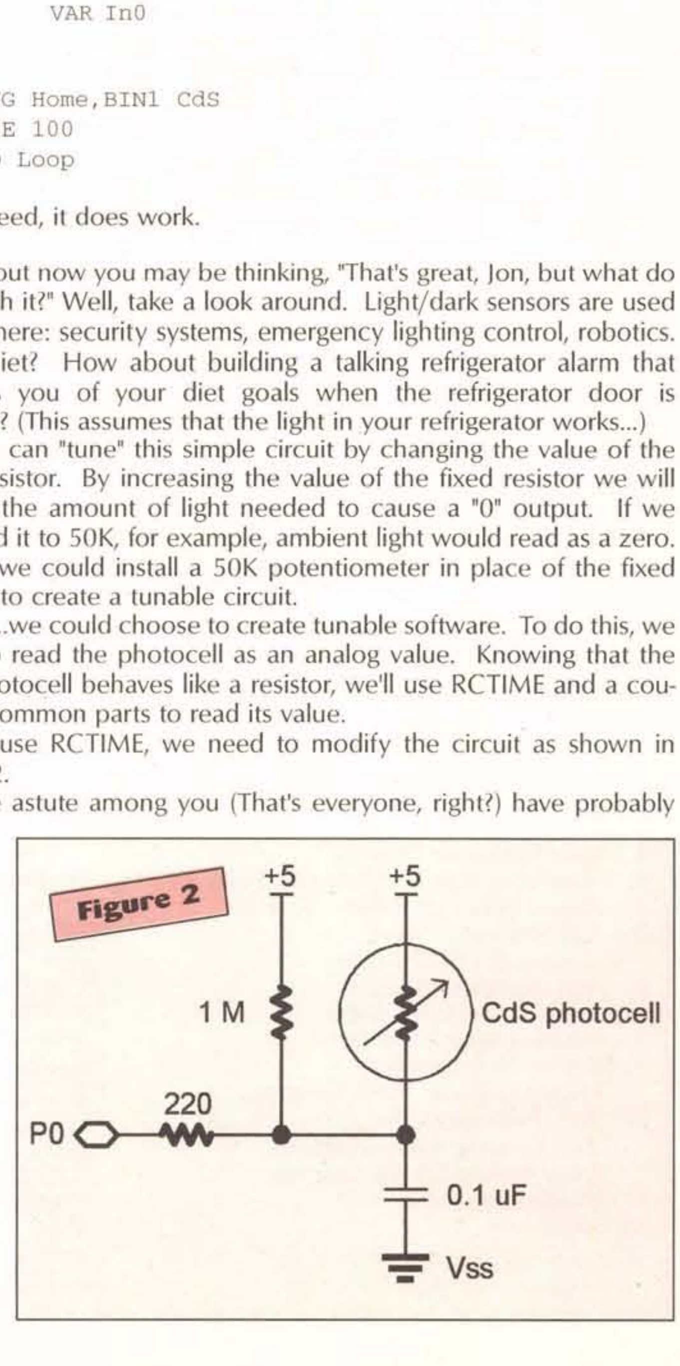

Figure 2

LOOKIN' FOR THE LIGHT

checked out RCTIME in the Parallax manual and are thinking to yourself, "Hey, dude, that is NOT the recommended circuit for RCTIME! And you added a resistor...." You're right, dude. Here's the story:

The RCTIME function measures the time it takes for the capacitor to discharge. In the "recommended" configuration, the voltage at the Stamp-side of the capacitor will have to swing from 5 volts (discharged) through 1.5 volts; a span of 3.5 volts.

We're using the "other" configuration. In this circuit, the capacitor voltage will swing from 0 to 1.5 before RCTIME ends; a span of 1.5 volts. So you can see that the "recommended" circuit will give us better resolution.

The problem for us, though, is that the dark value of the CdS photocell is so large that RCTIME might return 0 (due to roll-over). This would, of course, be erroneous. By using the resolution-reduced circuit and reducing the maximum value of the CdS (by added a parallel resistor) we can measure the photocell without problems. On my breadboard I saw readings from 0 (bright light) to about 17,000 (dark).

Here's the code:

```
CdS         CON 0

light       VAR Word

Loop:
  LOW CdS
  PAUSE 1
  RCTIME CdS,0,light
  DEBUG Home,DEC5 light,CR
  PAUSE 100
  GOTO Loop
```

When you run this program you'll see the value bounce around quite a bit. We can smooth out the bouncing by increasing the PAUSE between readings or we could digitally filter it. A simple method of applying a digital filter is to add a portion of the last reading to a portion of the current reading. The ratio of last-to-first values will determine the behavior of the filter. The larger the last reading portion, the slower the light reading will climb toward the current value. We can use this technique to filter out glitches (so our sunrise detector isn't affected by a passing police car).

Try this:

```
CdS         CON 0

light       VAR Word
last        VAR Word

Loop:
  LOW CdS
  PAUSE 1
  RCTIME CdS,0,light
  light = (light */ $40) + (last */ $C0)
  last = light
  DEBUG Home,DEC5 light,CR
  PAUSE 100
  GOTO Loop
```

In this version we slow the response of the photocell by taking 25% of the current reading (light */ $40) and adding it to 75% of the last reading (last */ $C0). Experiment with different ratios (make sure that they add up to 100%) to see how the circuit responds. What you'll see is that

Okay, let's wrap-up the CdS photocell. We've seen that it's easy to use with just few parts and built-in PBASIC functions. For you hardcore types, you could insert the CdS in a 555 timer circuit and read the value using PULSIN or COUNT (see below). Or you could connect the first circuit to an ADC and read the value that way. Do whatever works best for you - just keep the goal in sight and don't let the method get in the way of results.

The TAOS TSL230

At a recent DPRG (Dallas Personal Robotics Group), one of our members shared a new light sensor from Dallas-based Texas Advanced Optoelectronic Solutions (TAOS). The TSL230 looks like any other 8-pin PDIP, except that the body is clear.

This neat little sensor combines a configurable silicon photodiode and a current-to-frequency converter on the chip. The output is a pulse train with frequency directly proportional to light intensity.

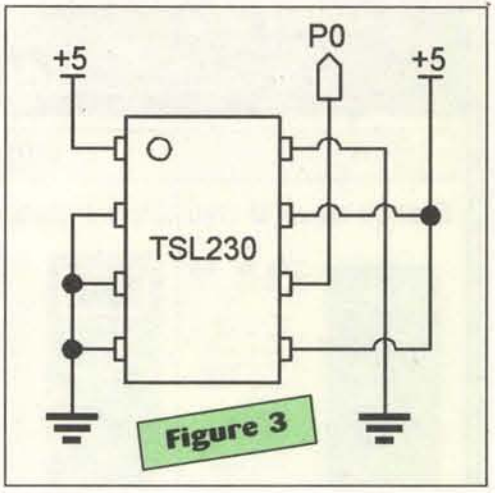

Figure 3

Connecting the TSL230 to the Stamp is very easy. Figure 3 shows the basic connections.

I wired-up the circuit on an INEX-1000 breadboard and used this bit of code to test the output of the TSL230.

```
TSL230      CON 0

light       VAR Word

Loop:
  COUNT TSL230,100,light
  DEBUG Home,DEC5 light,CR
  PAUSE 100
  GOTO Loop
```

The output of the TSL230 is a pulse stream so the code uses COUNT (with a 100 ms window) to read the light value. In this case, the value is directly proportional to the amount of light falling on the sensor (more light = bigger values).

You may be tempted to use PULSIN to get a quicker measurement. You can do this when there is sufficient light falling on the sensor. At low light levels, the time between pulses exceeds the PULSIN window parameters and you could get erroneous readings.

Aside from being very easy to use, the TSL230 has a couple of neat features:

- Programmable Sensitivity
- Scalable Output Frequency

The connections to Pins 1 and 2 (S0 and S1) control the sensitivity of the photodiode. These inputs are TTL compatible so advanced applications could actually control the TSL230 sensitivity on-the-fly.

Pins 7 and 8 (S2 and S3) control the output scaling. When the output frequency is scaled by 2, 10 or 100 it will appear as a square wave. When not scaled, the low-going portion of the output pulse train carries the light value. Like S0 and S1, these pins could be connected to the Stamp to dynamically control the output scaling. Why? The idea is to allow the best possible resolution for a given processor speed for a given light value. Go ahead and play with it. You'll learn a lot in the process.

Be sure to download the TSL230 specs from TOAS.

Hopefully you found this month a nice break from the big projects we usually do. I believe it's good to experiment with new parts, even if there is no specific goal in mind at the time. Play time doesn't always bring immediate results, but I promise, it brings results. I have pulled myself out of many project holes with information gleaned from play-time experiments.

Let's Sound Off Again

Of the 20 or so articles I've written for Nuts & Volts, the speech and sound articles (SP0256-AL2 and ISD2560) have been the most popular. Clearly, speech and sound are hot topics for Stamp uses. Next month I'll have some really neat stuff to share. See you then. **NV**

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UNUSUAL TRACE SWITCHER

by Stanley J. York

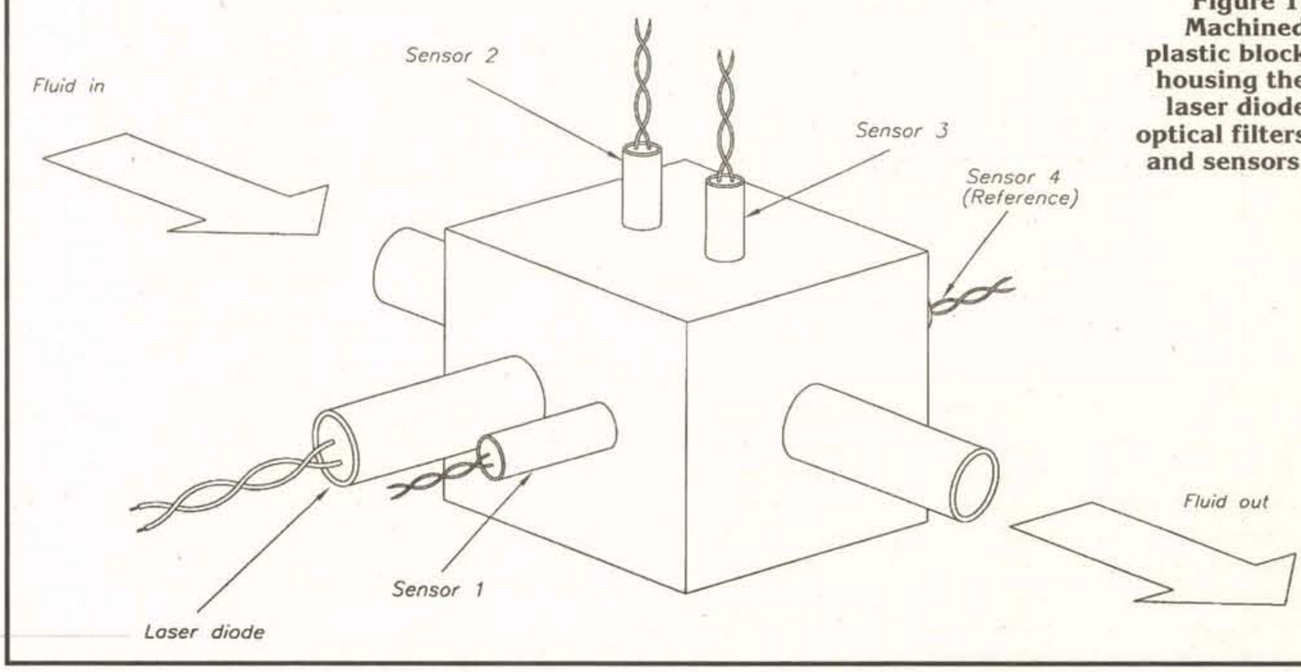


Figure 1. Machined plastic block housing the laser diode optical filters and sensors.

Have you ever tried to adjust the gains of a number of analog signal stages for equilibrium when those signals interact with each other? I did, and it was a painful exercise. What follows is a circuit that I used to help me adjust the levels in a four-stage control module, and maintain a good handle on what all the other levels are doing.

The problem ...

Before I describe the circuit, let me first give you a bit of background. I was involved with some experimental work some years ago, and the device I was working on was designed to monitor the consistency of paper pulp during the manufacturing process. The examination chamber was machined out of a solid block of opaque plastic, and was fitted with a laser diode and various filters and sensors that monitored the consistency of the slurry, and average particle sizes of the pulp as it flowed through.

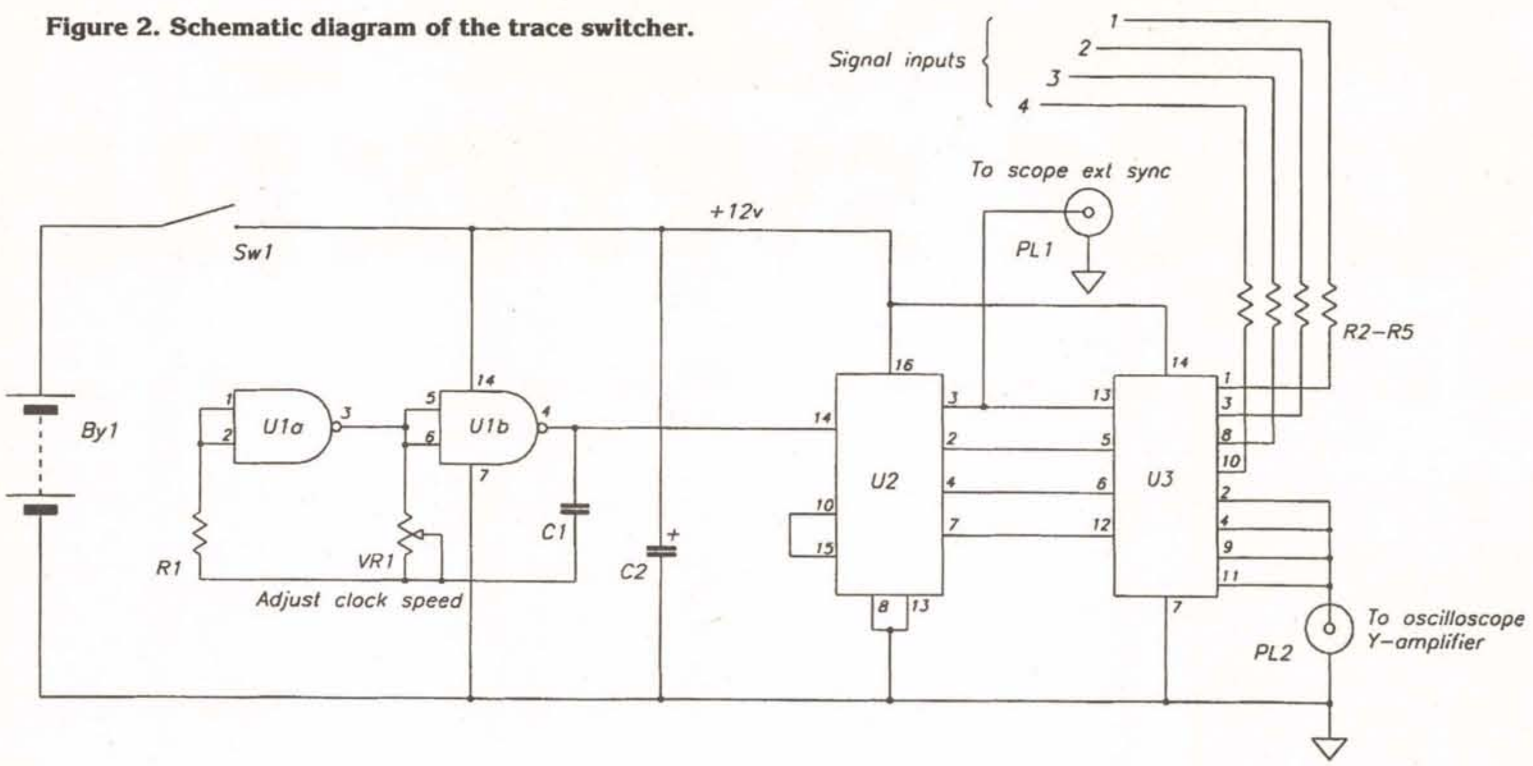
For calibration, a known solution was flowed into the device, and the sensors adjusted in orientation and rotation to produce four balanced outputs, which were then fed into a four-channel A/D (analog-to-digital) converter, and from there to the computer that controlled the mixture. The flow rate through the block was carefully controlled so as not to influence the readings. A brief illustration of the sensor set-up is shown in Figure 1.

The laser diode was aimed across at a sensor, and side sensors monitored the scattering and absorption of the light under fixed polarization conditions. Rotating the laser or sensors changed the polarization effects of the slurry, and therefore the way in which the light was scattered within the fluid, making the initial set-up tricky, to say the least.

The problem I encountered was that of adjusting the sensors for balanced output, because of this mutual interaction. Because of the way the sensors were mounted, adjusting the position of each sensor independently was not possible, so adjusting the position of one sensor affected one or more of the others. Added to this, of course, were the inevitable differences in each sensor due to manufacturing tolerances. As a result of all these factors, the task of aligning the sensors accurately and consistently from unit to unit was a nightmare.

What was needed, I thought, was a four-trace oscilloscope so that I could monitor all the sensors at the same time, and adjust them until I got just one line. But no, that wouldn't work either, because when all the traces were

Figure 2. Schematic diagram of the trace switcher.



close together, I wouldn't be able to determine which trace came from which sensor. If I separated the traces, I would be in no better shape than if I were to use four separate voltmeters. It needed a clever approach to solve this problem, and one where I could see all four levels independently and simultaneously without any delays, and without turning my head or going cross-eyed in the process.

... and the solution

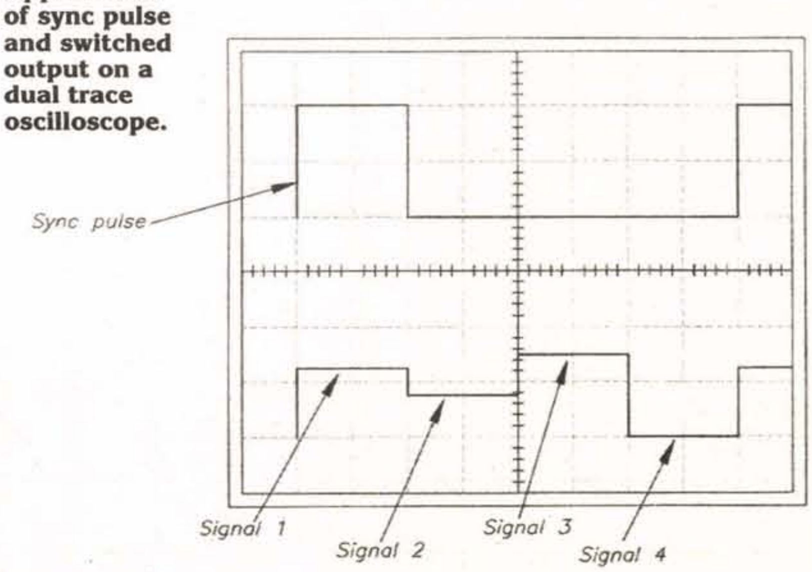
The circuit that follows worked beautifully, and could be quite easily adapted for any number of inputs.

Here's how I overcame the problem. Figure 2 shows a simple adjustable CMOS clock, using two gates of a 4011 (U1) driving a 4017 (U2) wired up as a divide by four circuit.

The four outputs from the 4017 then go to the control inputs of a 4066 (U3) quad bilateral switch. The four input signals to be measured are fed to the inputs of these switches through R2-R5, and are gated through by the divided clock. The summing junction then goes to the output terminal PL2 for connection to an oscilloscope. A synchronizing signal is taken off the number one output of the 4017 (pin 3) and is taken to another terminal (PL1) and is used to trigger the oscilloscope.

As the 4017 is clocked, it presents each input to the output terminal sequentially. The resistors in series with the inputs do not modify the input signal levels; they are there to protect the input circuit in the event of a short circuit on the output. The on-to-off resistance ratio for the 4066 is very high, and there is no measurable crosstalk between the four channels, unless the signals are greater than the DC supply rails (more on this later).

Figure 3. Appearance of sync pulse and switched output on a dual trace oscilloscope.



A sketch of a typical output is shown in Figure 3. In my experiments, I adjusted the sensor positions while watching the relative movements of the four levels. Using this, it was very easy to set up the individual outputs to get an equal reading on all four channels. The current requirements of this circuit are very modest, and a simple DC supply using batteries provides enough power to run the unit. Quiescent running current is below 5mA, and so a battery should last a long time.

Construction

Use whatever construction method you feel most comfortable with. In my prototype, I used simple point-to-point wiring. In the current model, the perfboard from RadioShack provides plenty of room. It worked so well and goes together so quickly, I didn't bother to make a PCB for it. You may prefer to make a PC board however, depending on how much you intend to use the device (or how many you make).

Component layout is not at all critical, and component values may be changed to alter the clock frequency or number of input channels to better suit your application. I used a 4011 as a clock generator in my unit because it was handy, but you can also use a 4049 or a 555 with suitable changes in the wiring. Because of the way the 4017 works, the mark/space ratio on the four gating signals is very uniform, and there is no need to obtain an accurate 50/50 ratio on the clock signal.

Resistors R2-R5 provide some current limiting in the event of an accidental short on the output side of the 4066. If you follow the layout shown, you will need to make some wiring connections on the underside of the board, as well as on top, so check your work with the underside solder connections as well, as shown in Figure 4.

There isn't a lot of room to spare at the ends of the little board, so you will need to bend the leads of the 100µF capacitor a little in order to squeeze everything in. Make the connection to the clock speed control components (VR1, R1, C1) underneath the board to save space on top, and also make the connections to the IC's power pins underneath.

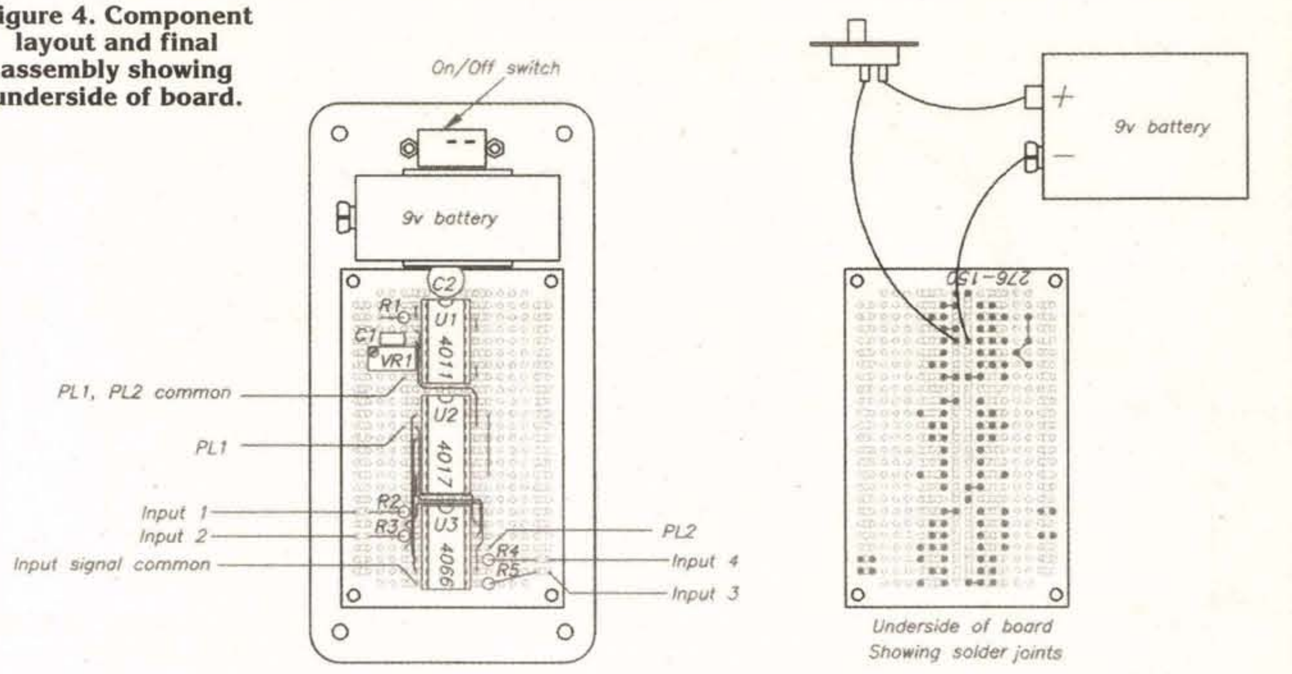
Figure 4 gives details of wiring above and below the board.

Drill the case for the two BNC connectors, and use the solder lugs that come with the connectors to make the common connection. Make a small hole or a shallow slot to receive the wires for the input connections. In my prototype, I used small clips that I had left over from another project (ITT Pomona "minigrabber" MCM #201-020). They are a little tricky to connect wires to, and you should try to use as little solder as possible when assembling these probes.

On my unit, I used a brown wire for the #1 probe, a red wire for the #2 probe, and so on. This makes identifying the channel number easy. You may use alligator clips if you wish, but RadioShack carries small "mini-clip" or "microclip" probes that come with 20" wires attached (RS part numbers 270-016 and 270-017). These particular probes are similar to the ones I used, and are ideally suited for use on IC chips, and can grab IC pins comfortably without risk of shorting out adjacent pins.

Finish up the case by drilling holes for the switch, battery holder, and board standoffs. File the hole to suit the switch, and label everything before mounting the hardware to the case. This part of the operation is much easier to do if there is nothing sticking out from the surface to get in the way. I used the "press-on" type of lettering on my projects, available at most craft shops and graphic outlets. Cover the finished lettering with a coat of clear varnish to protect it when you are done.

Figure 4. Component layout and final assembly showing underside of board.



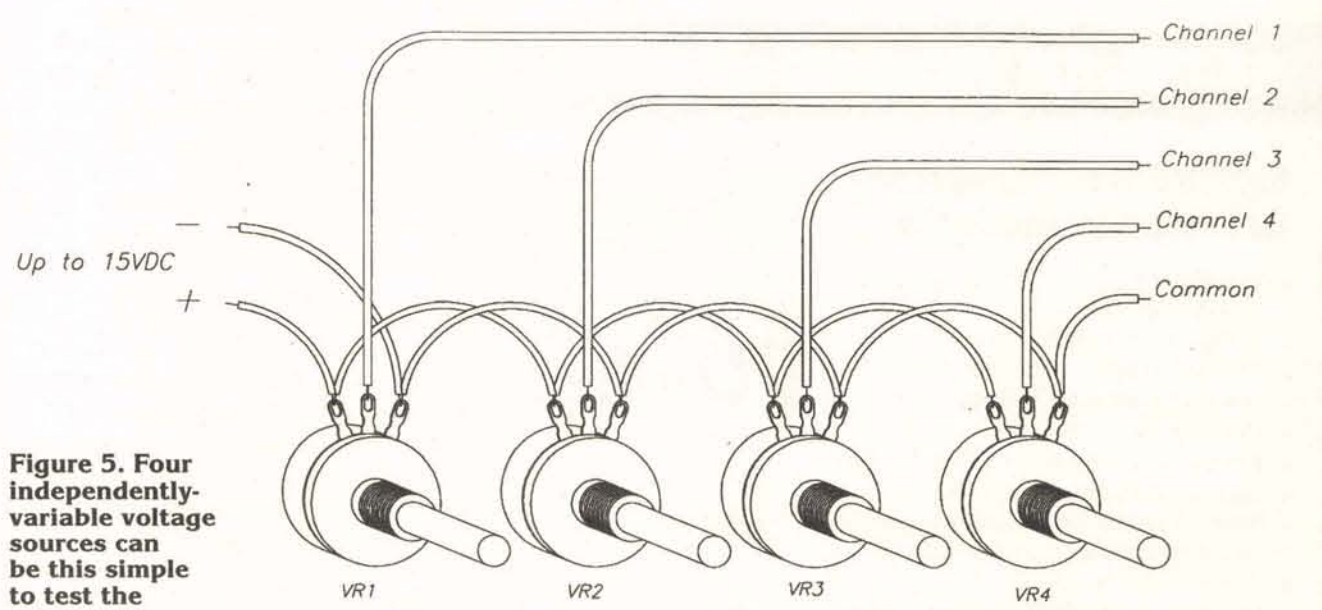


Figure 5. Four independently-variable voltage sources can be this simple to test the switcher.

Setting up

In the present design, adjust VR1 to get the clock frequency to approximately 4kHz. By using the sync pulse to trigger the oscilloscope on #1 trace, the output display will repeat at a 1kHz rate. Syncing from #1 trace is the best way to operate, then the displayed signals will follow in order of connection (i.e., signal #1 is in the first time division, Signal #2 is in the second time division, and so on).

In use, set the oscilloscope timebase to 0.1mSec/Div., and the vertical gain to suit the signals being presented. The length of the trace (the full screen width) will then be 1mSec, and each input signal time period will be 0.25mSec, which is more than adequate if you are looking at slowly changing signal levels. Use short BNC cables to connect the sync pulse output to the ext sync input, and the output from the switcher to Channel 1 on the oscilloscope.

Set the timebase to positive trigger from ext sync with normal operation (not free run); you will then get one sweep for each sync pulse, and therefore a steady trace on the screen.

Testing the unit

To test the unit, you will need to get four independently variable signals. To test my unit, I simply used a DC power supply with four potentiometers wired in parallel, and took the four pot wipers to the inputs of the device (Figure 5).

The values of the pots used are not important here, since we are only looking at a voltage on the wiper.

Set up the power supply for nine volts (or use another battery) and turn everything on. Adjust the clock speed or timebase if necessary, so that the trace fills the

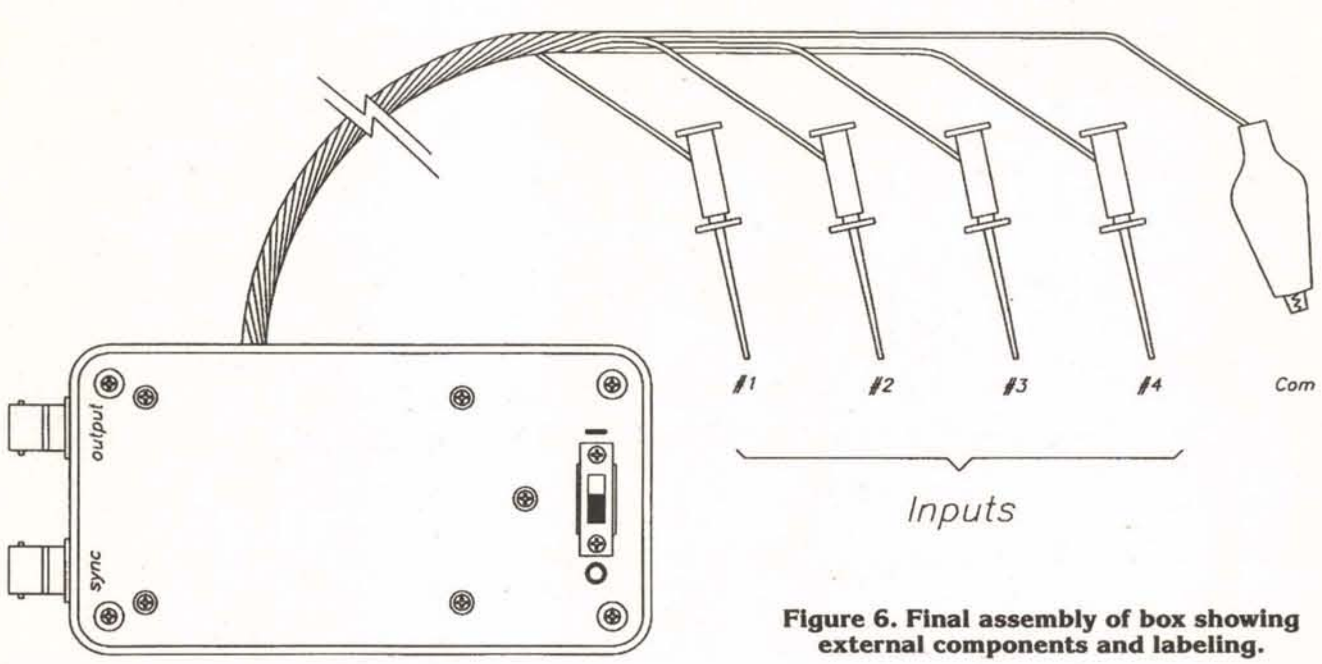


Figure 6. Final assembly of box showing external components and labeling.

A word of caution might be prudent here though, and was first referred to earlier in the article. It is that the voltage presented to any of the inputs should not be greater then the battery voltage powering the device. It won't cause any damage, unless it exceeds the maximum voltage for the device, but it will give some unexpected results! The maximum safe operating voltage for these devices is about 15VDC. This is both the operating voltage and the input voltage to the 4066 gates.

Other than operating voltage constraints, this circuit is very forgiving on component values and you are free to experiment with them.

Although this unit was originally designed for a DC application, there is no reason why it cannot be used for AC signal comparison, as well. In fact, the 4066 has a frequency response that extends well into the MHz region.

This device could also form the basis of a very unusual signal generator; the four inputs being fed with sine, square, ramp, and triangle waveforms of different amplitudes and frequencies, and with or without a DC offset. Instead of using a clock to toggle the signals through, a manual switch may be used to switch between different signal sources.

To expand the system, and increase the number of input/output channels, it is merely necessary to add another 4066, and extend the count of the 4017 before the reset is made. With one 4017, it is thus possible to go up to 10 I/O channels before the limit is reached. **NV**

screen without repeating the #1 signal (or perhaps you could operate the unit at a different clock (or timebase) speed and view two sets of output cycles. But whichever way you choose, you should aim for a steady trace on the screen. Vary the four input signal pots and see how the divisions in the trace behave.

You should see something similar to that shown in Figure 3. If you are careful with your connections, pot #1 should control section 1 of the trace, pot #2 should control section 2, and so on. There should be no interaction between the input signals, and turning all the signals to zero should result in a straight line at the zero reference level on the scope (i.e., there should be no humps or depressions in the resulting line).

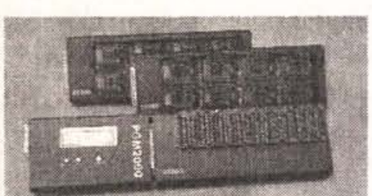
UNUSUAL TRACE SWITCHER PARTS LIST

R1 . . . . .22kΩ
R2-R5 . . . . .10kΩ
VR1 . . . . .100kΩ trimmer pot
VR2-5 . . . . .Values not important (used for test purposes only)

All resistors 1/4 watt unless otherwise indicated.

U1 . . . . .CD4011 Quad two input NAND gate
U2 . . . . .CD4017 CMOS counter
U3 . . . . .CD4066 Quad bilateral switch
C1 . . . . .0.01µF Ceramic
C2 . . . . .100µF 25V Electrolytic
Sw1 . . . . .SPST slide switch RadioShack 275-406 or similar
PL1, PL2 . . . . . .BNC male connector
By1 . . . . .Nine-volt battery
Perfboard . . . . . .RadioShack 276-150
Plastic case . . . .RadioShack 270-222
Alligator clips or probes.....See text
Miscellaneous: Hook-up wire, solder, IC sockets, short standoffs, suitable plastic case.

All these parts are available from Digi-Key, MCM Electronics, and RadioShack.



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MAY 2001

May 4-5

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LA - BAKER - State Convention. Baker Municipal Auditorium, 3225 Groom Rd. Fri: 5-9pm, Sat: 8am-4pm. VE testing Sat. Talkin: 146.19/79. Baton Rouge ARC, Herb Ramey W5LSU, 225-654-6087, 1-800-256-FEST. Email: W5LSU@att.net

May 5

AZ - SIERRA VISTA - Hamfest. Cochise ARA, Robert Warren KF7TJ, 520-803-1453. Email: warnel@juno.com Web: http://www.qsl.net/k7rdg
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MD - GRASONVILLE - Hamfest. Kent ARC & Anne Arundel ARC, Ray Allen W2KBR, 410-969-8042. Email: w2kbr@bayserve.net
MI - CADILLAC - Hamfest. Cadillac Junior High School. 8am-12pm. VE exams. Talkin: 146.980/K8CAD-R. Wexaukee ARC, Rick Hockridge K8WZS, email: k8wzs@arrl.net
MI - MIDLAND - Hamfest. Valley Plaza Resort. MI Antique RC, Mike Dale, 517-872-5387. Email: mdale8@visteon.com
NY - OWEGO - Hamfest. Binghamton ARA, Jack Connors WB2GHH, 607-724-8822. Email: wb2ghh@arrl.net Web: http://www.wtsn.binghamton.edu/bara/
SC - GREENVILLE - Hamfest. Blue Ridge ARS, Bob Watson W4RGW, 864-833-2204. Email: w4rgw@arrl.net Web: http://www.brars.org
WI - CEDARBURG - Hamfest. Ozaukee Radio Club, Gene Szudrowitz KB9VJP, 262-377-6792. Email: szudg@msn.com
WI - SUPERIOR - Hamfest. Arrowhead RAC, Bud Fisher KB0SBL, 218-879-9284. Email: kb0sbl@cpinternet.com

May 5-6

AL - BIRMINGHAM - Hamfest. Zamora Temple. Sat: 9am-5pm, Sun: 9am-4pm. FCC exams. Talkin: 146.88. BARC, Glenn Glass KE4YZK, 205-681-5019. Email: ke4yzk@bellsouth.net Web: http://www.w4cue.com
NJ - EDISON - Trenton Computer Festival. NJ Convention Center, Raritan Center. Sat: 10am-5pm, Sun: 10am-4pm. KGP Productions, Inc., 1-800-631-0062. Web: www.tcfshow.com
TX - ABILENE - West TX State Convention. Abilene Civic Center. Sat: 8am-5pm, Sun: 8am-2pm. VE exams. Talkin: 146.160/760. Key City ARC, Peggy Richard KA4UPA, 915-672-8889. Email: ka4upa@arrl.net Web: http://www.angelfire.com/tx/kcarc76/hamfest.html

May 6

IL - SANDWICH - Hamfest. Sandwich Fairgrounds. 8am-1pm. Talkin: 146.73- or 146.52 simplex. KARC, Bob Yurs W9ICU, 815-895-3310. Email: w9icu@home.com http://tbcnet.com/~jleonard/hamfest.htm
MD - HAGERSTOWN - Hamfest. Washington County Agricultural Center. VEC exams. Talkin: 147.090. Antietam Radio Assn., Carl Morris WN3DUG, 717-267-3411. Email: morriscw@cvn.net Web: http://www.qsl.net/w3cwc
NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talkin: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. Email: wb2slq@juno.com Web: http://www.metro70cmnetwork.com
PA - WRIGHTSTOWN - Hamfest. Middletown Grange Fairgrounds. VE testing. Talkin: 147.09 and 443.950. Warminster ARC, Tony Simek N3YNH, 215-674-5218. Email: tsimek@aol.com Web: www.voicenet.com/~juno.com
WV - RIPLEY - Hamfest. Jackson County ARC, Valerie Hunter KC8PPT, 304-372-9518. Email: salamander54_25239@yahoo.com

May 12

NY - NEWBURGH - Hamfest. Temple Hill Academy, 525 Union Ave. 6am-2pm. VEC exams. 146.16 input (100 PL), 146.76 output. Orange County ARC, Inc., Ed Moskowitz N2XJI, 845-534-3492 after 7:30pm
OK - EUFAULA - Hamfest. Community Center, corner of High & First St. Talkin: 146.955 -600, 144.250 USB. Lake Eufaula Hamfest, Mark Magreevy N5PNE, 918-689-5366. Email: n5pne@yahoo.com Web: http://go.to/eufaulahamfest
OR - EUGENE - Hamfest. Up The Crick Radio Club, Karl Fuller K7ARL, 541-942-1624. Email: karljb@earthlink.net
TN - MOUNTAIN CITY - Hamfest. Johnson County ARC, John Hillsman K9HE, 423-727-4889. Email: grhackle@preferred.com
WA - STANWOOD - Hamfest. Stanwood-Camano ARC, Dave Huppert KA7FDC, 360-387-6123. Email: huppert@whidbey.net

May 14

MA - GREENFIELD - Hamfest. Franklin County ARC, Kathy Hebert N1XSQ, 603-239-4480 or 413-498-2292. Email: tim@cheshire.net

May 18-19-20

OH - DAYTON - Hamvention. Dayton ARA, Jim Graver KB8PSO, 937-276-6930. Email: info@hamvention.org Web: http://www.hamvention.org/

May 19

GA - STATESBORO - Hamfest. Statesboro ARS, Tom Evans KF4YLF, 912-863-4970. Email: kf4ylf@arrl.net Web: http://www.cs.gasou.edu/stars
RI - FORESTDALE - Spring Flea Market & Auction. RI Amateur FM Repeater Service. Rick Fairweather K1KYI, 401-725-7507 (7-8 pm only). Email: k1kyi@arrl.net

May 20

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
NY - FARMINGVILLE - Hamfest. Radio Central ARC, Frank Peppe KB2WQU, 631-289-7757. Email: frank.peppe@verizon.net

May 26

CT - VERNON - Hamfest. Natchaug ARC, Wayne Rychling N1GUS, 860-487-1921. Email: warych@neca.com
IA - NEWTON - Hamfest. Newton ARA, R. J. Hellstern K0FAT, 641-792-2222. Email: trim@netins.net
KY - DAWSON SPRINGS/HOPKINSVILLE - Hamfest. Dawson Springs ARC, Hopkins County ARC, Hopkinsville ARS, & Princeton ARS, Mike Taylor KF4QDX, 270-365-7777. Email: kf4qdx@apex.net

May 27

MD - WEST FRIENDSHIP - Hamfest. Howard County Fairgrounds. 8am-2:30pm. Talkin: 146.76, 224.76, 444.00. Maryland FM Assn., Craig Rockenbauch WA3TID, 410-987-6042.

JUNE 2001

June 1-2

MS - PASCAGOULA - Hamfest. Jackson County Fairgrounds. Fri: 5-9pm, Sat: 8am-2pm. VE testing. Talkin: 144.510/145.110. Jackson County ARC, Ira Groff NN5AF, 228-826-5095. Email: nn5af@arrl.net

June 1-2-3

NY - ROCHESTER - Atlantic Division Convention. Monroe County Fairgrounds, Rt. 15A. Fri: 6am-5:30pm, Sat: 8:30am-5:30pm, Sun: 8:30am-1:30pm. Rochester ARA, Harold Smith K2HC, 716-424-7184. Email: harold@rochesterhamfest.org Web: http://www.rochesterhamfest.org
OR - SEASIDE - Northwestern Division ARRL Convention. Convention Center. SEA-PAC, Randy Stimson KZ7T, 503-297-1175. Web: www:seapac.org

June 2

CO - MONUMENT - Hamfest. Lewis-Palmer High School, 1300 Higby Rd. 8am-2pm. VE testing. Talkin: 146.970 or 146.520 simplex. Pikes Peak RA Assn., Inc., Bob Ryals KI0GF, 719-265-9950. Email: rryals@pcisys.net
GA - MARIETTA - Convention. Jim Miller Park. 9am-4pm. License Exams. Talkin: 146.82-. Atlanta RC, Gwinnett ARS, & Paulding ARC, John Talipsky, Jr. KA4VQH, 770-995-6446. Email: johnka4vqh@aol.com Web: http://www.saf.com/arc/atlfest.htm
IL - SPRINGFIELD - Hamfest. IL State Fairgrounds, Cooperative Extension Bldg. AR exams. Talkin: 146.685. Sangamon Valley RC, Edmund Gaffney KA9ETP, 217-628-3697. Email: egaffney@family-net.net Web: http://www.w9dua.net
MI - GRAND RAPIDS - Hamfest. Hudsonville Fairgrounds. VE exams. Talkin: 147.16. IRA, Kathy KB8KZH, 616-698-6627 between 4-7pm EST. Web: www.iserv.net/~w8hvg
NJ - HACKENSACK - Hamfest. Bergen ARA, James Joyce K2ZO, 201-664-6725. Email: jjjoyce@cybernex.net Web: http://www.bara.org

June 3

CT - NEWINGTON - Hamfest. Newington AR League, Tom Ponte WB1CZX 860-666-4539. Email: wb1czx@arrl.net
IL - PRINCETON - Hamfest. Bureau County Fairgrounds. Talkin: 146.955 -600 PL 103.5. Starved Rock RC, Jerry Hagemann N9ZJK, 815-538-6932. Email: w9mkshamfest@hotmail.com Web: http://www.qsl.net/w9mks
MI - CHELSEA - Hamfest. Talkin: 145.450-.

COMPUTER SHOWS

AGI Shows, 317-299-8827
E-Mail: info@agishows.com
http://www.agishows.com

Blue Star Productions
612-788-1901
http://www.supercomputersale.com

Computers And You, 734-283-1754
www.a1-supercomputersales.com

Computer Central Shows
630-782-4625 Fax 630-834-2594
E-Mail: cc@gats.com
www.computercentralshows.com

Computer Country Expo
847-662-0811 Web: www.ccxpo.com

Five Star Productions
810-379-3333 E-Mail: jeff@fivestar
www.fivestarshows.com

Gibraltar Trade Center, Inc.
734-287-2000 Taylor, MI.
E-Mail: taylor@gibraltartrade.com
www.gibraltartrade.com

Gibraltar Trade Center, Inc.
810-465-6440 Mt. Clemens, MI.
E-Mail: mtclemens@gibraltartrade.com
www.gibraltartrade.com

KGP Productions
1-800-631-0062, 732-297-2526
E-Mail: kgp@mail.com

MarketPro, Inc., 201-825-2229
http://www.marketpro.com

MarketPro, Inc., 301-984-0880
E-Mail: md@marketpro.com
http://marketpro.com

ComputerShow
770-663-0983
E-Mail: narisaam@aol.com
Web: http://www.shownsale.com

Northern Computer Shows
978-744-8440
E-Mail: inquiries@ncshows.com
Web: ncshows.com

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

Chelsea ARC, Inc., Bill Altenberndt WB8HSN, 19501 Bush Rd. Email: wd8lel@hotmail.com

NY - QUEENS - Hamfest. Hall of Science parking lot, Flushing Meadow Corona Park, 47-01 111th St. VE exams. Talkin: 444.200 repeat, PL 136.5, 146.52 simplex. Hall of Science ARC, Inc., Steve Greenbaum WB2KDG, 718-898-5599 eves only. Email: WB2KDG@Bigfoot.com or Andy Borrok N2TZX, 718-291-2561, email: N2TZX@webspan.net

VA - MANASSAS - Hamfest. Ole Virginia Hams ARC, Mary Lu Blasdell KB4EFB, 703-369-2877. Email: mblasd1638@aol.com Web: http://www.qsl.net/olevahams

June 8-9

IN - GREENFIELD - Spring Festival. Hancock County 4-H Fairgrounds. IN Historical Radio Society, Glenn Fitch 765-565-6911. Email: glenn.fitch@cnz.com. Herman Gross, 765-459-8308. Email: w9itt@mindspring.com

TN - KNOXVILLE - Hamfest. Radio Amateur Club of Knoxville, David Bower K4PZT, 865-690-8360. Email: d.bower@ieee.org Web: http://www.korrnet.org/rack

June 8-9-10

TX - ARLINGTON - Convention. Ham-Com, Maury Guzick W5BGP, 214-361-7574. Email: chairman@hamcom.org Web: http://www.hamcom.org

WA - DRYDEN - Hamfest. Wenatchee Hamfest, John Lathrop N7RHY, Email: n7rhy@gte.net

June 9

FL - FT. MCCOY - Hamfest. Ft. McCoy ARC, Tom Bench W4BTB, 352-546-2448. Email: w4btb@arrl.net Web: http://www.qsl.net/w4frc

GA - ALBANY - Hamfest. Albany ARC, Bob Smith K4PHE, 229-883-9633. Email: k4phe@isoa.net

MA - FALMOUTH - Hamfest. Falmouth ARA, Ralph Swenson N1YHS, 508-548-6405. Email: DEPSHER911@AOL.COM Web: http://www.falara.org

ME - HERMON - Hamfest. Pine State ARC, Edward Richardson K1DTW, 207-825-4417. Email: edandglo@earthlink.net

MO - MACON - Hamfest. Macon County, Tri-County, Nemo, & Schuyler County ARCs, Dale Bagley K0KY, 660-385-3629. Email: n0pr@arrl.net Web: http://www.istmacon.net/~kfoster/hamfest.htm

NC - WINSTON-SALEM - Hamfest. Forsyth ARC, Henry Heidtmann N4VHK, 336-761-8223. Email: info@w4nc.org Web: http://www.w4nc.org

PA - BLOOMSBURG - Eastern PA Section Convention. Columbia-Montour ARC, George Law N3KYZ, 570-784-2299. Email: n3kyz@jlink.net Web: http://www.bafn.org/~cmarc

VA - FRANKLIN - Hamfest. Franklin AR Repeater Assn., G. Stewart Tyler WA4JUO, 757-934-2115 or 757-934-5127. Email: stu.tyler@juno.com

WI - EAU CLAIRE - Hamfest. Eau Claire ARC, Jim Staatz KG9RA, 715-838-9108. Email: w9eau@ecarc.org Web: http://www.ecarc.org

June 10

IL - WHEATON - Hamfest. DuPage County Fairgrounds, 2015 Manchester Rd. VE testing. Talkin: K9ONA 146.52; K9ONA/R 146.37/97 (107.2). Six Meter Club of Chicago, Joseph Gutwein WA9RIJ, 630-963-4922 or 708-442-4961. Email: wa9rij@mc.net Web: http://www.cyberconnect.com/orion/smcc.html

IN - WABASH - Hamfest. Wabash County 4-H Fairgrounds, State Rd. 13N. Talkin: 147.03/147.63 -442.325/447.325. Wabash County ARC, Ralph Frank KB9PLV, 219-563-8487. Email: wia1@netusal.net

KY - INDEPENDENCE - Hamfest. Northern KY ARC, Robert Blocher N8JMV, 513-797-7252. Email: nkarc@juno.com Web: http://home.fuse.net/dom/

NY - BETHPAGE - Hamfest. Briarcliffe College, 1055 Stewart Ave. Talkin: 146.850 (PL 136.5). Long Island Mobile ARC, Ed Muro KC2AYC, 516-520-9311. Email: hamfest@limarc.org Web: http://www.limarc.org

OH - SUFFIELD (AKRON) - Hamfest. Goodyear ARC, Rich Kuster N8ZDQ, 330-796-3951. Email: rich.kuster@goodyear.com

June 15-16

NE - SOUTH SIOUX CITY - Convention. 3900 Club, Tom Brosamle WB0YNX, 712-252-4107. Email: tands@pionet.net Web: http://www.3900club.com

June 16

MI - MIDLAND - Hamfest. Midland ARC, Eldon Hall N8STF, 517-643-5101. Email: marc-swap@juno.com Web: http://www.qsl.net/w8kea/

MO - HOUSTON - Hamfest. Ozark Mountain Repeater Group, Blanche White N0FLR, 417-967-3000

NJ - DUNELLEN - Hamfest. Columbia Park. 7am-2pm. Talkin: 146.025/625, 447.250/442.250, PL 141.3 146.520 simplex. Raritan Valley Radio Assn., Doug Benner W2NJH, 732-469-9009. Email: wb2njh@aol.com Web: http://www.w2qw.com

OH - MILFORD - Hamfest. Milford ARC, Chris Reinfelder KB8SNH, 513-753-5066. Email: kb8snh@cs.com

TN - NASHVILLE - Hamfest. Nashville ARC, Bob Malone WB5ZDS, 615-865-6225

June 17

IN - CROWN POINT - Hamfest. Lake County Fairgrounds. VE testing. Talkin: 147.00 repeater, 146.520 simplex. Lake County ARC, Lee Raue, 6401 Kentucky St., Merrillville, IN 46410. Email: leeraue@msn.com

Continued on page 86

USING SEVEN-SEGMENT DISPLAYS

PART 1

by Ray Marston

Ray shows how to use seven-segment alphanumeric displays in this special two-part feature. This opening episode describes basic operating principles.

SEVEN-SEGMENT DISPLAYS

A very common requirement in modern electronics is that of displaying alphanumeric characters. Digital watches, pocket calculators, and digital multimeters and frequency meters are all examples of devices that use such displays. The best known type of alphanumeric indicator is the seven-segment display, which comprises seven independently-accessible photoelectric segments (such as LEDs or LCDs, or gas-discharge or fluorescent elements, etc.) arranged in the form shown in *Figure 1*.

The segments are conventionally notated from *a* to *g* in the manner shown in the diagram, and it is possible to make them display any number (numeral) from 0 to 9 or alphabetic character from A to F (in a mixture of upper and lower case letters) by activating these segments in various combinations, as shown in the truth table in *Figure 2*.

Practical seven-segment display devices must be provided with at least eight external connection terminals; seven of these give access to the individual photoelectric segments, and the eighth provides a common connection to all segments. If the display is an LED type, the seven individual LEDs may be arranged in the form shown in *Figure 3*, in which all LED anodes are connected to the common terminal, or they may be arranged as in *Figure 4*, in which all LED cathodes are connected to the common terminal. In the former case, the device is known as a common-anode seven-segment display; in the latter case, the device is known as a common-cathode seven-segment display.

SEVEN-SEGMENT DISPLAY/DRIVERS

In most practical applications, seven-segment displays are used to give a visual indication of the output states of digital ICs such as decade counters and latches, etc. These outputs are usually in four-bit BCD (Binary Coded Decimal) form and are not suitable for directly driving seven-segment displays. Consequently, special BCD-to-seven-segment decoder/driver ICs are available to convert the BCD signal into a form suitable for driving these displays, and are connected between the BCD signals and the display in the manner shown in *Figure 5*. The table in *Figure 6* shows the relationship between the BCD signals and the displayed seven-segment numerals.

In practice, BCD-to-seven-segment decoder/driver ICs are usually available in a dedicated form that is suitable for driving only a single class of display unit, e.g., either common-anode LED type, or common-cathode LED type, or liquid crystal displays (LCDs). *Figures 7* to *9* show the methods of interconnecting each of these IC and display types.

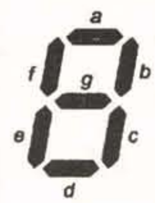


Figure 1. **Standard form and notations of a seven-segment display.**

Note in the case of the LED circuits *(Figures 7 and 8)* that, if the IC outputs are unprotected (as in the case of most TTL ICs), a current-limiting resistor must be wired in series with each display segment (about 150R with a 5V supply, or 680R at 15V); most CMOS ICs have internally current-limited outputs, and do not require the use of these external resistors. To drive a common-anode display *(Figure 7)*, the driver must have an active-low output, in which each segment-driving output is normally high, but goes low to turn a segment on. To drive a common-cathode display *(Figure 8)*, the driver must have an active-high output.

In the *Figure 9* LCD-driving circuit, the display's common BP (backplane) terminal and the IC's phase input terminals must be driven by a symmetrical squarewave (typically 30Hz to 200Hz) that switches fully between the two supply rail voltages (0V and V+), as shown. The full explanation for this is a little complicated, as follows.

To drive an LCD segment, the driving voltage must be applied between the segment and BP terminals. When the voltage is zero, the segment is effectively invisible. When the drive voltage has a significant positive or negative value, however, the segment becomes effectively visible, *but* if the drive voltage is sustained for more than a few hundred milliseconds, the segment may become permanently visible and be of no further value.

The way around this problem is — in principle — to drive the segment on via a perfectly symmetrical squarewave that switches alternately between identical positive and negative voltages, and thus has zero DC components and will not damage the LCD segment even if sustained permanently. In practice, this type of waveform is actually generated with the aid of an EX-OR True/Complement generator, connected as shown in *Figure 10(a)*.

In *Figure 10(a)*, the basic segment 'a' input drive (which is active-high) is connected to one input of the EX-OR element, and the other EX-OR input terminal (which is notated PHASE) is driven by a symmetrical squarewave that switches fully between the circuit's supply rail voltages (shown as 0V and +10V) and is also applied to the LCD display's BP pin.

When the segment 'a' input drive is low, the EX-OR element gives a non-inverted (in-phase) 'a' output when the squarewave is at logic-0, and an inverted (anti-phase) 'a' output when the squarewave is at logic-1, and thus produces zero voltage difference between the 'a' segment and BP points under both these conditions. The segment is thus turned off under these conditions.

When the segment 'a' input drive is high, the EX-OR element gives the same phase action as just described, but in this case, the 'a' OUT pin is high and BP is low when the squarewave is at logic-0, and 'a' OUT is low and BP is high when the squarewave is at logic-1. The segment is thus turned on under these conditions.

Figure 10(b) shows the circuit waveforms that occur when the 'a' segment is turned on, with the 'a' segment and BP driven by anti-phase squarewaves. Thus, in part A of the waveform, the segment is 10V positive to BP, and in part B, it is 10V negative to BP, so the LCD is effectively driven by a squarewave with a peak-to-peak value of 20V, but with zero DC value. This form of drive is generally known as a voltage-doubling 'bridge drive' system. In practice, many LCD-driving ICs (such as the 4543B) incorporate this type of drive system in the form of a seven-section EX-OR gate array interposed in series with the segment output pins, with access to its common line via a single PHASE terminal.

Note that any active-high seven-segment LED-driving decoder IC can be used to drive a seven-segment LCD display by interposing a bridge-driven seven-section EX-OR array between its segment output pins and the segment pins of the LCD display, as shown in *Figure 11*, in which a 74LS48 TTL IC is used in this specific way.

CASCADED DISPLAYS

In most practical seven-segment display applications, several sets of displays and matching decoder/driver ICs are cascaded and used to make multi-digit display systems. *Figure 12*, for example, shows a very simple way of using three sets of decoder/driver ICs and displays in conjunction with three decade counter ICs to make a simple digital-readout frequency meter. Here, the amplified external frequency signal is fed to the input of the series-connected counters via one input of a two-input AND gate, which has its other (GATE) input waveform derived from a built-in timebase generator. The circuit's operating sequence is as follows:

When the timebase GATE input signal is low, the AND gate is closed and no input signals reach the counters. At the moment that the timebase GATE signal switches high, a brief RESET pulse is fed to all three counters, setting them all to zero count; simultaneously, the input gate opens, and remains open for a period of precisely one second, during which time the input-frequency pulses are summed by the counters.

At the end of the one second period, the gate closes and the timebase GATE signal goes low again, thus ending the count and enabling the displays to give a steady reading of that second's total pulse count (and thus the mean signal frequency). The whole process then repeats again one second later, when the timebase GATE signal again goes high.

DISPLAY LATCHING

The simple cascaded system

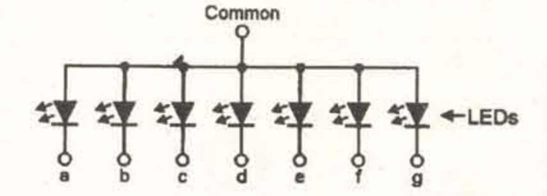


***Figure 3.* Schematic diagram of a common-anode seven-segment LED display.**

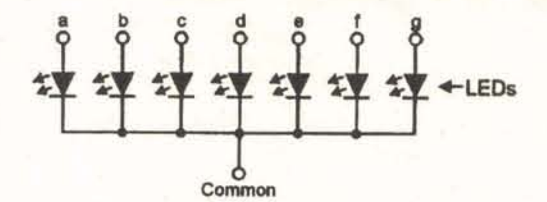


***Figure 4.* Schematic diagram of a common-cathode seven-segment LED display.**

BCD Signal				Display	BCD Signal				Display
D	C	B	A		D	C	B	A	
0	0	0	0	0	0	1	0	1	5
0	0	0	1	1	0	1	1	0	6
0	0	1	0	2	0	1	1	1	7
0	0	1	1	3	1	0	0	0	8
0	1	0	0	4	1	0	0	1	9

0 = logic low   1 = logic high

***Figure 6.* Truth table of a BCD-to-seven-segment decoder/driver.**

Segments (✓= ON)							Display	Segments (✓= ON)							Display
a	b	c	d	e	f	g		a	b	c	d	e	f	g	
✓	✓	✓	✓	✓	✓		0	✓	✓	✓	✓	✓	✓	✓	8
	✓	✓					1	✓	✓	✓			✓	✓	9
✓	✓		✓	✓		✓	2	✓	✓	✓		✓	✓	✓	A
✓	✓	✓	✓			✓	3			✓	✓	✓	✓	✓	b
	✓	✓			✓	✓	4	✓			✓	✓	✓		C
✓		✓	✓		✓	✓	5		✓	✓	✓	✓		✓	d
✓		✓	✓	✓	✓	✓	6	✓			✓	✓	✓	✓	E
✓	✓	✓					7	✓				✓	✓	✓	F

***Figure 2.* Truth table for a seven-segment display.**

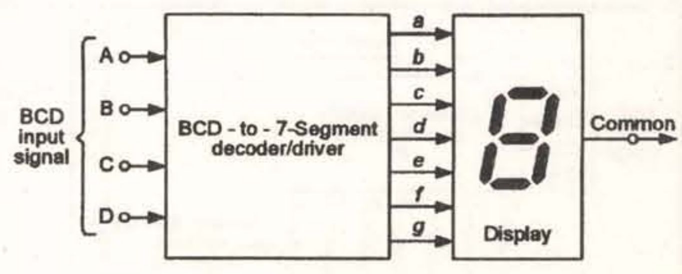


***Figure 5.* Basic connections of a BCD-to-seven-segment decoder/driver IC.**

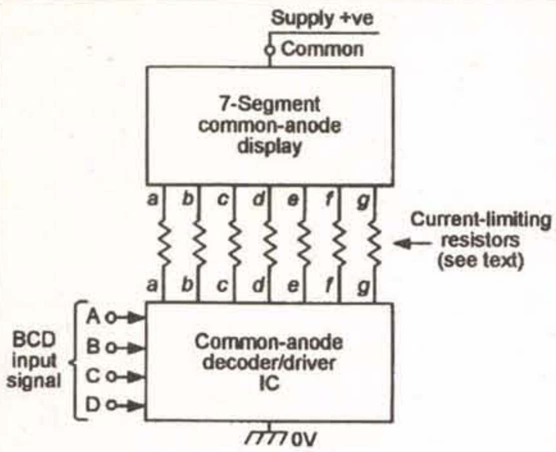


Figure 7. **Method of driving a common-anode LED display.**

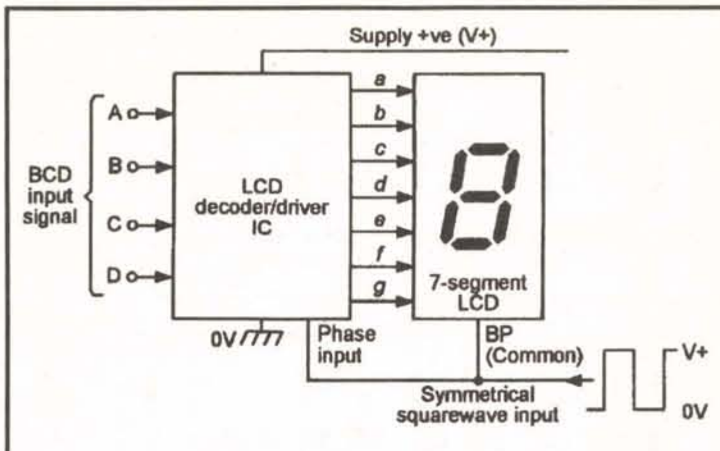


Figure 9. **Method of driving a liquid-crystal display (LCD).**

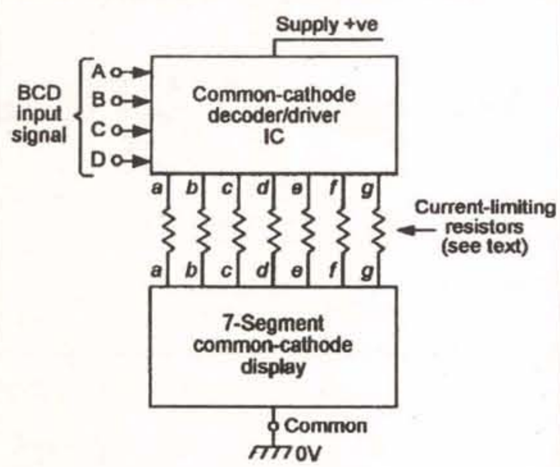


Figure 8. **Method of driving a common-cathode LED display.**

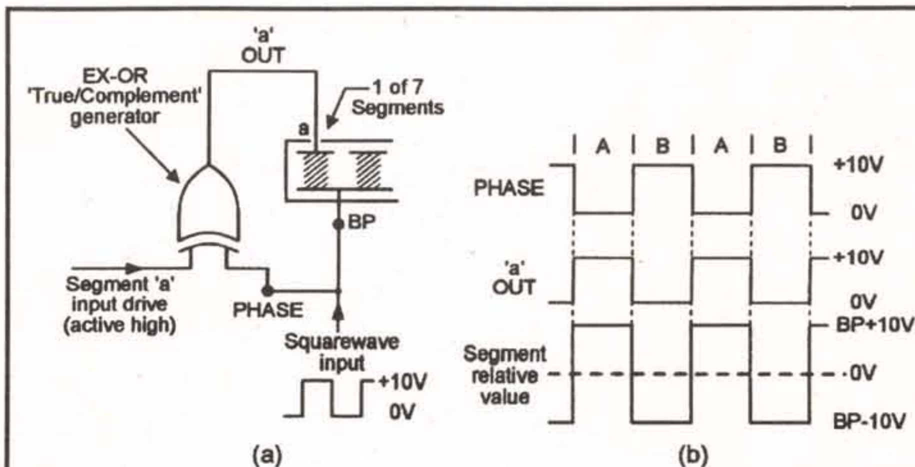


Figure 10. **Basic LCD segment-drive circuit (a), and voltage-doubling 'bridge-driven' segment waveforms (b).**

described previously suffers from a major defect, in that the display becomes a blur during the actual counting period, becoming stable and readable only when each count is completed and the input gate is closed. This 'blur-and-read' type of display is very annoying to watch.

Figure 13 shows an improved frequency meter circuit that uses display latching to overcome the above defect. Here, a four-bit data latch is wired between the output of each counter and the input of its decoder/driver IC. This circuit operates as follows:

At the moment that the timebase GATE signal goes high, a RESET pulse is fed to all counters, setting them to zero. Simultaneously, the input gate is opened and the counters start to sum the input signal pulses. This count continues for precisely one second, and during this period, the four-bit latches prevent the counter output signals from reaching the display drivers; the display thus remains stable during this period.

At the end of the one second count period, the AND gate closes and terminates the count, and simultaneously a brief LATCH ENABLE pulse is fed to all latches, causing the prevailing BCD outputs of each counter to be latched into memory and then fed to the display via the decoder/driver ICs, thus causing the display to give a steady reading of the total pulse count (and thus the input frequency).

A few moments later, the sequence repeats again, with the counters resetting and then counting the input frequency pulses for one second, during which time the display gives a steady reading of the results of the previous count, and so on.

The *Figure 13* circuit thus generates a stable display that is updated once every second; in practice, the actual count period of this and the *Figure 12* circuit can be made any decade multiple or submultiple of one second, provided that the output display is suitably scaled.

Note that a three-digit frequency meter can indicate maximum frequencies of 999Hz when using a one-second timebase, 9.99kHz when using a 100mS timebase, 99.9kHz when using a 10mS timebase, and 999kHz when using a 1mS timebase. In reality, many decoder/driver ICs have built-in four-bit data latches.

MULTIPLEXING

Note from the *Figure 12* and *13* circuits that a total of at least 21 connections must be made between the IC circuitry and the seven-segment displays of a three-digit read-out unit; a total of at least 70 connections are needed if a 10-digit display is used. In reality, the number of IC-to-display connections can be greatly reduced by using the technique known as multiplexing. This technique can be understood with the aid of *Figures 14* and *15*.

Figure 14 shows how each digit of a three-digit common-cathode LED display can be individually activated using a total of only 10 external connections; the circuitry to the left of the dotted line should be regarded as 'electronic,' and to the right of the line as 'display' circuitry.

In the display, all *a* segments are connected together, as also are all other (*b* to *g*) sets of segments, so that a total of only seven external *a*-to-*g*, connections are made to the display irrespective of the number of digits used.

Note, however, that none of the seven-segment displays are influenced by signals on these segment wires unless a display is enabled by connecting its common terminal to ground, and in *Figure 14,* this is achieved by activating switching transistors Q1 to Q3 via suitable external signals, which require the use of only one additional connection per display digit.

Note in *Figure 14* that three different sets of segment data can be selected via switch S1a which, in reality, would take the form of a ganged seven-pole three-way electronic switch (with one pole dedicated to each of the seven segment lines), and that any one of the three display digits can be selected via S1b and Q1

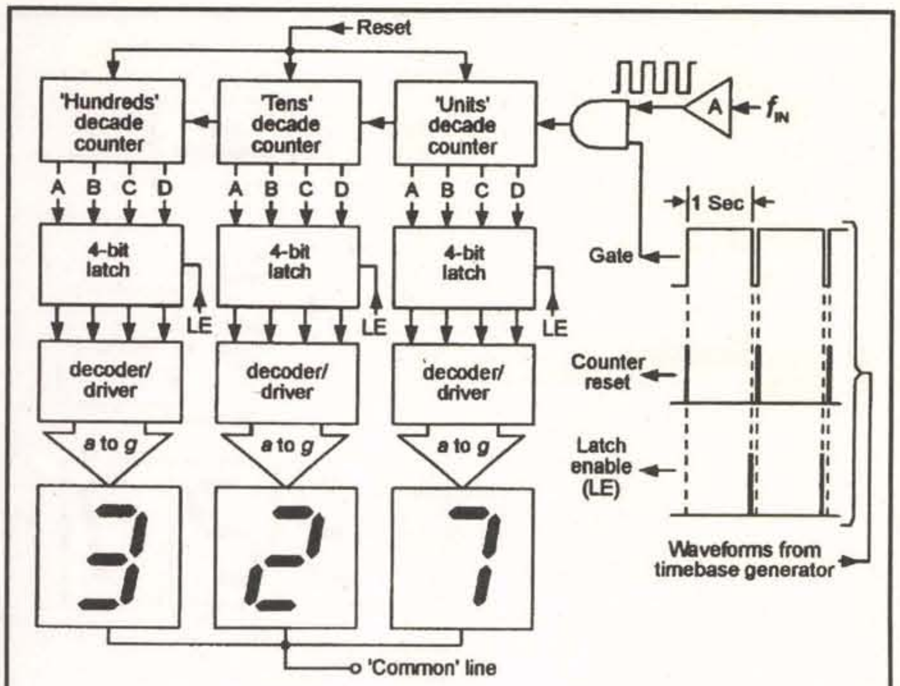


Figure 13. **Improved digital frequency meter circuit.**

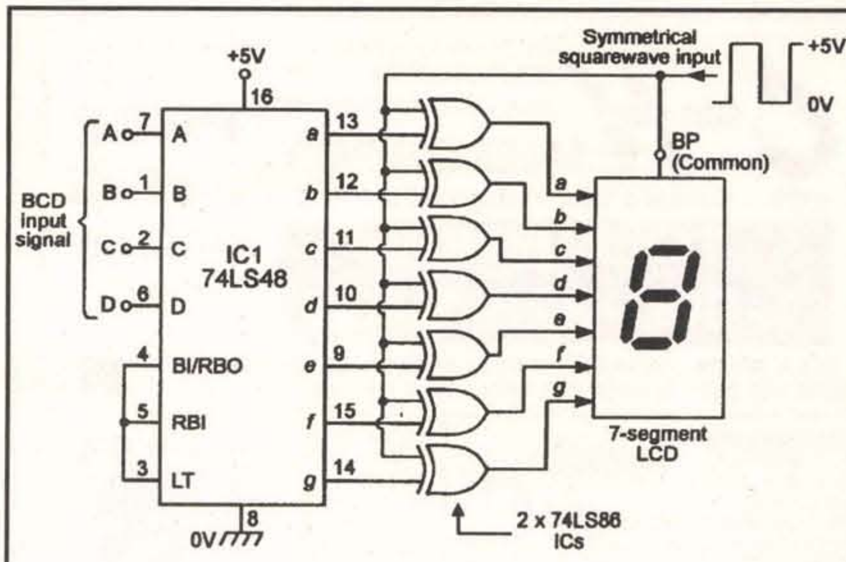


Figure 11. **Basic way of using an active-high LED-driving decoder IC (such as the 74LS48 TTL type) to drive a seven-segment LCD via a bridge-driven seven-section EX-OR array.**

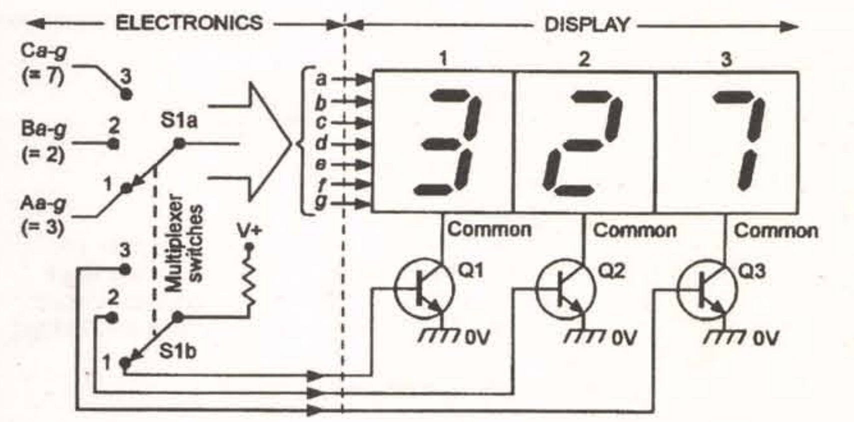


Figure 14. **Method of multiplexing a three-digit common-cathode LED display.**

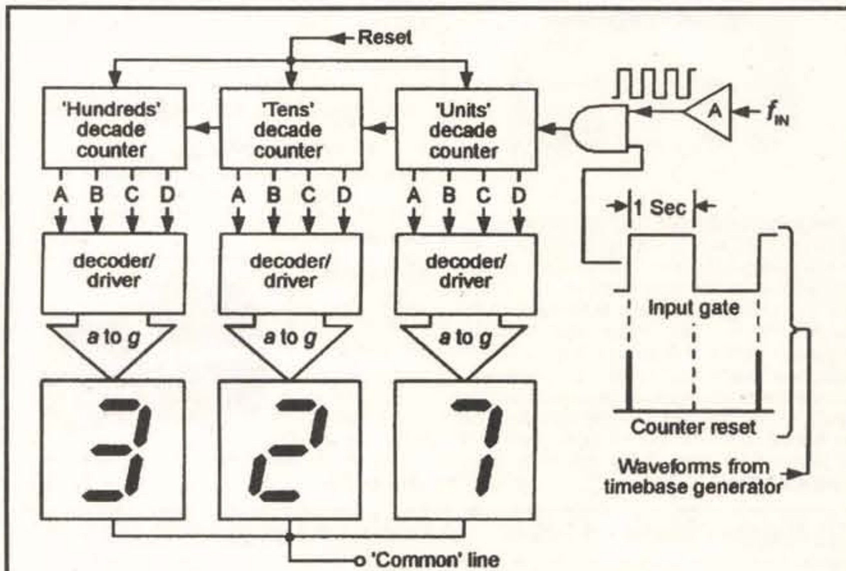


Figure 12. **Simple digital frequency meter circuit.**

to Q3. These switches are ganged together and provide the actual multiplexer action, and should be regarded as fast-acting electronic switches that repeatedly switch through positions 1, 2, and 3. The operating sequence of the circuit is as follows.

Assume initially that the switch is in position 1. Under this condition, S1a selects segment data A*a-g*, and S1b activates display 1 via Q1, so that display 1 shows the number 3. A few moments later, the switch jumps to position 2, selecting segment data B*a-g* and activating display 2 via Q2, so that display 2 shows the number 2.

A few moments later, the switch jumps to position 3, causing display 3 to show the number 7. A few moments later, the whole cycle starts to repeat again, and so on add infinitum.

In practice, about 50 of these cycles occur each second, so the eye does not see the displays being turned on and off individually, but sees them as an apparently steady display that shows the number 327, or whatever other number is dictated by the segment data.

Note from the above description that, since each display is turned on for only one-third of each cycle, the

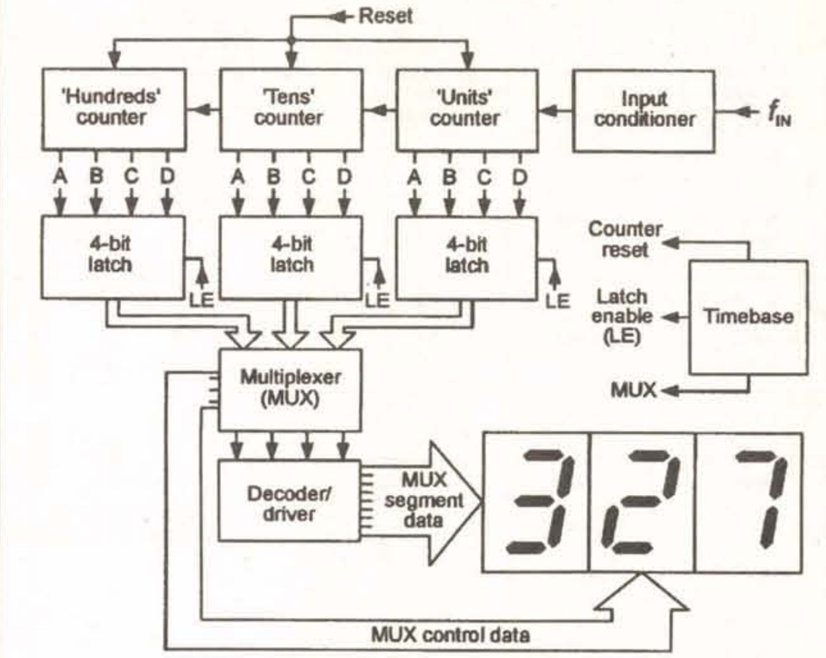


Figure 15. **Realistic implementation of the multiplexing technique in a three-digit frequency meter.**

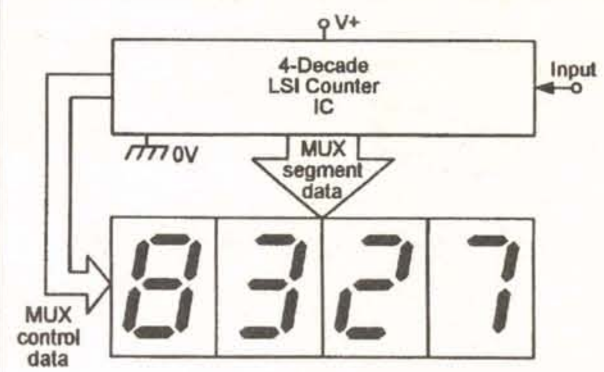


Figure 16. **A four-digit counter circuit, using a LSI chip.**

mean current consumption of each display is one-third of the peak display current, and the LED brightness levels are correspondingly reduced. In practical multiplexers, the peak display current is made fairly high, to give adequate display brightness.

Figure 15 shows an example of an improved multiplexing (MUX) technique, as applied to a three-digit frequency meter. In this case, the MUX is interposed between the outputs of the three BCD data latches and the input of the BCD-to-seven-segment decoder/driver IC. This technique has two major advantages.

First, it calls for the use of only a single decoder/driver IC, irrespective of the number of readout digits used. Second, it calls for the use of a MUX incorporating only five ganged three-way sequencing switches (one for the control data and four for the BCD data), rather than the eight ganged three-way switches (one for the control data and seven for the segment data) called for in the *Figure 14* system.

In practice, all of the counting, latching, multiplexing, decoding, timing, and display-driving circuitry of *Figure 15* (and a great deal more)

7 SEGMENT DISPLAYS PART 2

Next month, Ray looks at practical seven-segment decoder/driver ICs.

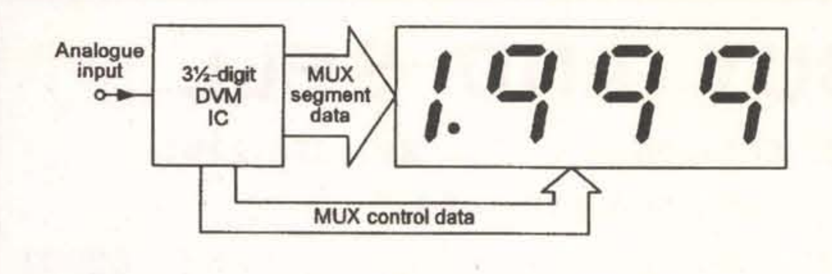


Figure 17. **A 3½-digit DVM using a LSI chip.**

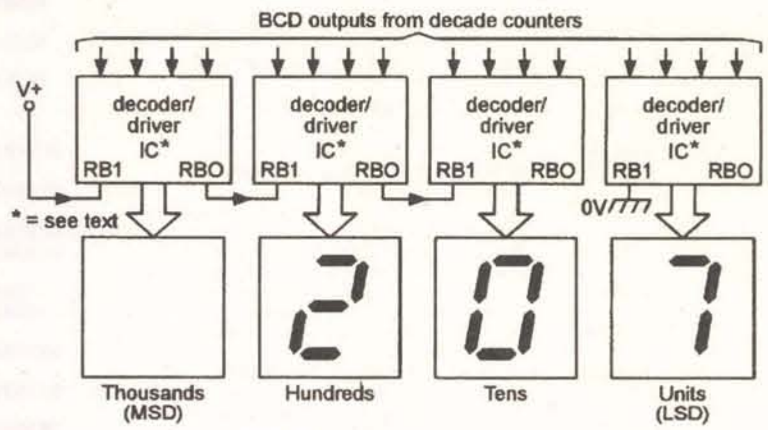


Figure 18. **Ripple-blanking used to give leading-zero suppression in a four-digit counter.**

can easily be incorporated in a single LSI (large scale integration) chip that needs only 20 or so pins to make all necessary connections to the power supply, displays, and inputs, etc. Thus, a complete four-digit counter can be implemented using a dedicated IC in a circuit such as that shown in *Figure 16*, or a 3½-digit DVM (digital voltmeter) can be implemented using a circuit such as that shown in *Figure 17*.

RIPPLE BLANKING

If the basic four-digit *Figure 16* circuit is used to measure a count of 27, it will actually give a reading of 0027, unless steps are taken to provide automatic suppression of the two (unwanted) leading zeros. Similarly, if the 3½-digit circuit of *Figure 17* is used to measure 0.1 volts, it will actually give a display of 0.100 volts, unless steps are taken to provide automatic suppression of the two (unwanted) trailing zeros.

In practice, automatic blanking of leading and/or trailing zeros can be obtained by using a ripple blanking technique, as illustrated in *Figures 18* and *19*. In these diagrams, each decoder/driver IC has a BCD input and a seven-segment output, and is provided with ripple blanking input (RBI) and output (RBO) terminals. If these terminals are active high, they will have the following characteristics.

If the RBI terminal is held low (at logic-0), the seven-segment outputs of the IC are enabled but the RBO terminal is disabled (held low). If the RBI terminal is biased high (at logic-1), the seven-segment outputs become disabled in the presence of a BCD '0000' input (= decimal zero), and the RBO output goes high under the same condition.

Thus, the RBO terminal is normally low and goes high only if a BCD '0000' input is present at the same time as the RBI terminal is high. With these characteristics in mind, refer now to *Figures 18* and *19*.

Figure 18 shows the ripple blanking technique used to provide leading-zero suppression in a four-digit display that is reading a count of 207. Here, the RBI input of the thousands or most significant digit (MSD) decoder/driver is tied high, so this display is automatically blanked in the presence of a zero, under which condition the RBO terminal is high.

Consequently, the RBI terminal of the hundreds IC is high, so its display reads 2, and the RBO terminal is low. The RBI input of the tens unit is thus also low, so its display reads 0 and its RBO output is low. The least significant digit (LSD) is that of the units readout, and this does not require zero suppression; consequently, its RBI input is grounded and it reads 7. The display thus gives a total reading of 207.

Note in the *Figure 18* leading zero suppression circuit that ripple blanking feedback is applied backwards, from the MSD to the LSD. *Figure 19* shows how trailing zero suppression can be obtained by reversing the direction of feedback, from the LSD to the MSD. Thus, when an input of 1.1 volts is fed to this circuit, the LSD is blanked, since its BCD input is '0000' and its RBI input is high. Its RBO terminal is high under this condition, so the 100ths digit is also blanked in the presence of a '0000' BCD input.

Practical decoder/driver ICs are often (but not always) provided with ripple blanking input and output terminals; often, these are active low. If a decoder/driver IC does not incorporate integral ripple blanking logic, it can usually be obtained by adding external logic similar to that shown in *Figure 20*, with the RBO terminal connected to the BLANKING input pin of the decoder/driver IC.

In *Figure 20* (an active high circuit), the output of the four-input NOR gate goes high only in the presence of a '0000' BCD input, and the RBO output goes high only if the decimal zero input is present while RBI is high.

Next month's concluding episode of this two-part feature will describe practical seven-segment decoder/driver ICs and circuits. **NV**

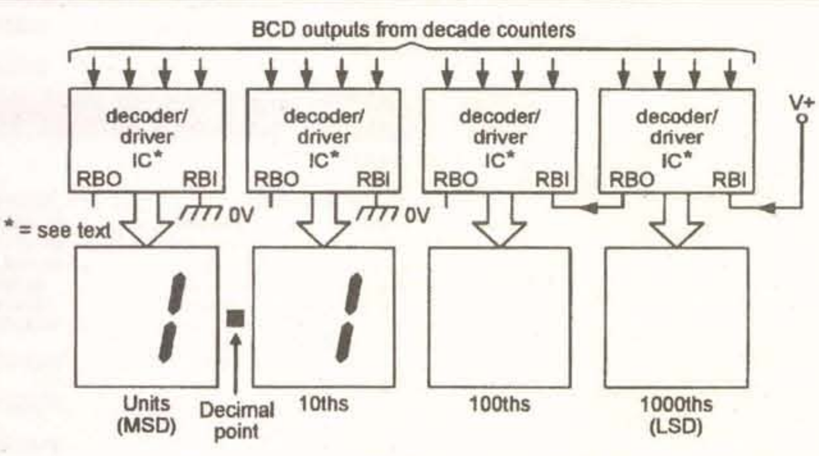


Figure 19. **Ripple-blanking used to give trailing-zero suppression of the last two digits of a 3½-digit DVM readout.**

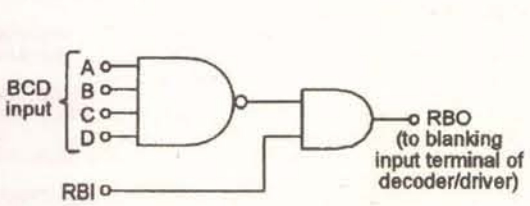


Figure 20. **DIY ripple-blanking logic (active-high type).**

Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by Nuts & Volts readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

Don't forget to check out the new online electronics forums at the *Nuts & Volts* website. There are currently boards for discussing Robotics, Microcontrollers, Radio, Computers, and a General forum for discussing any electronic topic at all. We'll even add new dedicated boards for hot topics. Just let us know!

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**

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.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

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.

QUESTIONS

While in Vietnam, one way to write home was to use a 1/4" tape recorder. These small 1/4" tape players (a reel-to-reel device) were a method to not just write, but to exchange between family and friends.

Well, I have a few tapes and no recorder/player.

Is there a recorder/player available that I can acquire, bid, or build to play these tapes, transfer these tapes to cassette, or even load them into my computer (sound card input)?

5011 **Robert Benson**
Toledo, OH
via Internet

I purchased a Fujitsu Stylistic 1000 with a 340 MB PCMCIA hard drive. On start up, the display shows "non-system disc." I have a laptop that I can use to modify the drive. Any suggestions?

5012 **Rich**
via Internet

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

5013 **Daniel Schlitt**
Springfield, IL

Some time ago, I bought a Piculator from Fred Eddy after seeing an article in Micro Computer Journal. I have lost the cable that connected the emulator to the PC. My understanding is that it was a special cable. I have been unable to contact Fred. Can you help with the specifications of this cable?

5014 **Tom**
via Internet

I bought an Icom PCR-1000 receiver and I had hoped to take it with me along with a new Toshiba 2805-S201 laptop computer.

One big problem, when I bought the laptop, I assumed it had a DB9 serial port. It didn't.

Okay, I thought I would get around this by buying a USB to serial cable on the Internet. I ended up buying the wrong cable. Instead, I received a USB to DB25 cable. Okay, so I got an adapter DB25 to DB9 and installed the software. The software had drivers for all the Windows OSs and, in my case, I installed the drivers for Windows Me.

The receiver worked on the laptop for about 5-10 seconds and then a COM port error popped up saying something like communication between the COM port and receiver hasn't been established. I checked the device manager and found no conflicts.

I then called Toshiba Tech support and was informed that a Targus port replicator was needed for this model of laptop. After going to the Toshiba website and looking under recommended accessories and checking compatibility info for my laptop, I ordered the port replicator. After installing the software for the port replicator, I tried the receiver again, but with not even a second of results.

I called Targus and was informed that I should download a patch for Windows Me and the replicator software. No go. The patch didn't work either. Device manager did show conflicts (yellow exclamations marks).

My last call to Targus brought me bad news. A Targus rep. informed me that its port replicator never works with Windows Me and I should give up. I installed Windows 98 on my laptop for fun and got the same results.

So, my question is, is there any way I can control my Icom PCR-1000 through my current laptop? Toshiba told me I was out of luck and there website was wrong when it showed compatibility with the port replicator.

I can't take the laptop back to Circuit City because it's 45 days old and the manager won't take it back.

5015 **Dave**
via Internet

I was wondering how this Motorola "can" is controlled? It was used to cut power to hot water heaters at peak demand hours. It has eight coils, an enclosed RF section, an antenna, and a plug-in "cube" with a Bramco patent, Part No. A01648 and frequency code 0757.5 (a crystal, I assume?). The switching is done via a relay with a N.C. contact. The relay also has a ratchet mechanism which advances a dial numbered from 1 to 20.

5016 **Peter Stratigos**
via Internet

I need a replacement for a WT8083 IC (eight pins) made by Weltrend, I believe. I also need transistor H1225. The IC has 1meg pot on pins 2 and 3 to adjust flash rate of Christmas lights. Output to each string of lights are on five, six, seven, and eight.

5017 **Lawrence Ferguson**
North Platte, NE

I own an automatic fabric cutting machine that works the same way a CNC machine does. This machine was built by Autometrix Model #5100. It has a total of four five-phase motion controllers; three of them are Model UDX5128NA and the fourth is also a five-phase driver Model-UDX5114NA all made by Vexta. Each drive drives a motor independently.

There are two identical five-phase motors for the X-axis, (0.72" step 2.8A DC and 0.53 ohm), Model PH599H-NAA made by Vexta, and one for the Y-axis. The Z-axis uses a five-phase motor (0.36 Deg/step1.4A 2.3 ohm) Model PH569M-NAA. I'm not sure if the motor Model PH569M-NAA is for the Z-axis because its function is to turn the cutting blade in the direction of the geometry.

What lowers and lifts the cutting blade is an electric/pneumatic solenoid. The blade is lowered at the start of the geometry and lifted at the end of it, i.e., if a rectangle of fabric is to be cut, the blade will be lowered and lifted four times. The carriage moves in Y-X axis unlike a CNC machine. My intention is to modify this machine as required to be used for drilling extruded aluminum with a 0.06" wall.

The software used by this

machine is called SmithPattern. If there is a possibility to modify this machine, what software should I use and how can I utilize the drivers to get this task done?

5018 **German Juarez**
Santa Ana, CA

I recently got a Fujitsu Stylistic 1000 pad computer, no longer supported by Fujitsu.

Does anybody have the DOS/WIN operating system for this machine or know where to get a copy?

I'm also interested in add-ons like floppies and documentation.

5019 **Otto**
via Internet

I'm trying to figure a way to link my Palm Pilot (PDA) to my (Home) cordless telephone. I want to walk around my house and be able to call my internet service using my Palm Pilot. I'm looking for some ideas on how to build or purchase a radio modem that operates in the 900mhz range and connects to my Palm Pilot. I will then need a dialer to dial up my ISP.

Thanks for your help!

50110 **Michael Geyer**
via Internet

ANSWERS

ANSWER TO #4017 - APR. 2001

I need to purchase a 400MHz AMD-K6R-2 with 3D now processor. This is the highest I can go with Trogon E-22 notebook which has been discontinued. AMD also discontinued the 400MHz mobile processor a couple of years ago and I have been attempting to locate one without any results.

For an older part such as this try **www.computergeeks.com/**. They may not have the processor speed you're looking for, however, since it is an older model laptop it is possible it didn't support faster than the K6-2 400 because that's all there was.

The faster K6-2s use the same socket as the 400 and should work since the voltage requirement difference should be minimal. I believe that they have used 450 and 475 MHz processors.

Also, check eBay since several people do resell older processors at auction.

Joey M.
via Internet

ANSWER TO #4018 - APR. 2001

Where can I find addresses of companies that supply super conducting wire?

"Superconductors: A Guide to Resources on the Web" (**www.shahlimar.com/superconductor/**) has everthing from manufacturer listings from university research to government policies.

Amos Bieler
Springfield, MO

ANSWER TO #4019 - APR. 2001

I have built a simple Dac system using a PIC, modem, and a Motorola bag phone. The cell converter for the bag phone is $200.00. Is there a way to direclty interface with the bag phone or a cheaper version of the cell converter?

The Motorola "Cellular Connection" interface, which adapts a bag phone to RJ-11, sells for just under $200.00. You can find them used on Ebay for approximately $55.00. They seem to appear every few weeks. If you don't see one, keep checking. I have bought several with no problems.

Robert Weil
via Internet

ANSWER TO #40110 - APR. 2001

I want to be able to call my home and not have my FAX card and/or machine answer when a voice call is being initiated.

Is there a simple kit I could construct to accomplish the desired results?

Unless you use "distinctive ringing" (two phone numbers on one line), there is no way to tell the difference between a fax call and a voice call until the call is answered.

A fax machine generates a CNG tone when operated in the "auto-mode." A device to detect this tone is available from any telephone interconnect company.

Your other request about it not going to a machine, I assume you mean an answering machine, would be kind of tough, too. If you don't want the call to go to the machine, how will others leave messages?

Dennis Hewett
Frontenac, KS

TECH FORUM

ANSWERS TO #4015 - APR. 2001

I have a Hewlett Packard 5342A frequency counter. I need what used to be an off-the-shelf IC, the LF13333N quad JFET switch.

Does anyone know of a source for these, since they are no longer being manufactured by National Semiconductor?

I've already tried most of the major IC distributors, such as Digi-Key, Arrow, Avnet, etc.

#1 Your best bet for finding obsolete components like the LF13333 is at a company that specializes in discontinued parts, such as Rochester Electronics www.rocelec.com/. I checked on their web site just before writing this and saw that they have over 1,600 of the LF13333D in stock, which is a case variation from the LF13333N that you specified. It also has higher temperature and power dissipation ratings. The 'D' case chip should work just fine in your counter.

Dave M.
via Internet

#2 Dial Electronics in the UK has them listed as available. They accept credit cards, price in US dollars and will ship to US. Find them at: **www.dialelectronics.co.uk/index2.htm**

Phil Shewmaker
Louisville, KY

#3 RadioShack.com lists the LM13333N by Anthem Electronics for $7.27 (900-6860). Also, Digi-Key lists a pin compatible part, Pericom #PS393EPE-ND for $2.48.

Russell Kincaid
Milford, NH

#4 If it turns out that a pin-compatible part can't be found, remove the defunct LF13333N, install a DIP socket, and then experiment.

An alternative that looks like it could be adapted is the Maxim MAX353CPE-ND available from Digi-Key (800)344-4539 at $5.43. That part has two normally-open switches and two normally-closed switches with the same pinouts as the LF13333N.

But for the MAX353CPE-ND, you need to connect +15 Vdc to pin 4, ground to pin 5, the "Logic Level voltage" (probably +5 Vdc) to pin 12, and 15 Vdc to pin 13. In other words, pins 4 and 5 are swapped, and pins 12 and 13 are swapped.

With a little more cutting and pasting, you could adapt the DG201-type analog switch that is available from Mouser Electronics (800)346-6873 as catalog number 513-NJU201AD at $0.98 each.

All four switches on the 201-type are normally closed. To adapt the 201 to your circuit, you would need to invert the logic level switching signal to pin 1, and also to pin 8.

And, like the Maxim part, the power pins are swapped around.

If it should turn out that the analog excursions being switched actually remain in the range of about plus to minus 5 volts, and it is just a voltage signal that is being switched, rather than a current, then you may be able to substitute an equivalent circuit made from the good old fashioned and readily available 4016 quad CMOS switch and a 4049 hex inverter, using a couple of 1N5236 zener diodes and resistors to regulate the rails down to plus and minus 7.5 volts. Worse lash-ups have been known to work.

Jack Dennon
Warrenton, OR

ANSWERS TO NOEL P. LARSON - APR. 2001

I'm restoring a number of Heathkit monobanders (HW-12, HW-22, and HW-32). What I need is a replacement for the output transformer T4 that goes to the speaker.

#1 In the RCA tube manuals I checked, the pentode unit of the 6EB8 tube used as the audio output amplifier does not have a characteristic load resistance specified. A number of other pentodes, notably power output types, do have a characteristic load resistance, typically ranging in value from 3,000 to 7,600 ohms.

In Class A voltage amplifiers, load resistance is defined as the parallel combination value of the plate load resistor and the grid resistor of the following stage. For audio output amplifiers, the load resistance is the characteristic impedance of the primary winding of the output transformer.

Tubes are rather forgiving creatures within their operating limits, and since you need voice band reproduction only in the 300 to 3,000 Hz range, the output transformer you choose need not be of optimal load resistance. This usually becomes a factor only in high fidelity sound applications.

The transformer for your Heather transceiver need only be an adequate impedance match between the plate circuit of the 6EB8 tube and the 8- ohm loudspeaker.

Some types of output transformers were marketed in the past as universal replacement transformers that would match a wide range of plate and load resistances. Two of these types with a primary impedance range of 4,000 to 14,000 ohms are the Chicago Standard Transformer (STANCOR) A-3823 with an eight-watt rating and the A-3856 with a four-watt rating. A transformer with a four- or five- watt power output rating should be adequate for your application.

Another requirement to keep in mind is the physical size and mounting method of the transformer. The higher the wattage rating of the transformer, the larger it will be.

You may be able to locate a type A-3856 or equivalent transformer at Antique Radio Supply. Another source may be larger hamfests or you may try posting your request on qth.com.

Glen Thome
Elyria, OH

#2 Since the tube has a max output of five watts, any small single ended output transformer will do. Several suitable ones are available at Antique Electronic Supply **www.tubesandmore.com**. Check the mounting dimensions for fit, they start at $5-$10 and go up from there.

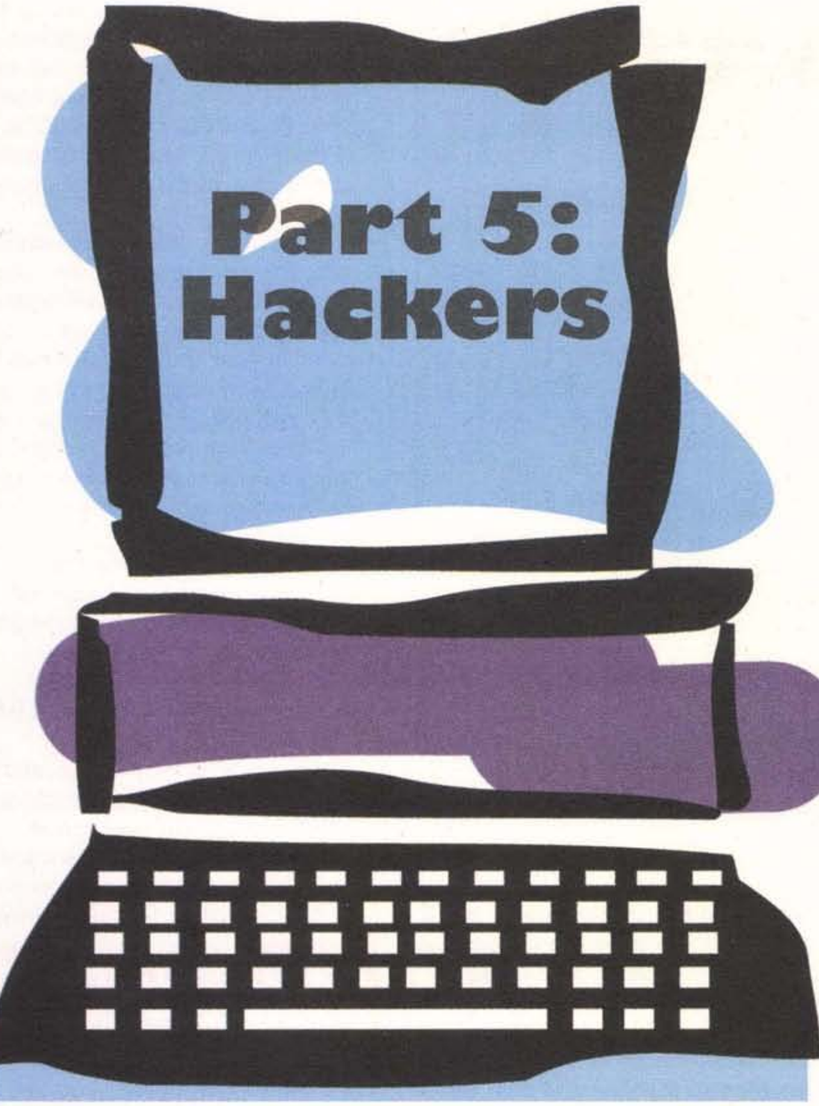
Douglas McCallum
Lansing, MI

#3 The specs for your transformer should be: 5K to 10K primary impedance, eight ohms secondary impedance. The primary must handle 25 mA DC. The higher primary impedance will give about two watts output, enough to drive you out of the room if the speaker is efficient. A search of the WWW may turn up a supplier, you won't find any in the commercial catalogs. Check out **http://radioclassified.com**.

Russell Kincaid
Milford, NH

Cyber-Street Survival

by M L Shannon



Welcome back again to Cyber-Street.

In Part 4, we read about Internet Stalking, Cyberporn, and CommView, a Packet Sniffer. Part 5 is about Hackers, Viruses, Trojan Horses, and Encryption: ways to 'scramble' your Email so no one but the recipient can read it. And, we will look at several programs, starting with a port scanner. This is one of the basic tools used by hackers, but it has a legitimate use in testing the security of an online computer. And while you may have heard otherwise, is not unlawful to own.

The Media Myth

Not long ago, there was a story on a Web news server that 'hackers' took control of a British military communications satellite. It didn't happen. The story was a complete fabrication. A reporter later admitted that he had made it up.

Another report had a teenager holding several big corporations 'hostage' by taking control of their networks. Another media lie. It didn't happen.

Kevin Mitnick was tried and convicted by the media of "costing" several big corporations hundreds of millions of dollars. However: Whenever a public, stock-issuing company is in a situation where the value of the stock is endangered, they are required by law to make a report to the Securities Exchange Commission. I made a search and could find no record of any such reports ever having been filed. Which should tell you something.

Evil teenagers, college students, terrorists who intend to destroy anything they can get their digital digits on. Some of these hackers can "launch nuclear missiles by whistling into a telephone." There are people who actually believe these things. After all, "they" said so in the newspaper, and on TV, so it must be true, right? Malarkey.

The mainstream media tends to badmouth hackers in particular and the Internet in general. Why? Maybe they feel threatened. No longer is the newspaper people read every day, and the "News At Ten" the only source of information available to them. You can learn more about current events, politics, sports, and whatever else on the web, from many different sources and perspectives and, unlike TV, you choose what stories you are interested in. Without commercials!

If you want to have a better, more objective idea of what hacking is all about, read on.

So, what is a hacker?

Hacking is a way of life, an attitude, a mindset. A hacker is someone who wants to understand how things work and who learns by taking them apart and putting them back together. A hardware hacker, for example, is someone who knows what is inside their 'box' and can work on it themselves. They don't need to hire someone to install a larger drive or new motherboard; they do it themselves.

A software hacker might be described as a programmer, since one has to know how to program to be able to edit and modify software.

Hacking is about wanting to know things, sometimes things that we aren't supposed to know, or allowed to know. Sometimes it is about getting into places that are "forbidden." Hackers tend to be independent thinkers who are inclined to dislike authority.

There are hackers who might be described as 'playful' who make unauthorized modifications to web sites. Some of these people are very imaginative and the results are funny, as well as getting their point across. That doesn't make it right, and I make no excuse for defacing other people's sites, at least most of the time. But hate groups and religious fanatics who would take control of the Internet and force their beliefs on everyone else, I have no sympathy for. And anyway, if the site maintenance people are doing their job, the original site can be restored from back-up files in a matter of minutes. It is rare that any screens beyond the opening index.html has been 'modified.'

Then, there are those who are destructive. Who crash systems, such as was done to Yahoo a few months back. They are a very small minority. Contrary to what you may read in the newspapers, there really are not 'gangs' of evil hackers plotting to shut down the Internet. These destructive people should be punished for what they do. Hackers who cause no destruction, who steal nothing, should not be persecuted. But we are.

Security Tip

In the Windows/command directory are two programs: fdisk.exe and format.com. Fdisk is used to partition a drive, to divide it into logical drives which the computer 'sees' as if they were separate physical drives. Each logical drive has its own letter. This machine, for example, has two physical drives partitioned into 10 logical drives C through L. Format is, of course, the program that formats a drive, wiping out all data.

If you rename these files temporarily, they cannot be used by certain viruses or Trojans. You can change fdisk extension to .exx and format to .cox or something like that, and they will not run.

The easy way to rename files is to use Ztree for Windows available from www.ztree.com. If you don't have Ztree, do the following: Start, Programs, MS-DOS prompt. You will see C:\>. Type cd\windows\command and hit Enter. You will see C:\windows\command

Next, type rename format com format.con and hit Enter. That's it!

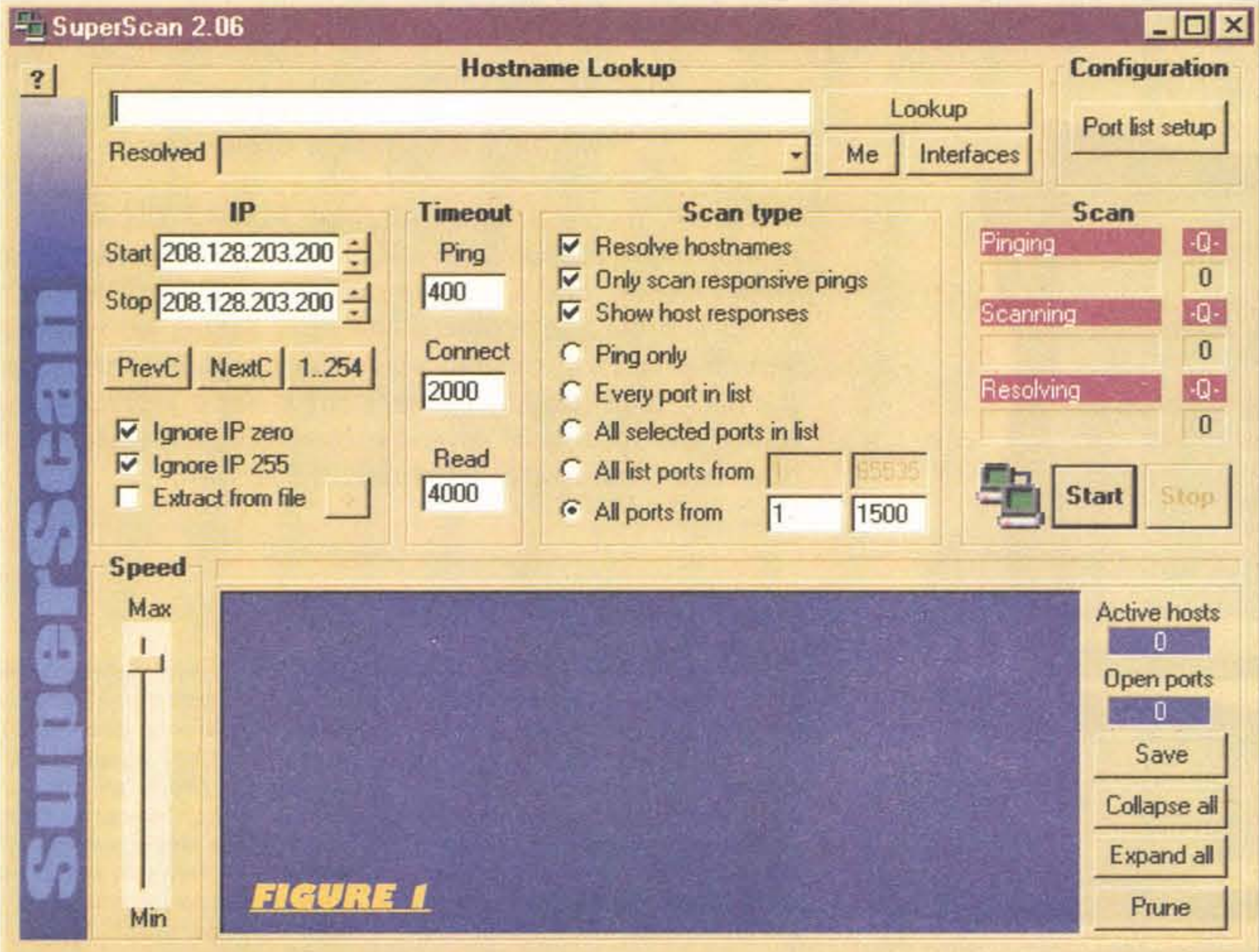


FIGURE 1

Again, hacking is an attitude, a way of life. Either you understand or you don't.

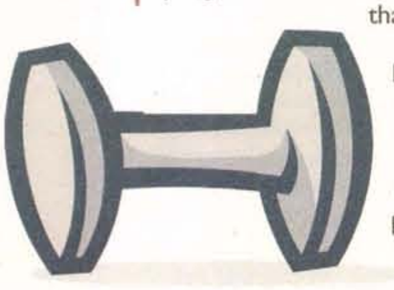
Why you should be glad there are hackers ...

When Netscape was released some years ago, a "teenage hacker" in Europe quickly found a security breach. Another version was developed, and it, too, had vulnerabilities. Ditto later versions, ditto Microsoft Internet Explorer. Matter of fact, new versions of IE are sometimes followed by 'patches' that are required to close some of its security leaks.

The same was true of other Microsoft programs. One of them — Office — was revealed to be easily vulnerable to invasion by Trojan Horses by hackers at L0pht Heavy Industries in Boston (www.lopht.com). They discovered this serious flaw which Microsoft tried to deny.

And the list goes on. If it weren't for hackers, these weaknesses would continue to exist making every Windows computer easier to attack.

So much for ideology. Now, let us get into technology.



An Exercise

Remember about using Gibson Research to check if you have any open ports through which someone might get access to your computer? And about making sure that you have File and Printer Sharing disabled? For someone to get access, one or more of these ports have to be "listening." You would have to install some kind of program that turns some of these ports on.

File and Printer Sharing does this. But none of the other ports are open and listening unless you open them. Or, someone else opens them. This can be done by having a Trojan Horse installed on your computer, which can get there in any of several ways. More on this coming up.

Port Scanning

A port scanner is, obviously, a program that is used to scan ports. Openings or doorways into a computer.

If you know the IP of a particular computer that is online, you can type it in to the scanner and the program will scan all the ports on that machine.

If you don't know the IP, which may be dynamic and so changes whenever the computer goes online, then you can scan all of the IPs that are assigned to the ISP the target computer connects to. In other words, if you know that someone has their account at joeblow.com, then you can determine all of the IPs that are assigned to joeblow and scan them, looking for open ports. With some luck and determination, you will find the IP that the computer is using, and then start scanning the ports.

And, of course, you can scan through any range of IP addresses, just to see what's there.

Keep in mind, though, that if you scan IP addresses that you do not have authorized access to, this may well be seen as a malicious attack. It is very possible that someone will see this happening, and log your IP address. The records at your ISP will reveal who was using that IP at the time of the 'attack.' And you are caught.

However, there is no reason why you cannot use a port scanner on an IP that you are authorized to access, and there are ways to do this. The first is if you have two online computers; use one to scan the other which is what I have done in writing this article. Or, if you have a friend who wants to work together, then you can scan each other's computers.

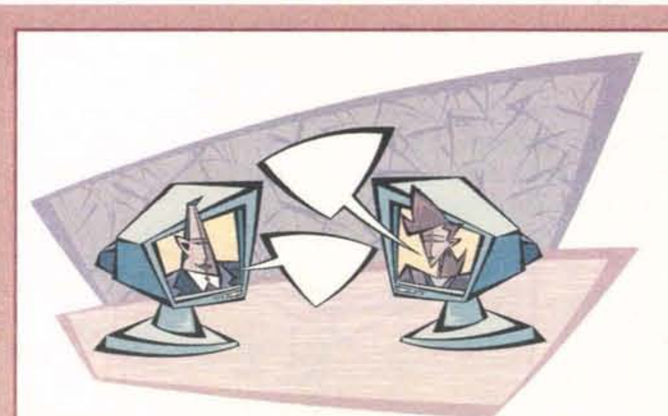
Just to avoid any possible problems, you could advise your ISP that you are conducting these experiments.

Super-Scan Version 2.06

Super-Scan is easy to use, and has very good help files should you need them. It was available at http://keir.net/software.html, but has been sold to another company and, as of this writing, it is still freeware. Download and install it, and you will see the screen in Figure 1.

What's the IP address?

In the top left corner, you see IP with two windows below it: Start and Stop. Determine the IP to be scanned. If using a second computer, get online and use IP Agent from Gibson Research (www.grc.com) to



1984 Revisited?

In Orwell's classic story, everyone had a camera in their home. "You never knew when they might be watching ..." Today, many people have cameras hooked up to their computers so people they are chatting with can see them. Great idea, I guess. Unless you are feuding with your granny again.

But there is a bit of a problem here. A new Trojan called Sub Seven can be used to turn your camera on. When you might not want it on. I mean heck, we all do things we don't want broadcast on the Internet, right? And, like other Trojans, if someone gets it on your machine, they can have total control of it.

What can you do about this potential problem? Go to www.macafee.com and get the latest Anti-Virus software, and also check out The Cleaner.

find the IP. If working with someone else, have them do the same, and send the IP to you. Since you are scanning only one IP, enter that IP in both the Start and Stop windows.

Under Scan Type, for now use Ping Only. At the bottom, click All Ports From: and enter a range such as 1 to 140. You can use any range you like, but scanning the entire range from 1 to 65,535 takes a long time and places a load on your computer, and most of them aren't even used. Later, after you read more about ports, you can try different ranges.

For now, all of the other settings can be left as they were when you first installed Super-Scan.

Okay, you're ready. Click the Start button on the right side of the screen and observe. It happens fast, since you are scanning only a few ports.

Results

So, what happened? Probably nothing on your end. Look at the large purple box at the bottom of the screen. If Super-Scan found any open, 'listening' ports, they would be listed there. If you see something, click Expand All at the bottom right corner and you will see a list of open ports.

What about the other end? Again, probably nothing. This is as it should be — it means the computer that was scanned is secure. Unless you decide to open one or more ports.

Cross or Double-Cross?

In the last issue, you read about Cue Cat, the free barcode scanner that RadioShack was giving away. Well, what with everything becoming portable these days, the A. T. Cross company, maker of those nice gold filled pens that no attorney would be without, came out with the Convergence Pen. Now nothing that Cross makes is cheap, and the Convergence Pen is no exception at $90.00, but you can take it anywhere and scan barcodes wherever you find them — it can hold up to 300. Then, you can dump them to an online computer using the included cable.

A clever idea, but naturally, I wondered if this gadget included a serial number like Cue Cat, and if it secretly sends your personal information to a database somewhere.

So, I fired off a letter to Cross. A copy of the Email is on the Cyber-Street Message Board as will be their reply, should they answer. The board is at http://members3.boardhost.com/CyberStreet

Thanks to a reader in New York for sending me the article on the Convergence Pen, published in *Computer Shopper*.

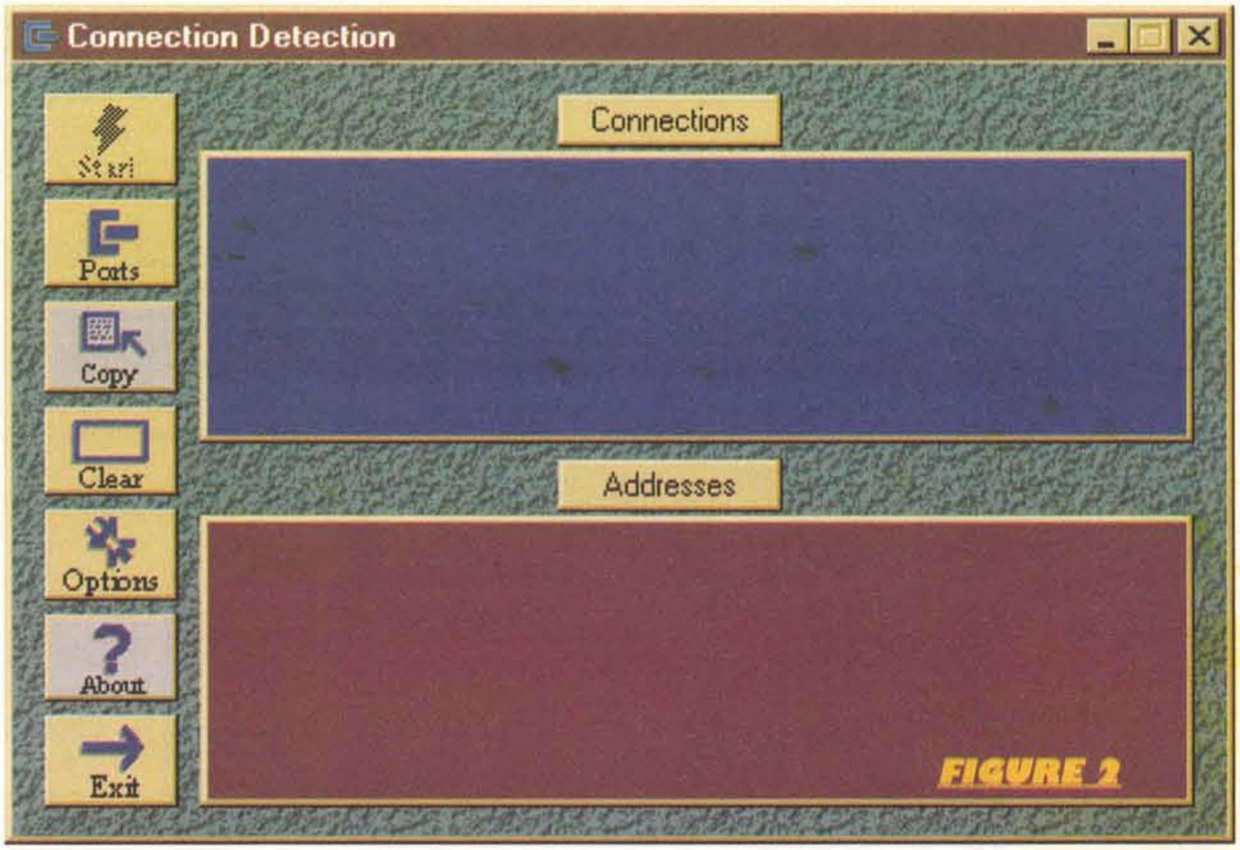


FIGURE 2

Do try this at home!

If you want to see how Super-Scan reacts to finding an open, listening port, go back to keir.net and download a program called Attacker. It is in compressed form (zip), so to use it, you need to use a program like Winzip to convert it so you can install it. Winzip is available at www.tucows.com and www.winfiles.cnet.com. Install it as you would any other program. Help files are available should you need them. Once installed on the computer to be scanned, you will see the screen in Figure 2.

Click on Setup, then check Automatically start listening ... Then click Ports. TCP should be checked, and under that is a list of ports. Add some, remove some if you like, or just leave it as-is and click OK. Finally, click Start. Attacker is now ready; it has opened the ports that were in the list so that they are listening. Now, repeat what you did with Super Scan, selecting the ports on the remote computer that have been opened with Attacker, or a range that includes them. In the large window, you'll see the IP address, indicating that some open ports were found. Again, click on Expand All in the bottom right corner to see a list of ports that Super Scan found. (See Figure 3.)

Now, if one of those ports is for File Sharing, and a shared drive has been selected, you may find that you now have complete access to the scanned (target) computer.

Okay, troops, that's how port scanning works. A bit of an oversimplification, but it shows you the basics. In Part 6, I will have details of an actual scan done to a notebook computer here in my office, from someone in Australia.

If you were scanning for real, rather than your own computer or that of a friend, and there are open ports, you may have found a computer that has a Trojan installed (something had to open that port). The next step is to refer to a list of those ports known to be used by Trojans. These two sites have a list of Trojan ports:

http://www.sans.org/newlook/resources/IDFAQ/oddports.htm

http://www.silverdragon.yndns.org/trojans/

If you find matches, then you need to make a search for the right Trojan. Dogpile is a good multiple engine search tool. If you find it, or them, then follow the installation instructions and run the client program (the one on the other computer is the server) and you may be in. It won't always work, but sometimes it does.

So, what exactly is a Trojan horse?

A Trojan is a small piece of code, a little program that can be installed on the target computer to open a port, to make it listen. Then, the person who placed it there may be able to use the Trojan to take control of the machine. They may be able to do anything you can do from your keyboard: copy, move, delete files, and even format the drives. This depends on the type of Trojan, of which there are more being written every week.

Types of Trojans

Different types do different things. Some are Keystroke Monitors that capture the passwords you use to access your computer, the Internet, or password restricted areas on the net. Others are merely an annoyance used to harass people.

Probably the most common type is called a RAT: Remote Access Trojan, which — as mentioned above — is in two parts: the 'client' and the 'server.' The server is the file that goes on the target computer and the client on the 'hackers' system. Back Orifice (http://www.cultdeadcow.com/tools/) for example, has a server program that is called boserve.exe. This is one of the more famous programs that can be called a Trojan or a Remote Administration Tool. Semantics. It does what it does, even though Microsoft claimed for some time that it was 'theoretical.'

Now, someone is gonna ask, "Yeah, but how can the installer find out the IP of the target since most computers have dynamic addresses?"

In Part 6, we will get into IP Tools, one of which is used to find the block or range of IPs assigned to an ISP. Any ISP. Meanwhile, there is a plug-in for

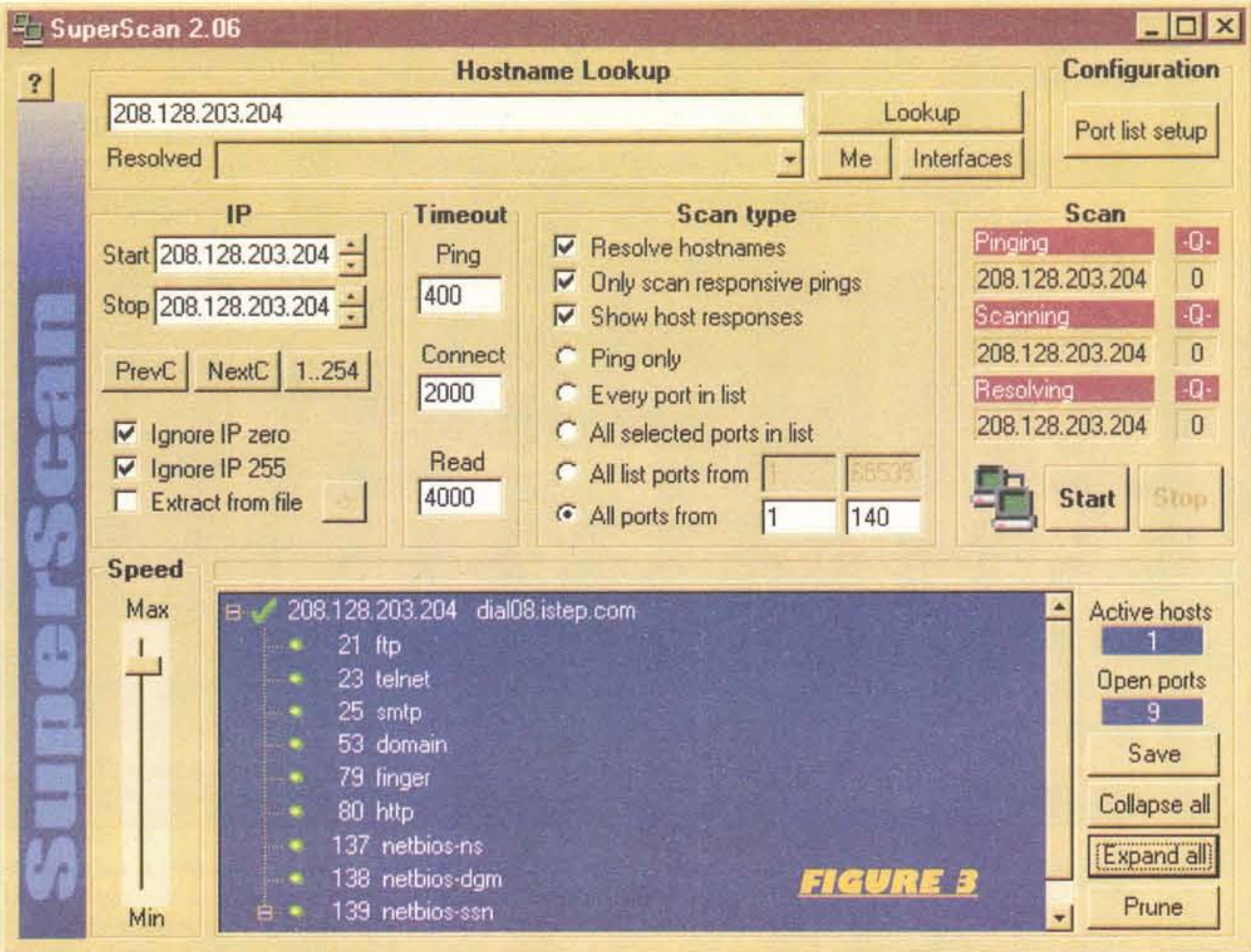


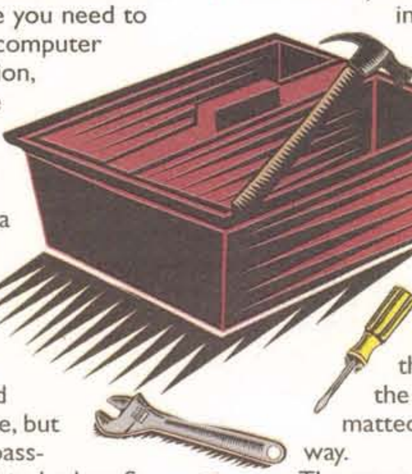
FIGURE 3

Back Orfice, called Butt-Trumpet that will send Email whenever the target computer goes online. Clever. Useful. Dangerous. Another reason to limit access to your machine to people that can be trusted. Ditto any disk you receive in the mail. And double-ditto about opening Email attachments. Back Orfice, at 125K, may be too obvious as an attachment, but there are Trojans that are only a few Kilobytes in size.

Remote Administration

There are a number of programs called "remote administration and monitoring tools" which are similar to Trojans in that they provide remote access to a computer. If you will be in a situation such as a business trip, where you need to access your home computer from another location, you take a portable computer with you. On both computers, you have installed such a tool. PC Anywhere from Symantec or Carbon Copy.

These programs are password protected, of course, but when it comes to passwords, people tend to be lazy. So they use something stupid. In one case, I remember, a System Administrator used the default password — the one that came with Carbon Copy. Stupid. But it happens. And then they get hacked, but can't understand why.



How would I recognize a Trojan?

The most obvious indication is when you see the mouse cursor moving but you are not doing it. Should this happen, hit the power switch or Reset button INSTANTLY! Don't wait for your computer to disconnect or shut down, just hit the switch!

If files become corrupted or disappear completely, new files are added that you know you didn't install or, worst of all, when you turn your computer on you get an error such as Sector Not Found or Bad or Missing Operating System, this means there has been serious damage to the files, or even that the drive has been formatted. That's the hard way.

The easy way is — as always — prevention.

The Cleaner

There are lots of programs that are written to Search and Destroy Trojans. One of the most popular is The Cleaner from www.moosoft.com. Download and install the same as any other program.

Select which drive(s) are to be tested and click the Scan button. It took about three minutes to search my drive C and half an hour for all 11 logical drives. The Cleaner has a list of known Trojans, hundreds of them, and their database is updated frequently so you can download the latest information.

Viruses: What is a virus?

A virus is defined as a small program or routine — a few lines of programming code — that has the ability to duplicate itself and spread throughout a computer, and that can cause things to happen. This may be anything from harmlessly placing a few words on your screen to formatting your hard disk and wiping out everything on it. Or them, if you have multiple drives.

How it all started: Mr. Morris and the Infamous Internet Worm

I don't know when the first viruses (virii?) were created, but they didn't get a great deal of attention, probably because they had little effect — did little damage. The first to be widespread and to get publicity was the Internet Worm which was created by a programming student at Cornell University. While technically this was not a true virus (it was, in fact, a worm), it caused a lot of problems on Unix computers in many locations as it spread through the Internet.

Since then, umpteen viruses have been written. The Jerusalem from a few years ago, Melissa, I Love You, Snow White, The Naked Wife ...

How can they get into my computer?

While sipping a cup of coffee, you fire up your computer and the first thing you probably do is check your Email. Hmmm. Message from the boss ... another message from the boss, this one in bold caps, a letter telling you how to turn $6.00 into $60,000.00 in only six days ... and, what's this? A greeting card from Ecards Limited. You open it, and there is a message: Just click here to see your birthday greeting card. While absently thinking that, this is June, I was born in October, curiosity has overcome you and you click. The click of death. And suddenly, all hell breaks loose. The entire screen turns blue. Or the drives start chattering as every file

Sites To See

http://grc.com/su-bondage.htm
Gibson Research's *Network Bondage*. One of a series of articles about Windows' lack of security and what you can do about it. Somewhat technical, but well written.

http://www.spybusters.com/security_scrapbook.html
This is the site of Murray Associates, one of the best TSCM companies in the US. And in addition to the conventional spy devices, Kevin's company has a great deal of expertise in computer security. On this site, you will find all kinds of interesting things, particularly the Security Scrapbook which has links to many recent stories from the world of espionage. And, yes, hacking.

www.fusionsites.com
This is my site, where you can find a long article on surveillance and within it, a detailed explanation of how the public-private key encryption system works. Also, on the opening screen is a button — Nuts & Volts — that takes you to the Cyber-Street Message Board.

you have is erased.

Prevention

This is not difficult. To repeat myself yet again, don't use your browser for Email. Use a separate program such as Eudora or Pegasus. This is especially true if you use Internet Explorer — Outlook Express may be convenient, but unless you have it configured right, you are better off not using it at all.

Don't ever run a program you received from an unknown source. Such as an Email attachment. It may be a Trojan or virus. The message will show the name of the attached file, which will usually have the extension of .com, .zip, or .exe. One example is picture.exe which, if opened, searches for the user name and password of those who have an account at America Online, and then sends it to a computer somewhere in China.

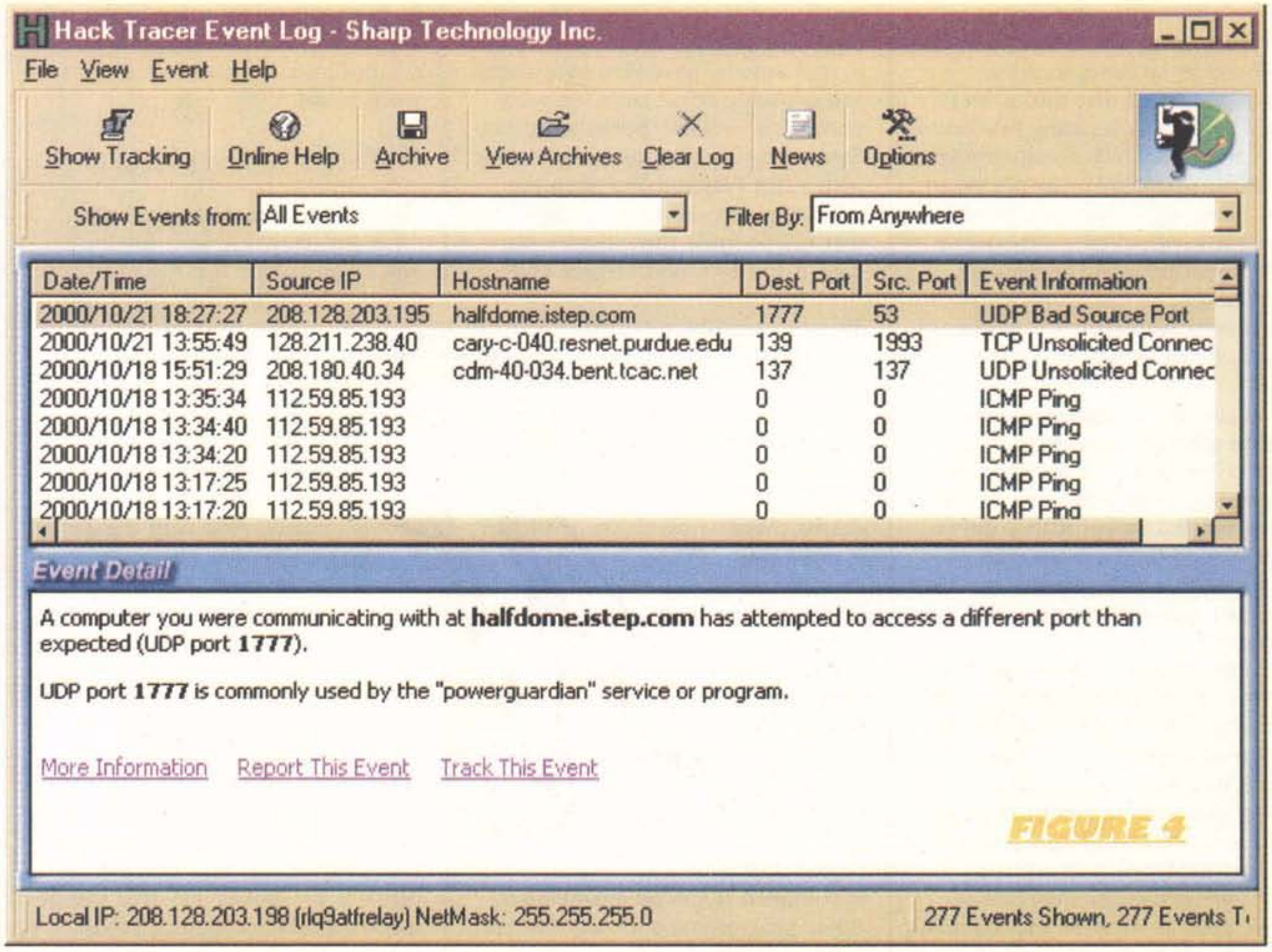


FIGURE 4

Detecting Attacks

Back in Part 1, we discussed Zone Alarm, a very good Firewall that will protect you against port attacks. Recently, I stumbled across another program that can be used at the same time as Zone Alarm. Originally, this was Hack Tracer (see Figure 4), which has been replaced with NeoTrace. It works in the background and when anyone tries to contact your computer, it alerts you, as well as preventing the intrusion. More on this new program in the next article.

Serious Hacking

This overview has explained a little about hacking — understanding ports, using a scanner, and ways to possibly get into a remote Windows computer. But big time hacking, such as getting into mainframe computers at corporations, ISPs, and like that, is something else. These machines are usually running UNIX or a variation such as Linux, and to do anything on them, you have to know these operating systems.

Another thing that an experienced hacker knows is how to cover their tracks; removing any trace that they were ever there, and the path that was used to make contact.

A shell account would likely be used to start, and then the hacker would work through any number of other computers using Telnet. Telnet is a protocol with which you can connect to a remote computer and then, depending on permissions, it is like you were sitting at the keyboard of that computer. You can enter commands, copy files, upload files, and with the right permissions, you could erase everything on the computer.

Ordinarily, such permissions, called 'root access' are available only to selected personnel; System Administrators, technicians, and others. But with the right skills, a hacker can 'get root.'

How do you learn more?

If you want to learn Internet Technology in great detail, consider studying for network certification. Read everything you can find. Spend endless hours searching the Internet for hacking and network certification sites. Learn a programming language, and most of all, learn the Unix operating system.

Yes, you read that right: An Internet Technology expert and a skilled hacker know many of the same things and use the same tools and programs. The difference? Semantics.

Meanwhile, you have already learned enough to ask intelligent questions. Attend the 2,600 meetings held the first Friday of every month in many cities across the country. Show up regularly. Listen a lot before you ask. But keep two things in mind. If you ask dumb lamer questions such as, "Hey, tell me how to hack" or if you show interest in doing anything destructive, you'll just be ignored. Unwelcome.

Data Encryption, From Caesar to Zimmerman

Encryption is a method of "scrambling" information so that it cannot be read by anyone except those who are supposed to read it. We all know that. Encryption has existed for centuries, and enough has been written about these methods of "secret writing" to fill a library. However, it is not necessary to spend a lot of time learning about the technical aspects of ciphers any more than you need to be a mechanic to drive your car. There are programs that are very easy to use, and some that are more difficult. Some very secure, others that cannot be trusted.

But which ones are which? That's what we all do not know. Here are some of the answers.

But, Do I Really Need Encryption?

This is a question only you can answer for yourself. If you have information to transmit over the Internet that is proprietary, business data, trade secrets, marketing plans of a new product; anything that someone else might make the effort to intercept, then yes, you do. As to your latest feud with your Granny, well, no offense intended, but who the hell cares? Would your cousin make the considerable effort to hack into your Email so that next Thanksgiving, he will get one of the coveted drumsticks instead of you? Unlikely. The decision is yours, but if you are going to use encryption, then why not use something that provides the level of security you need?

Okay, already: What programs are safe?

Well, there is some disagreement over what is secure, or rather if there is actually anything that truly is. Some people believe that agencies such as the NSA, the CIA, and NIST (National Institute of Standards and Technology) can instantly decrypt any message regardless of what program was used to scramble it.

It is the policy of the NSA, so I have heard, to refuse comment on what they can and cannot do. But if an encryption program is used as it is supposed to be used, then I am totally convinced that this is not true. At least not by using the 'brute force' method which means trying out every possible key or password used. Some algorithms are so complex that it would take a thousand of the most powerful computers available tens of thousands of years. Or millions, whatever, it is academic since none of us will be around then.

A year or so ago, one of the Federal agencies busted an organized crime figure on the basis of information in his computer. It was encrypted, but to get it they didn't break any codes. They sneaked in and installed a little gizmo that records keystrokes to snarf the passwords.

Since this was a major case, if they were able to "break any code," then why didn't they? Why take the chance of breaking into a place where, if caught, they could get themselves shot at, and unless they had a warrant, the evidence would not be admissible in court?

There are other methods of attack, such as libraries that contain long lists of common words and phrases that some people use as passwords. And there are ways to steal passwords, especially if people leave them laying around.

For your personal Email, just about any encryption program will keep honest people honest, assuming that they can even get access to your Email. There are dozens of these programs listed at www.winfiles.cnet.com. Many of them use the Data Encryption System (DES) which was an industry standard for many years. It is no longer considered safe because it can be defeated in real-time by government agencies and probably some large corporations with a million bucks to spend. But not by the average programmer with a hot Pentium. For absolute military grade security, a program that has become the industry standard is Pretty Good Privacy, PGP.

What about other, proprietary ciphers?

Regardless of the level of security you desire, there is one main consideration: Is the source code available? Source is the program as written by the programmers, in sort of plain English, before it is compiled. It can be examined by other programmers to see if it has weaknesses such as "trap doors" or secret 'master' keys that can be used to defeat it.

If the source code is not available, then the program should not be trusted. It may well be very secure, but unless the source has been made public, or at least carefully analyzed by experts, you have no way of knowing. Why take the chance when these proprietary ciphers are often expensive, but the DES and PGP are available free? PGP is 'open source' and it has been examined by some of the best cryptographers and programmers in the business. No such weaknesses were found.

Key Sharing

To decode an encrypted message, obviously you require a key, or password. But the problem that existed until a few years ago was getting the key to the persons authorized to have it. Sending the key through unsecured channels meant it could possibly be intercepted. And with the security weaknesses known to the Internet, this was a big problem.

Then, three programmers found the answer in what is known as the Public Key system. It was called RSA after the names of the inventors, Drs. Rivest, Shamir, and Adleman. The program generates two keys. One is your private or secret key that you keep to yourself, and the other is the 'public' key that can be made available to others. When someone wants to send you a secret message, they use your public key. When you receive it, you use your private key to unscramble the message.

A few years later, Phillip Zimmerman of Colorado wrote a program that used this public key system and released it to the public free of charge. This program is PGP, Pretty Good Privacy, and is now available in several different versions. One of them is free, others are available commercially.

Where can I get it and how do I use it?

Both the free and commercial versions are available at www.pgp.com. As to using PGP, it is not like the other programs in these articles; it takes some time to learn. Help is available from within PGP itself and many web sites, so if you really want to use PGP, take your time and you'll soon have it up and running. There are also plug-ins for using PGP with some Email programs.

Eudora
http://www.eudora.com/central/plugins/
Pegasus
http://www.pmail.com/links_enc.htm

NV

Next Month

Part 6, last in the series, is about Internet tools. Here, we will rehash some of the basics from the previous articles, and then jump into some exercises. The programs reviewed will be Net Demon — a suite of Internet tools that I have mentioned throughout this series — and NeoWatch.

If you haven't downloaded Net Demon, please do so and get familiar with it. It is available at www.netdemon.net, has an evaluation period, and only costs $15.00 to register. Which is far less than it is worth. To configure it, you will need the name servers (IP addresses) from your ISP.

HAM GEAR FOR SALE

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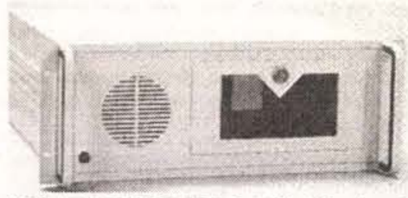

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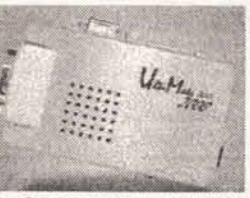

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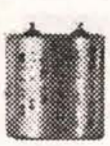

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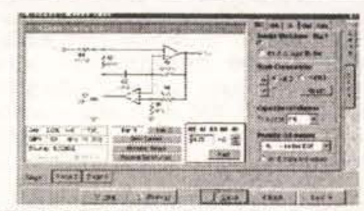

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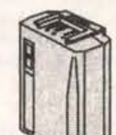

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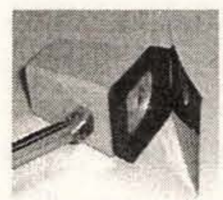

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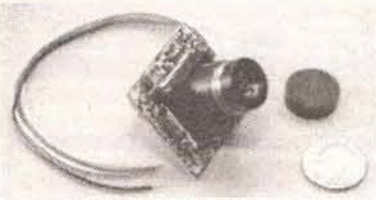

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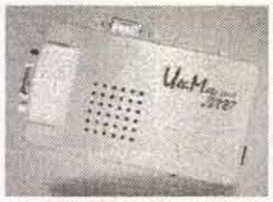

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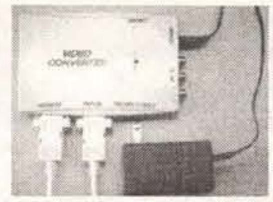

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Separates stereo signals from the cable TV input, feeds RF signals to TV/VCR tuner and stereo signals to FM (either RF or fixed/variable level audio). Hundreds of useful parts which may be removed for audio/RF projects. Controller board has CPU and socketed EPROM as well as Mitsumi varactor tuner, cable/FM separator board, regulated power supply subassembly, channel select board, and stereo separation output board. Black metal case, 14" x 10" x 3". Sold for experimental purposes only. With documentation.

92V020 Two for $39.95

MINI HORN TWEETER

2" dia., 4 Ohm tweeter is ideal for car stereo applications. 7" wire lead. Two mounting holes are 2.375" on center.

99V003 $1.95 each

SMALL BEIGE BOX

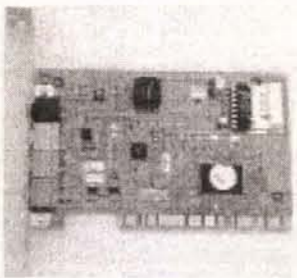
Plastic. 2.5" x 3.5" x 1".

97U011 59¢

GEAR REDUCTION DRIVE WITH 12VDC MOTOR

Output 8 RPM, max. torque 30 in.lb. shaft 5/16" dia. x 1-1/16" long. Dimensional diagram enclosed. Multi Products #600B.

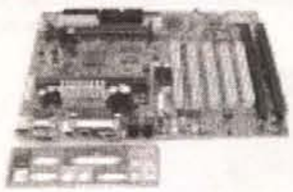
20M011 $14.95 each



COMPAQ PCI SOUND CARD

Creative chipset. Part #CT505.

20C018 $20.00 each



COMPAQ P-II BX MOTHERBOARD

Slot 1 board with 2 DIMM slots, USB, onboard sound and video, 1 AGP, 5 PCI, and 2 ISA slots.

20C017 $35.00 each

115VAC MUFFIN FAN

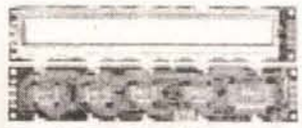
Input 50Hz @ 0.20A or 60Hz @ 0.18A. Size 4.875" square x 1.5". Rotron #MX2A3.

21F001 $7.95 each

BIPOLAR STEPPER MOTOR DRIVER IC

600mA output current capability per channel. 1.2A peak output current (non-repetitive) per channel. 36V max. Enable facility. Temperature protection. Logical "0" input voltage up to 1.5V (high noise immunity). Internal clamp diodes. With documentation.

L293D $3.00 each



Back In Stock! 2x40 CHARACTER LCD DISPLAY

Has 14-pin interface with documentation to help you interface to microcontroller projects.

94L005 $14.95 each

HIGH VOLTAGE PROBE

BK Precision model HV-44, with direct reading 0-40 KV meter.

95Z003 $49.95 each

RACK MOUNT CABINETS

High-quality rackmount enclosures come in an attractive charcoal grey epoxy finish. The top, bottom and sides have ventilation holes to assist in colling. The front and back panels are made of 0.059" thick aluminum for easy custom design. The top, bottom and sides are 0.035" steel. Choose from six sizes. All include handles except RC3120A.

RC3120A - Front panel 19" x 1.75" 1.5"H x 16.75"W x 9.5"D - **$38.00**
RC3120B - Front panel 19" x 3.5" 3.25"H x 16.75"W x 9.5"D - **$46.00**
RC3120C - Front panel 19" x 3.5" 3.25"H x 16.75"W x 13"D - **$53.00**
RC3120D - Front panel 19"x 5.25" 5"H x 16.75"W x 13"D - **$58.00**
RC3120E - Front panel 19" x 5.25" 5"H x 16.75"Wx 16.75"D - **$63.00**
RC3120H - Front panel 19" x 8.75" 8.5"H x 16.75"W x 16.75"D - **$83.00**

EQUIPMENT RACK COOLING FANS

Size 2RU by 19"W x 18"D.

21Z004 $24.95 each

6-METER FSK RECEIVER BOARD

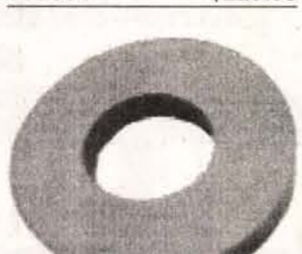
Crystal controlled on 50.675 receive frequency. Superhet with 10.7MHz IF. Three ICs and one transistor. Not a kit! New, with schematics and spec sheet for major components at our web site.

92A067 $9.95 each

WEATHERPROOF CCD COLOR BULLET CAMERA

Get crisp and clear picture quality with this sleek small bullet camera. Reliable operation in virtually any environment. 1 Lux minimum illumination, 400 lines of resolution, 3.6mm, 8-12VDC, 120 mA. 115VAC power supply included. 2" Length x 1 1/4" Diameter.

99V004 $229.95



DONUT MAGNET

750 Gauss. 2¾" OD, 1¼" ID, ½" thick.

99N005 $4.95

WE'RE MOVING!

We've lost our lease and would rather sell our inventory than move it. Dealers are invited to purchase our retail store inventory in bulk. Substantial discounts may apply to *bulk* purchases. Check our website for new address announcement.

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010102

CCD BULLET CAMERAS B/W & COLOR. AX-800 series, weather resistant high impact design with swivel bracket. Will work with Matco's scanning motor. 3/4" diameter x 3" long approx. B/W: 400 line/0.2 lux. **$79/each**. Color: 350 lines/2 lux, **$119/each** — price reduction. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

14" B/W high resolution SECURITY MONITOR. A standard 12" monitor is just too small for most applications. Attractive dark gray enclosure with audio and built-in speaker. 75 ohm termination switch for balancing with all types of CCD board cameras and other video inputs. **$139/each**. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

9 VOLT IR sensitive B/W high res 430 TVL camera with optional black low-profile swivel adjustable enclosure. Pin hole or Std. lens type. 6, 8, and 12mm lens are available. 1/3" CCD, 3.6mm/F2.0 lens included; works from **7.5-13 VDC**, highest voltage range in market. 0.08 lux, 1.27" x 1.27" x 0.5"D pinhole or 1" deep standard. **$49 each**. Enclosure: $8; optional lens: $18. Dealers welcome. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

SCANNING MOTOR — A-330SC with universal mounting bracket accepts all standard 1/4 x 20 threaded CCTV cameras. No tilt, just PAN. 75 degrees of continuous motion with a scan rate of 5 seconds per cycle. 110 volt indoor operation, but can be adapted for outdoor use. Includes 12 foot power cord. Perfect solution to triple your effective camera viewing angle! **$39/each**, or **$25/each** in qty. of 4. Small size, 3-1/2"D x 2"H. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

Continued on page 53

Circle #37 on the Reader Service Card.

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

Sleek black anodized, BRASS, housing is O-Ring sealed & WATERPROOF. 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**

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 MINI and WEATHERPROOF,

"LIPSTICK" CAMERA Sleek black anodized, alum. housing, O-Ring sealed & RAINPROOF. Adj. tilting mount. 1/3" CCD, 380 Lines, 0.3 Lux, AGC, Auto Shutter. 9-12VDC @100mA, 4mm, f1.8, 78° FOV real glass lens, NTSC video. <1 ounce! IR SENSITIVE. 3mmdX50mm, 36" cable with BNC video & DC barrel jack.

GM-200K-STD..$69
GM-200K-PH....$69

PINHOLE Model. So tiny you can install it directly into a door. Only a 0.9" diameter hole! Specs as above. 90° FOV Pinhole lens. 1/2 once! Size only 23mm d.x35mm long. Think of the places you could put this little jewel.

NEW! 0.005 Lux, COLOR NIGHT VISION CAMERA!
UNBELIEVABLE LOW LIGHT PERFORMANCE.
State of the Art Video, Our GMV-3K, DOES it ALL!

For covert, military & scientific applications that must be color, this is it. Unbelievable 0.005Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. 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/Man. white balance 3200° to 10000°K, auto/man 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 standard c-mount lens not included.
SPECIAL, GMV-3K....$449ea. High performance auto iris lens, 12mm, f1.2...$199ea.

NEW, "COLOR STEALTH CAM" MICRO SIZE, with AUDIO!

That's right! COLOR! In the same size package too! Sleek aluminum housing fits like a glove! Removeable mtg. bracket & a 1.3M cable with BNC vid., RCA aud., (internal mic) & DC pwr. jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the "COLOR STEALTH CAM" • 1/3" • 350 Lines • 0.7 Lux • AGC • Auto Shutter • Pwr. 6-12V @30mA • 270k pixels • Std. 7 mm, 56° FOV lens • Focus:10mm to inf. • NTSC video • 1<ounce! • Size: 31mm sq. x 28mm d.
GM-4000S-STD w/audio, SPECIAL...$79ea.

NEW, "STEALTH CAM", MICRO, with AUDIO!

The sleek aluminum housing fits like a glove! Removeable mounting bracket and a 1.3M cable with BNC vid., RCA aud., (internal mic) & DC barrel jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the "STEALTH CAM". 1/3" CCD, 410 Lines, 0.3 Lux, AGC, Auto Shutter. Pwr. from 9 to 12VDC @110mA, 250k pixels, Std. model, 4mm, 78° FOV lens, Pinhole model, 90° FOV. A real glass lens. Focus from 10mm to infinity. NTSC video out. Only 1.7 ounce! SENSITIVE to IR. Size Std: 30mm sq. x 29mm d. PH is 16mm d, **WARNING:** Don't confuse these models with LOW RESOLUTION, HIGH LUX C-MOS CAMERAS.
GM-2000S-STD, w/audio $69.00
GM-2000S-PH, w/audio $69.00

NEW, 470 LINE "DSP COLOR Micro CAM"
The HIGHEST PERFORMANCE available.
MICRO SIZED PACKAGE too!

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, 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.Mounting bracket & 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 • 1 Lux • AGC • Auto Shutter • 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.

NEW! DAYLIGHT to LOW LIGHT MINI CAM,
with AUTO IRIS LENS!

For those applications that must work from dawn 'till dusk, this is it. Rugged aluminum housing with dual mounting sockets. Specs: 1/3" CCD, 420 lines resolution, 0.1 Lux sens., AGC, Auto shutter. 12VDC @120mA. Take full advantage of camera sensitivity with the super, 4mm, f1.4, 78° FOV Auto Iris lens included. Video out on BNC. Size: 50mm sq. X 65mm long. Power adapter included. Ready to go!
SPECIAL, GM-510-A/I....$199ea. or 2 for $369

PRICE BUSTER, DSP, COLOR, MINI C-MOUNT

New, model GM859, Size only: 2" x 2" x2.5"L, Latest 1/4" CCD technology. Res. 350 lines, sens. , <3lux, auto white balance, AGC. Auto iris connector. 9-12VDC @150ma power. BNC video out. Switchable gain. Superior cast aluminum housing with top and bottom mounting. Perfect for general surveillance. Less lens. LESS lens. See options below. **Special, GM859....$139ea.**

SUPER, MINI C-MOUNT CAMERAS,
Super sensitive, GM410 or the general purpose GM412, The GM-412 (bottom) specs: B&W, size 1.5"sq. X 2.4"L, 250,000 Pixels, **380** Lines Resolution, Sensitivity **0.3** Lux, The GM410 (top) specs: size only 1.5" SQ. x 1.6"L,

>270,000 Pixels, **410** Lines Res., Sens. **0.05 LUX.**, Both cameras are 1/3" CCD with AGC & Electronic shutter. 12V @110mA power. NTSC out. IR SENSITIVE, BNC video out, Both use std. DC pwr. jack. Aluminum housings with dual threaded top and bottom mounting. True performance not hype! These cameras will outperform *ANY* camera in this magazine. Multi- lens options are available to exploit their superior performance.
GM412, less lens..$99, GM410, less lens..$149

END FIELD of VIEW GUESSWORK!
3.5 to 8mm VARI-FOCAL LENS

Brand New, super f1.8 lens allows you to smoothly adjust from a 97 ° FOV @ 3.5mm to a 44° FOV @ 8mm. Now you can frame your area of interest just the way you want it! Standard CS-Mount with adjustable focus and iris.
SPECIAL.....$89ea. or 2 for $169

C-MOUNT LENSES

STANDARD
4mm, 80° FOV $22
6mm, 60° FOV $22
8mm, 40° FOV $22
12mm, 28° FOV $22

LOW LIGHT
16mm, f1.6, 15° FOV $35
8mm, f1.3, 40° FOV $49
4mm, f1.4, 78° FOV $49
2.8mm, f1.3, 90° FOV $69

AUTO IRIS, LOW LIGHT
4mm, f1.4, 78° FOV $99
2.8mm, f1.3, 90° FOV $129
Custom cable...................$12

NEW, Universal Time and Date generator. Provides user programmable cam ID too! Type TG-060, is only about the size of a pack of cigarettes but solves the problem of time stamping and identifying any video signal. Has RCA jacks for video in and out. Operates from 12VDC, AC adapter included. Super simple 3 button operation. Rugged plastic case with Velcro strip for easy placement. Hrs., Min., Sec., Mo, Day, Yr, Cam ID.

TG-060, time date unit......$49ea.

NEW GM182, 580 LINE, CCD CAMERA,

1/3" CCD, 580 Lines Res., 0.1 Lux sens., AGC, Auto Shutter. Pwr. 12VDC @120mA, 3.6mm, 71° FOV, Real glass lens. Focus from 10mm to infinity. Standard NTSC video out. 1/2 once! SENSITIVE to IR. Size: 1.7"sq. x 1"d. with 6" leads. Superior quality for demanding applications. **GM182..........$149ea.**

PRICE BUSTER, DSP, COLOR CAMERA,

Brand New, model GM550, Size: 1.6" x 1.6" x1.5"L, 1/3" CCD with SONY CCD & DSP technology. 4mm, f1.8 glass lens, 80° FOV. Resolution >350 lines, sensitivity, 0.3lux, AWB, AGC & auto electronic shutter 1/60 to 1/10,000 sec. Pwr. 12VDC @160ma. NTSC out. Budget color surveillance. Standard / Pinhole.
GM550-STD......$99ea. GM550-PH.......$99ea.

MICRO CAMERA, with MIRROR IMAGE

Perfect for "rear view." 1/3" CCD, with 266K Pixels. 410 lines Res., 0.3 Lux sens. AGC and Auto/Man Shutter. Low Power 12VDC @100mA 3.6mm, 92° FOV, focus from 10mm to infinity. A real glass lens! WHY BUY DISCONTINUED OR SURPLUS? New first quality Standard NTSC video out. 1/2 once! IR SENSITIVE! Mating connector w/ cable included.
GM-251, w/AC Pwr.......$79ea.

low cost MICRO BOARD CAMERA, w/audio 1/3" CCD, 410 Lines Res., 0.3 Lux sens., AGC, Auto Shutter. Pwr. from 9 to 12VDC @100mA, 250k PIXELS, Std. model, 4mm, 78° FOV lens, Pinhole, 90° FOV. A real glass lens. Both focus from 10mm to infinity. Std. NTSC video out. 1/2 ounce! SENSITIVE to IR. Size Std: 1.25"sq. x 1"d. PH is 0.6"d, 1.6M long wiring harness with connectors included. **WARNING:** Don't confuse these models with LOW RESOLUTION, HIGH LUX C-MOS CAMERAS. Six models to choose from.

GM-1000A-STD......$59	**GM-1000A-STD/Aud.....$64**
GM-1000A-PH........$59	**GM-1000A-PH/Aud.......$64**
GM-1000A-CMNT..$59	**GM-1000A-CMNT/Aud.$64**

Micro Lenses for GM1000 series

2.5mm, 150°........$20	**8.0mm, 40° f2.0.....$20**
4.3mm, 78° f1.8...$20	**12.0mm, 28° f2.0....$20**
6.0mm, 60° f2.0...$20	**5mm, 70°PH.......$20**

A COOL COLOR CAMERA, "The ROVING EYE CAM" with Ultra Compact, 12X ZOOM, PAN and TILT, AUTO IRIS and AUTO FOCUS to boot! Another super quality color conference camera designed as part of a high end system from PictureTel. The unit consists of a camera head attached to a base PC board. The attachment is via a moveable mount. There are two tiny stepper drives which create the pan and tilt motion. The tilt stepper is mounted to the PC board.The pan stepper is unmounted and attaches to the side on your base or enclosure. We assume the camera is controllable via serial commands however we have no info on how to do it. Anyone who can tell us can have some free cameras. The camera module specs: 400 lines @ 1lux, the power required is 12VDC @ 500mA. size of head is: 5.5" diam. x 3.2"H, The attached PCB is 3W" x 4L" x 1.3"H. Oh, and did we mention it's auto focus and auto iris too? Composite video output. We think it has Y/C also. Check our web site for further details as they become available. Order now, the price goes up when we get the serial commands. Removed and tested. **FLYER PRICE, R2D2....$99ea. NTSC or PAL avail.**

Items we are looking for:
• Esoteric electronics/electro-optics. • Small precision gearmotors
• Optical mounts • Detectors, Stirling coolers etc. • Thermal imaging

MOTORIZED ZOOM LENS SPECIAL,
6X Magnification and Auto Iris too!
12.5 to 75mm & Super Fast f1.2

New, fabulous hi-res. optics with std. C-Mount. Superior Fujinon and Vicon lenses. Normally cost from $600 to $1500. There is no substitute for a good lens! All drive motors will operate from 6-12VDC. The Auto iris has a built in amp which works with any cameras video output. No special connectors or A/I plug required. Model B-6XENC has HP optical encoders for postion feedback of focus and zoom as well.
Special, Type B-6X...........$179ea. or 2 for $349
Special, Type B-6XENC....$229ea. or 2 for $399
New ZOOM LENS CONTROLLER.............$169

MOTORIZED 10X ZOOM, SURVEILLANCE LENS

New, 11mm to 110mm, f1.8, C-Mount, Fujinon, industrial quality optics paired with precision drive enable smoooth remote operation of FOCUS, ZOOM and IRIS. Unit is open frame, black anodized alum. structure supports the sophisticated drive. Two models: Mod Z5 std, or Mod Z10 has HP optical encoders for position feedback (128cpr) on zoom & focus Edmunds sells the lens w/o drive for $869ea. Motorized unit sells for >$2000. Very limited quantity. Don,t cry when these are gone! SPECIAL PRICE.
Model Z5......$349ea. Model Z10......$399ea.
New ZOOM LENS CONTROLLER...............$169ea.

NEW! 4 or 8 CHANNEL, VIDEO AUTO SWITCHERS

Model GM34 & GM38. Connect to any four standard video signals and they will be sequentially output to the dual rear panel BNC outputs. Front panel user adjustable, variable dwell 1 to 15 sec per channel. Auto or manual switching with channel bypass. Compact only 8.6"W x 3.7" D x 1.75" H, ac powered. Video loop through.
GM-34, 4 Channel....$65, GM38, 8 Channel......$75

VISA•MC•AMEX•DISC•COD•ORDER: 800.810.4070 ($20 minimum)•TECH. 603.668.2499•FAX: 603.644.7825
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Circle #153 on the Reader Service Card.

•FEATURED FLYER SECTION•

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

Type GM-6000, offers 410K pixels, 570 Lines resolution, < 0.1 LUX sensitivity. >45db s/N with AGC off. Access to all operating parameters from outside the camera! C or CS mount. Adjustable shutter speed from 1/60 to 1/100000sec, BLC on/off with adjustable area weighting, 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......$189ea.

NEW, 470 LINE "DSP COLOR Micro Board CAM" The HIGHEST PERFORMANCE available in a MICRO SIZED PACKAGE in the world. You will say YES!

Yes! We've done it again. A PINHOLE board camera so powerful it's amazing. So small it's unbelievable. What good is small when the performance is LOUSY. Yes! Its' got 470 lines with a 60db S/N ratio to back it up! Yes! That's 16X better than a typical 46dB standard camera! Yes it's a CCD camera. Yes! 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. Yes! The 18mm x 26mm pc board is so small you can put it almost anywhere. Yes! A pre made cable with BNC video and DC pwr. jack is included for, no sweat hook up. Yes! It requires only 12VDC@ 65mA. Yes! Optional mirror function available. Don't be fooled again. You can't touch this. This camera has it all. • 1/4" CCD • 1 Lux • AGC • Auto Shutter • 270k pixels • 5.5 mm, 30° FOV lens • Focus:10mm to infinity • 1/4 ounce! There is no reason to say NO.

GM-4500B-PH, SPECIAL...$89ea.

NEW, 9" SECURITY MONITORS

We were fortunate to obtain these Hi-res 700 Line. B&W units. Original manufacturers boxes, 90 day warranty. BNC video in and loop through. Rugged steel case. Current production model. Limited qty. They will make your video look super!

SPECIAL, MONITOR-9-1....$99ea.
MONITOR-9-2........... 2 for $189

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

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF down to 60 feet. Adjustable mount included. Specs: 1/3" CCD, 400 Lines res.,super 0.003 Lux sensitivity, AGC, Auto Shutter. 12VDC @220mA, 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. **GM300KX-12.......$179**

NEW and IMPROVED, COLOR, UNDERWATER, CCD CAMERA, (down to 60 ft.) now with 12, Built-in SUPER, 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 @220mA, 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 COLOR remote area inspection camera. Now with TWELVE, super bright, white LED'S! BRAND NEW,

GM400K-12 with LEDs..........$229ea. or GM400K-N without LEDs.........$199ea.

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 standard c-mount lens not included.

SPECIAL, GMV-6K....$449ea. High performance auto iris lens, 12mm, f1.2...$199ea.

WEATHER RESISTANT Camera Enclosure, Solid, extruded aircraft aluminum. Glass window.Strain reliefs for cables. Available with 110VAC heater as well. Size: 3.5"w x 3.7"h x14"L, New. Perfect for our new "Night vision cameras"

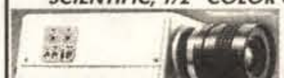
ENCL-B............$55ea. ENCL-HEAT......$69ea.

WORLDS SMALLEST ••• 100mW ••• VIDEO TRANSMITTER,

Incredibly only 0.98" x 0.8" x 0.037" in size. Transmits crystal controlled hi-res. images with 100mW output! The transmitter you've been waiting for. **Shown actual size.** Smaller than the 9V battery which powers it. Draws only 35mA! Factory tuned. Receive on cable channel 59. Will work with color or B&W cameras. UHF Bow tie antenna with balun and 3' F cable for TV included. Perfect with our GM1000A. Both will fit in a cig. pack with battery!

TVX-100.$179. with GM1000A-PH CAM...$249.

SCIENTIFIC, 1/2" COLOR CCD CAMERA



- *YC/SVHS out*
- *380K Pixels*
- *460 Lines*
- *<1 lux sens.*

All parameters adjustable from outside camera! Perfect for microscopy, inspection or surveillance. Internal or external sync, Interlaced or N/I, Adj. shutter, 1/60 to 1/10000 Sec., Three step Auto White Bal. Auto iris output, C or CS mount, Manual/auto gain or ext. variable gain. BNC video out, 12V@ 250mA pwr., via std. barrel jack. The GM470-C has it all! Aluminum housing. Size: 50mm W x 50mm H x 145mmL

SPECIAL GM470C, less lens.........$389ea.

SUPER DEAL, RCA, 4 CHANNEL, VIDEO, AUTO SWITCHER, Model TC-1404 . Connect up to four standard video signals to the rear panel BNC inputs and they will be sequentially output to a rear panel BNC video output. Front panel has adjustable, variable dwell time from 1 to 15 seconds per channel. LED channel indicators. Four, auto or manual toggle switches with channel bypass. Mini size only 4.2"W x 7.8"D x 1.2" H, ac powered. Video loop through. Direct 110VAC power. Used.

Special, TC-1404 Video Switcher....$39ea.

New GME-1000, 2.4GHz FM Wireless Video FCC Approved, Range to 3 Miles* Line of Sight !

Commercial quality and functionality with features not available elsewhere! Transmits color or B&W, NTSC or PAL up to 460 lines resolution plus audio channel and two alarm contact closures. The ultra high sensitivity receiver provides superior Line of Sight range *outdoors with gain antenna. The video signal is protected by a video loss alarm as well as a 24-bit identification code. Stand by mode reduces transmitter power draw to 10mA when no video is present. Four user selectable channels. Rugged all steel construction. Size: 3.4"W x 4.3"H x1.2"D, Both units powered by 12VDC. 200mA TX ,350mA RX. Via simple screw terminal connection. System incl: Transmitter with omni antenna, Receiver with 8dB patch antenna, 2 AC power adapters and manual. 14dB patch and 24dB parabolic 30" X 24" antenna also available.

Complete system......... $595, less recv. antenna.

VERY NICE, NIKON X-Y MICROSCOPE STAGE with DUAL 0.0001" MICROMETERS.

Nikon stage provides 1" of precision travel. The unit is extremely substantial, weighing in at 19lbs.! Stage has a 2.8" diam. clear aperture and a 3.7" diam. top opening with removable clear plastic top. Stage also provide 360° specimen rotation with a 2 min. vernier setting ring. Overall dimensions: 8" L x 8" W x 3"H, not including micrometers, 12" x 12" with micrometers. Slightly used, overall in mint condition. One available. **NIKON-XY....$395.**

NEW! LCD COLOR, TFT, ACTIVE MATRIX DISPLAY Offers a super 5.6" VIEWABLE AREA, Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables and charger. Super Deal.

Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables & charger. Finally we found a unit with exceptional quality at an affordable price. 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 etc. Perfect as a rear view system with any video camera with its built in, mirror image function. Fully enclosed unit has adjustments for color, contrast, brightness & volume, for it's internal stereo speakers! A 1/4 x 20 Tripod socket & a tilt down stand for table top viewing. Inputs include: audio (L&R) and video on std. 1/8" mini jacks. External 12VDC on std. barrel connector. Spec: 5.6", TFT active matrix LCD with 76.8K Pixels, CCFL backlight with 270cd/m Luminance, 500mW audio output available on std. 1/8" jack. 12V@600mA powered, 50mV min. or std. line level audio input. Size: 6.4"W x 5.25"H x 2.2D" First quality. Pro model includes: A luggage quality, custom made, padded case, dual removable straps for shoulder and/or holding at waist level for hands free viewing. Built into the case is a 12V Gel Cell, rechargeable battery plus a complete set of A/V cables. AC power adapter, power switch & charger.

GMTFT56-PRO $344ea. GMTFT56 Display $299ea.

SUPER FAST, f1.8, 10x SURVEILLANCE LENS, unbeatable for long range observation.

New, Fujinon, 11mm to 110mm ZOOM optics, standard C-Mount. Make any of our C-Mount cameras a long range stealth-cam! WOW! Provides 20X on a 1/3" CCD camera. A super lens. Edmunds' price $800

11-110ZM-1......$249ea.

COMPLETE SELECTION of COVERT CAMERAS, all available with audio,

Specification for all models include: 1/3" CCD, 410 Lines Res., 0.3 Lux sensitivity, Power from 9 to 12VDC @100mA, 90° FOV lens except dome and PIR which are 80°, All focus from 2 ft. to infinity. Standard NTSC video out. SENSITIVE to IR. note: Smoke & Motion detectors not functional, Clock & Exit operate normally. Dome is 3.5"H x 5.5"Diam. Don't see what you want? We can put a camera in anything you desire. Call tech. support for quote.

Smoke Detector, Motion Dector (PIR, Clock) or Dome Camera, Special.....$79ea. Exit Sign, Special.....$89ea. Please add $10 for audio. (any model)

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.**

INFRA RED TRANSMITTER and RECEIVER MODULE. *Perfect for remote control or covert signal system.*

New, Key FOB style IR transmitter from Polaroid, becomes the perfect companion to the tiny SHARP GP1U581Y Integrated, high sensitivity receiver module. Size: 0.6"x0.6"x0.5h" Typical range of 25 to 40 feet. With data. Rcvr. has only three connections! Excellent classroom project. Package includes 4 IR transmitters and 2 IR receivers.

IRFOBSET-4, $10 or IRFOBSET-6 sets for $50

NEW, 2.4GHz VIDEO + STEREO AUDIO TRANSMITTER and RECEIVER PAIR

Simply connect ANY VIDEO SOURCE to the completely self contained 2.4GHz transmitter. All cables supplied. You can transmit up to 700 feet clear line of sight! Companion matching receiver works with any TV or VCR. Internal patch antennas. 12DC. (all pwr. adapters and cables included) Can also be used to transmit VCR or camcorder output to another TV for remote viewing. Brand new, boxed set.

TRANSMITTER/RECEIVER, AST-1......$99 set.

RF MODULATOR, Basic unit converts video input to Channel 12-15 UHF.

Nicely made unit from ATV Research. Aluminum enclosure. Unit operates from 4AA batteries (not supplied) Simple on/off and tuning controls. "New old stock" Size: 3.2"W x 2.4"H x 4"D Ltd. qty. **ATVMOD-1....$15**

•PAGE THREE• •VIDEO•

VISA•MC•AMEX•DISC•COD•ORDER: 800.810.4070 ($20 minimum)•TECH. 603.668.2499•FAX: 603.644.7825
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Circle #153 on the Reader Service Card.

Circle #153 on the Reader Service Card.

FEATURED FLYER SECTION

TEST EQUIPMENT • PAGE SIX

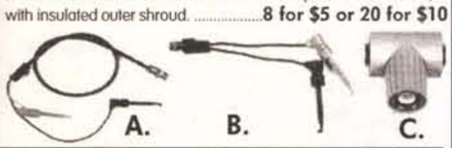
HP5335A, UNIVERSAL SYSTEMS COUNTER

Providing true automatic measurement functionality. This system has 16 built in front panel accessible measurement functions, all available via the HPIB or manually. One of the most powerful universal counters availble. Math and statistics include averaging, mean, sample size, standard deviation, engineering units display offset scale and normalization. Matched dual inputs provide 200MHz on chan. A and 100MHz on chan. B. Nine digit resolution from 30Hz to 200Mhz. 1meg. and 50 Ohm inputs. Auto trigger and much more. All the toys in one package! Excellent condition.

New......$3900 HP5335A.........$295

LAB NECESSITIES, Quality E.F.Johnson test leads. Always handy, especially at 75% off!

A. 18" BNC to red and black hooks .... **$3.00ea.**
B. 6" BNC female to red & black hooks. For use with .... **$2.50ea.**
C. NEW BNC male to Dual BNC female 'T' adapter. Deluxe model, with insulated outer shroud. .... **8 for $5 or 20 for $10**



BERTAN, HIGH VOLTAGE POWER SUPPLY MODEL 315, 0-5000VDC @ 0 -5mA

Automatic current limiting & arc protection assures reliable operation. Remote output high voltage programming & high voltage operation interlock are included. Specs: Reg: ±0.001% line, 0.002% load. Temco (0 to 50°C): 50ppm per °C. Stability (after ½ hr warm-up) 0.01%. Ripple: 25mV p-p. Calibrated front panel 10-turn potentiometer with 3 digit counter with resolution 0.25% of max. Programmable input for remote control of the output high voltage. 115 Vac ±10% @ 0.5A powered. Size: 12" deep x 9" High x 2.75" wide, weight 11 lbs.

BERTAN315-PS.............$225ea.

ESD FIELD SCANNER, STATIC METER, from Scientific Enterprises.

A hand held, professional quality instrument using microprocessor technology to detect, locate and measure electrostatic charges. The device provides a 40 degree cone of view for accurate readings. Self zeroing an self calibrating. Measurements can be made from ±10 Volts up to ±9,990 Volts with 10 Volt resolution and from ±10,000 Volts up to ±99,900 volts with 100 Volt resolution. Measurements are displayed on an LCD display. Readings are continuous at a rate of 6 per second. Reject interference from lighting or motors. Internal NiCad battery. Unit size: 7.5"L x 3.5"W x 3.5"D, weight 16.5oz. Used in excellent condition.

STATMETR-1..................$125ea.

A PAIR of HIOS brand, DIGITAL TORQUE METERS, The HD-50 and the HD-100

Super industrial quality units are built like a you know what. Features common to both include: • 4 digit LCD display • Tracking or Hold select mode switch • Front panel zero adjust • Selectable unit of force, either kgf/cm or lbf/in • Momentary reset switch for the hold function • Internal NiCad batteries • External charger and transit case • External analog output. The HD-50 measures to 50 lbf/in while the HD-100 measures to 100 lbf/in. The HD-50 has a handpiece with standard hex tool head, tethered (via a coiled cord) The HD-100 has a 1/2" drive socket on the front panel. Both units are in excellent condition. Size: HD-50: 6.25"W x 3.75"H x 1.9"D, the HD-100 size: 9"W x 4.3"H x 2.3"D

TORQ-HD50..................$325ea.
TORQ-HD100................$495ea.

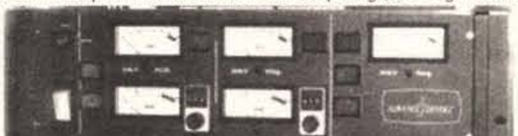
NEW! UNITEK, REFLOW SOLDERING POWER SUPPLY, type PHASEMASTER IV,

A single phase, resistance heating control with a time-at-temperature feature. The system is used for reflow soldering as well as resistance brazing and other heating processes which can be monitored via a thermocouple. Presettable parameters include: proportionally controlled heating current, temperature set point, at temperature period, auto release of air actuated reflow head, (head not included) preset release temperature. System is microprocessor controlled offering several modes of operation. Operation is via a 20 key keyboard with readout via a 2 x 40 LCD display. Maximum output current is 15Amps with 50% duty cycle. System is new in the box. Includes Unipulse X5 transformer as well. This is a lucky find. Only one. **UNITEK-PM4.....$950**

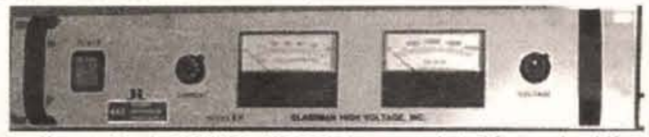
WOW! HIGH VOLTAGE POWER SUPPLIES

Top photo, Advance Hivolt, Quadrupole power supply with three outputs: -30KVDC@ 1.5mA, +30KVDC@ 1.5mA and -300V fixed. The 30KV supplies are adjustable via the front panel multi turn controls with counting dials. Voltage and current is displayed on five front panel meters. Standard rack mount package, 5 1/2" high. 120VAC operation. Like new condition.

AH30KVQW........$995 with HV cable.
AH30KVQN.........$895 No HV cable.

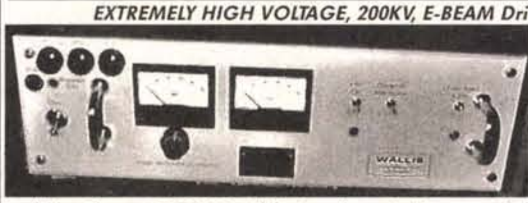


Bottom photo, Glassman, EH series, EH02N50-0XS3, -2KVDC@50mA power supply. Voltage and current limit are adjustable via the front panel multi turn controls with counting dials. Voltage and current is displayed on two front panel meters. Standard rack mount package, 3 1/2" high. 120VAC operation. Excellent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

EXTREMELY HIGH VOLTAGE, 200KV, E-BEAM Driver Supplys,



Like new, Glassman Model: EX180P5A rack mount style. E-Beam power supply. We have no tech. data. If you need one, you know what it is. Panel meters indicate 0-180KV and 0-5mA. Remote controlled. Also available a Glassman EX200P005 with front panel mounted 10 turn controls for output voltage and current limit. We would like to get a copy of the ops. manual. Either unit same price. Ltd. Qty. Other related items: High voltage stacks, accelerator tubes etc., call with your requirements. **EX-HVPS.........$1495**

MORE OSCILLOSCOPE SPECIALS

TEK 7834, 400 MHz Storage with two 7A18 dual trace vert.,2/ 7B53 T/B.........**$595**
TEK 475, 200 MHz portable, Dual trace, Delayed sweep..............**$549**
TEK 475A, 250 MHz portable, Dual trace, Delayed sweep..............**$649**

ALL PORTABLE SCOPES INCLUDE PROBE, MANUAL and COVER, MAINFRAMES NO COVERS.
TEST EQUIPMENT RECONDITIONED & CALIBRATED WITH 6 MONTH WARRANTY

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.**

HP 6034A, AUTORANGING POWER SUPPLY,

With output of 0-60 volts at up to 10 amps amps, 200Watts max. All digital with dual LED displays and GPIB interface. Rack mountable. Front panel adjustable OVP.

HP-6034A......$695ea.

CAVRO SCIENTIFIC, ELECTRONIC, SYRINGE METERING PUMP

These New, boxed units are intended to use the slide to activate the plunger of a metering syringe (not supplied) to meter out and pump precision uL volumes of fluid. We have the mechanics and drive electronics. Looks like an eprom and a micro as well as all the power drive electronics. We have no data, it should be available from Cavro. Motion is supplied via the Pacific Scientific P21NRXS-LNS-NS-03, 5.4V @1.63A unipolar stepper. This is coupled via a toothed belt to the 5.5"L lead screw with slotted optical position sensor. A slide with bronze bearings rides on a polished steel rod and provides 3" of very smooth travel. Contruction is of cast and machined aluminum.

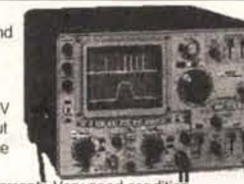
CAVROPUMP-1...............$99ea.

TEKTRONIX J16 PHOTOMETER

Digital LED readout. Accurate spectral responce. Probe not included. Good condition. Untested

TEK PRICE $1595 less probe! TEK-J16........$79ea.

TEKTRONIX 485, 350MHz, Surely the fastest and lowest cost scope available today. Superior performance at low cost! Dual Trace, Delayed sweep 1 nS/div Sweep rate, 5mV Vert. sensitivity. Switchable input imped., 50 ohm /1meg. Package includes 1 probe, cover and operation manual. Six month warranty. Very good condition.



New.....$9100 Now..........$729

Motorized, VARIABLE-DENSITY BEAM SPLITTER,

50mm diam. wheel, (dens. 0.2 -2+), mounted to 3VDC Canon gear-motor. Includes a 5mm photo-voltaic cell for feedback. Riser & base machined from a single block. Optical center 46mm high. Black anodized. Overall size: W63mm x H92mm x D69mm. Removed from new equipment.

VARIDENS-1.........$89.00ea.

TREK- 678 or 676, HIGH VOLTAGE POWER SUPPLY / AMPLIFIERS

TREK-678, 0 to -30KVDC, high voltage , high speed "amplifier" provides a high voltage output which follows a 0-10VDC control voltage with fast response and settling time. Rack size. Like new condition. With data.

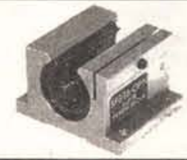
TREK-678, -30KV.....$795ea.
TREK-676, -20KV.....$695ea.

GCA/TROPEL type 576-GX LENS,

A fantastic lens with an unbelievable replacement Extremely flat field. From Photo-lithography system, excellent condition. One only.

GCA-LENS.........$495

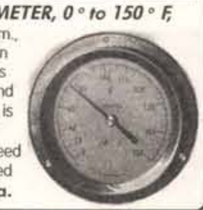
NEW! THOMPSON LINEAR BEARING, PILLOW BLOCK, type SPB-16-OPN.



New in the box. Make your own heavy duty linear motion system. You supply the guides. Very limited quantity.

THOMP-SPB.....$24ea.

NEW! REMOTE BULB THERMOMETER, 0° to 150° F,



A spiffy, expanded scale, industrial, 4" diam., chrome trimmed face with black lettering on white background. U.S. made by Weiss, it is mercury free, resists shock and vibration and sports 1% accuracy. The remote brass bulb is attched via a flexible copper tube over 48" long! This is a serious unit. The more you need to know the temperature, the more you need this thermometer. **WEISS150.....$24ea.**

ELECTROSTATIC DISCHARGE GENERATOR, Up to 25,000 Volts! Andy Hish Associates model ESD-255

System consists of a charging source and probe. The static discharge generator is variable from 0 to 25KVDC. An analog meter indicates the applied voltage. Front panel selectable inhibit rate from one discharge in two seconds, one per second or two per second. The output waveform closely approximates that originating from persons causing static discharge to a metal object. A digital readout indicates the number of discharges per test. A nice compact, portable unit packaged in a covered metal carry case. Size: 16.5"W x 11"H x 8.5"D weight is 15lbs. Used in very good condition. **HISHESD-255........$225**

OPTICAL X-Y DISPLACEMENT MEASUREMENT ANALOGIC 7000C, provides resolution to .005% of lens displacement down to 0.00001"

Full scale range of 0.225". Comprised of PMT based optical camera and control unit. Capable of measuring displacement, motion and elongation. Measurement is non contact thus eliminating any change in the target dynamics. Operation is achieved by locking onto a target area which has a contrasting property. LIKE NEW condition. Includes heavy duty wheeled transit case for system. Analog outputs for waveform analysis and direct digital display. **New.....$50K Now........$749**

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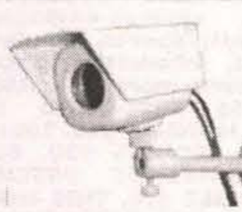
Continued from page 44

QUAD VIDEO CABLE MODULATOR. CVS-600 inserts 4 composite video signals on unused cable channels, 81 thru 95. Watch 4 remote security cameras from any TV in your home! Built-in signal amplifier and comb filter eliminates any ghosting and actually **IMPROVES** existing video! Only one unit needed with existing cable system. $199/each and **$169/each** in qty. of 4. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

14" COLOR — high resolution SECURITY MONITOR w/4 channel switcher. High impact enclosure with modern front panel 4 channel video and audio switcher. High quality speaker built-in. Components purchased separately would exceed $500. Winter special. Price slashed to **$249/each**. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com



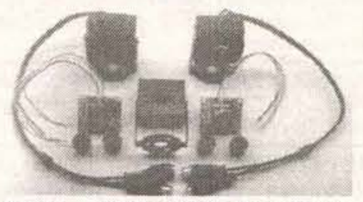
WEATHER RESISTANT OUTDOOR CAMERAS. WR-700 type, high impact tempered glass with stand. Black & white (430 lines), or color (420+ lines) available. Standard 3.6mm lenses with optional lenses of 6, 8, and 12 mm at $20 extra. **B/W $119/each. Color $179/each**. Small compact size with sun shield. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

SECURITY DISTRIBUTORS needed for our complete line of products. Complete line of products shown above. MATCO, Inc. Visit www.matco.com and call 630-350-0299 for more info.

5" AND 5.5" LCD high definition color monitors w/stereo. 960 x 240 pixels w/brightness and tint controls. Attractive enclosure with built-in speaker. Great for security or general purpose use. Both models have a small compact footprint, with an ultra-bright display, RCA inputs NTSC or PAL. Special price **this month only** with regulated power **$249/each**. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

40 DAYS and 40 NIGHTS RECORDER. Time lapse, can be activated by either contact closure or continuous duty operation with standard T-120 tape. **Models from $349-$529**. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

THE TLC-1 records automatically all telephone conversations up to 12 hrs. on a single tape. The **FMX-1** detects and locates bugging devices. The **TLP-1** stops others from listening in or recording your telephone conversations. Send check to Vakis, 2930 Pine Ave., Niagara Falls, NY 14301. Buy wholesale directly from manufacturers.



COLOR — LOW LIGHT 2 LUX 32mm x 32mm, 350 TVL with optional enclosure. Pinhole and standard lens types available. Price reduction, **$99/ea.** Add $10 for enclosure with swivel mount. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

COUNTER-SURVEILLANCE=$250 HR! Electronic eavesdropping is unbelievably widespread! Are you sure you're safe? Learn how others (without prior experience) earn **$250 HR** in the fascinating field of COUNTER-SURVEILLANCE! For FREE catalog call: **1-800-732-5000**. HTTP://WWW.SPY-CITY.COM

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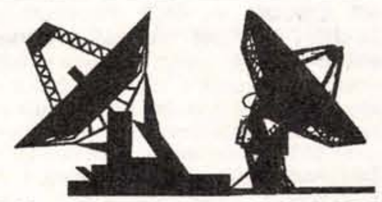

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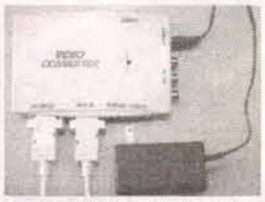

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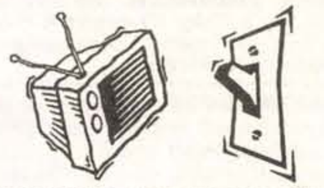

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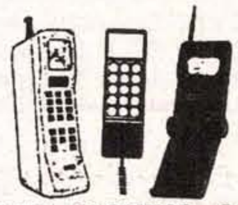

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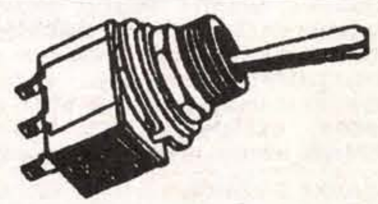

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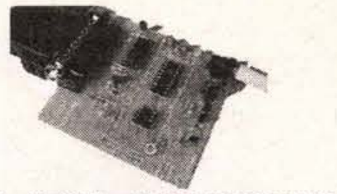

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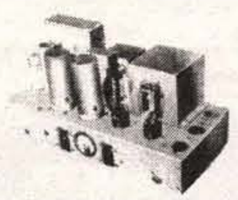

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Continued on page 74

The Mauna Loa beacon tower in Hawaii.

HAWAII TO CALIFORNIA TROPO TIME SOON

by Gordon West

West Coast amateur radio operators will have a new opportunity for some tropospheric ducting excitement this summer, thanks to a generous donation by Chip Margelli K7JA, and the untiring efforts of Paul Lieb KH6HME.

Ready for 2,500 miles of FM: (L to R) Gordon WB6NOA, Marvin KF6HVJ, and Paul KH6HME.

This year, the tropospheric ducting opportunity will not be limited just to specialized single-sideband or CW emissions, but will encompass common frequency modulation mode communications between Hawaii and the mainland on two meters.

"Working the tropospheric duct between California and Hawaii on single sideband and CW is quite common in the months of July and August," explains Margelli K7JA, well-known DXer and the technical specialist for Yaesu. "But this year we bring the excitement of DX to all West Coast hams with just a simple two-meter FM transceiver," adds Margelli, making final adjustments to the Yaesu FT-2500M, 50-watt, two-meter mobile now in place and ready to go at the KH6HME beacon site at the 8,200 foot level of the Moana Loa volcano on the big island of Hawaii.

"We know we can work FM over 2,500 miles from here to the California coast with complete full quieting signals," adds Lieb, world record holder of many VHF and UHF tropospheric duct DX contacts.

"A few years ago, I operated exclusively FM with this column's author, Gordon West, on two meters, 432 MHz, and 1296 MHz, and our signals were unbelievably crystal clear and without any background noise," adds Lieb. During my many club talks, I regularly play these FM contacts to prove that good tropospheric ducting conditions can lead to relatively wide types of emissions for 2,500-mile contacts. We even successfully received a 6-MHz wide ATV signal over this path on 428 MHz, too.

The tropospheric duct that forms between California and Hawaii is an almost every year occurrence. It also shows up quite regularly for several days on end during periods of hot weather conditions between California and Hawaii in the winter, too. You could picture in your mind a tropospheric duct as an upside down mirage that occurs in the atmosphere above you.

A mirage is customarily seen lower than you, down the road on a hot day out in the desert as shimmering blue sky refracted from above by the sharp boundary layer of hot air lying inches above the ground. Conversely, a tropospheric duct is a sharp boundary of hot air associated with a high-pressure system that is stratified above us, at around the 1,000 foot level along the West Coast, causing VHF and UHF signals to refract along the bottom side of this layer, which sometimes extends between Hawaii and the West Coast.

Tropospheric ducting also occurs throughout all of the United States, and along the eastern seaboard in the presence of stable high-pressure systems. Shortwave listeners into televi-


"Gordo" admires the beacon tower in Hawaii.

sion DXing will well appreciate the tropospheric ducting of TV signals over hundreds and sometimes thousands of miles, giving crystal-clear pictures for hours on end. Unlike sporadic E- or F-layer skip, tropospheric ducting is not necessarily short-lived – skip signals on VHF may only last for a few minutes, but during periods of windless days and nights in the presence of a high-pressure cell between you and the distant stations, the path may remain open for days on end. VHF and UHF weather band signals, TV signals, FM broadcast signals, and UHF police calls may be heard well over 1,000 miles away.

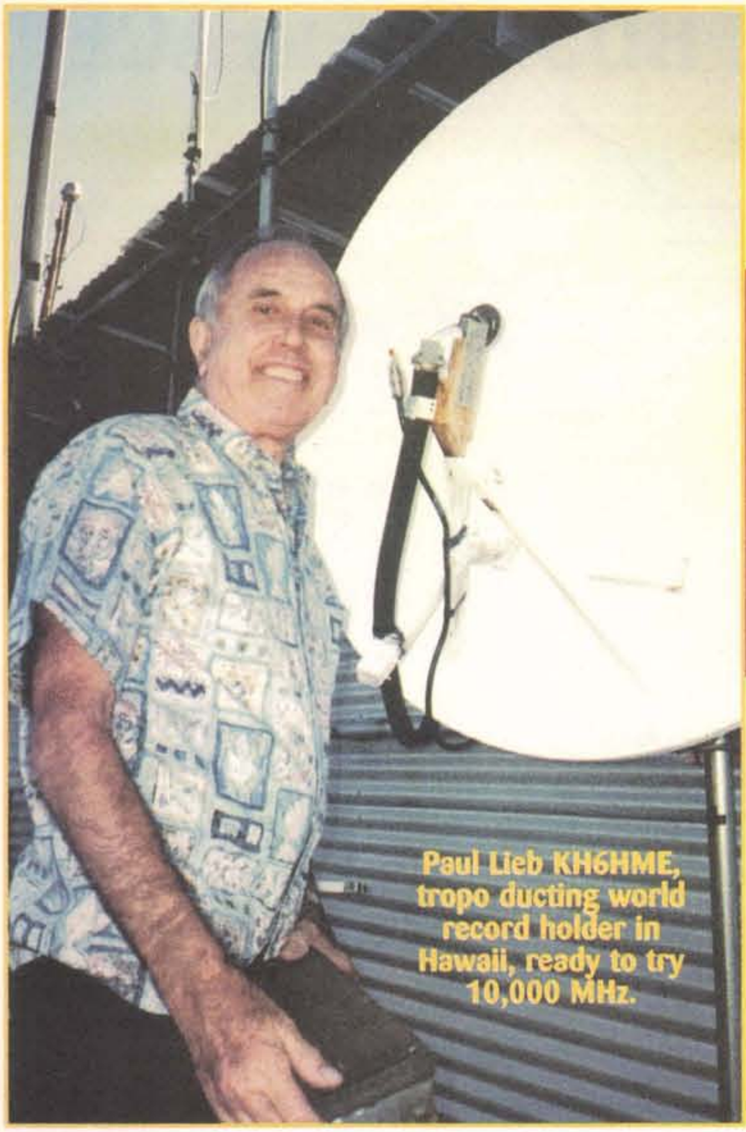
The actual technical mechanism of a tropospheric duct is based on the radio refractive index of air, represented by the symbol "n" for "normal," slightly over 1. Specifically, 1.000345 to 1.000300. Pressure normally decreases with height in a logarithmic manner at about one millibar for every 10 meters in altitude. Temperature decreases 20 degrees Fahrenheit for every mile of increasing altitude in the troposphere, up to approximately 40,000 feet. Along with pressure and temperature dropping as altitude increases, water vapor content also decreases, and this is why the air in your airplane cabin is very dry as you are flying along at 30,000 feet.

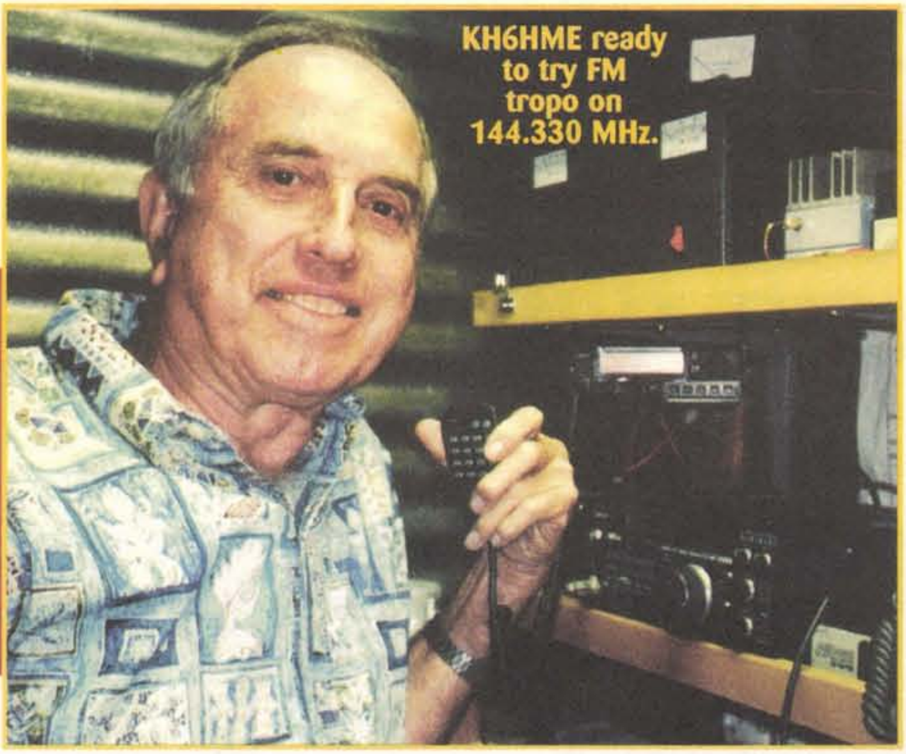
During periods of stable high-pressure cells that may combine and build together over a specific geographic area – such as in the area between California and Hawaii every July and August – there is a major "bump" in the "normal" smooth refractive index. At about the 1,000-foot level, air temperature, water vapor, and pressure invert in a thin stratified layer in the troposphere, commonly referred to as an upper level inversion layer.

A well-pronounced inversion layer, usually accompanied by at least a six-degree temperature RISE, may create a large enough refractive index change to support the bending of VHF and UHF radio signals. The greater the temperature inversion, the more pronounced this stratified layer becomes, and this may lead to an increase in the highest operating frequency that might be achieved between the 2,500-mile separation between California and Hawaii.

Bruce Eggers WA9NEW, an expert in the study of the super refractivity says, "In the northern hemisphere, there are two very permanent high-pressure systems which combine all of the parameters contributing to super refractivity and tropospheric ducting – the Pacific high to the north and east of Hawaii, and the East Coast of the United States high were the Gulf stream brings warm water north along the coast. And in the southern hemisphere, there are some interesting potential tropospheric ducts, from the most southern islands in the Pacific like Pitcairn to Chile and Peru. There is also the path between St. Paul and Perth, over the Indian Ocean."

Experts agree – relatively warm, dry air associated with a stable high-pressure system overlying cool, moist air, sometimes triggered by a southern hurricane, may develop a stratified layer that may easily support VHF and UHF long-range communications. And the most consistent summertime





record-breaking tropospheric duct occurs between the West Coast of the United States and Hawaii.

The discovery of this yearly phenomena was confirmed on July 8, 1957, when John Chambers W6NLZ, in California successfully contacted Ralph Thomas KH6UK, on two meters, and then on 220 MHz, with Lou Louis WB6NMT, completing contacts on the 430 MHz band in the early 70s. In 1983, Chip Angle N6CA, and Paul Lieb KH6HME, made a record-breaking contact between California and Hawaii on the 1296 MHz band.

These two operators have now pushed the record well above 5,000 MHz, and this year, we will all again try for 10,000 X-band between California and Hawaii.

But most important this year will be the regular FM monitoring on two meters to increase the awareness of the California/Hawaii tropospheric duct to new operators with just mobile or base FM two-meter equipment. The frequency chosen for this year's operation is 144.330 MHz, simplex. Now get the frequency correct – NOT 144.300 MHz, but rather 144.330 MHz, simplex. Just remember "44 33," and double-check that you are in the simplex mode.

We will regularly make announcements on 144.330 MHz, plus on other West Coast repeater frequencies that the band is open between Hawaii and California, and to standby for FM calls to Paul Lieb. FM operators will soon realize that the path between the West Coast and Hawaii can be crystal clear for a couple of hours, and then completely disappear for a couple more hours while stations only 50 miles away are now making solid contacts.

And just when you think your radio equipment might be broken, the tropospheric duct will again reform directly to your station, and you will enjoy crystal-clear FM communications from the West Coast to Hawaii with Lieb.

Our indicators that the band is developing for a 2,500-mile path between the West Coast and Hawaii are the series of beacons that we can regularly hear along the West Coast from Hawaii. The first beacon that comes out of the noise transmits on 144.170 MHz, CW. This takes a multimode radio to pick up the signal. On 70 cm, the beacon is 432.070 MHz, CW, and on 1.2 GHz, the beacon is 1296.303 MHz, CW.

These Hawaii beacons are on the air 24 hours a day, and members of the Western States Weak Signal Society (www.wswss.org) regularly monitor for the telltale signs of the CW sneaking through their squelch SSB/CW rigs, and will then begin to correspond with Paul in Hawaii via land line to get ready for a day or two band opening. Paul assembles his equipment; and when Paul hears FM music stations coming over his little portable FM receiver down by the water in Hilo, HI, he knows that the 2,500-mile path is getting ready to open.

Incidentally, one of the hottest, most sensitive, FM, portable receivers is distributed by C. Crane Company (ccrane.com; phone 707-725-9000) called CC Radio from Sangean. This portable is what many VHF/UHF DXers use to locate the right elevation of the tropo signals coming in hundreds and thousands of miles away on FM or weather band. The CC Radio has several different antenna options, and the sensitivity of the receiver is well above what you would ever expect out of the very best boom box. The radio measures 11 inches wide x 6.5 inches high x 4 inches deep, and weighs just under four pounds – so it is a relatively large radio that can even take a C. Crane solar panel to keep it running out on the slopes of Hawaii or the mountains along the West Coast.

If your better half wants a more sensitive AM bedside receiver, this is the set! I have tried all sorts of portable AM and FM receivers, and this one is absolutely the best for sensitivity, volume, fidelity, and the ease of operation with simple memory channel buttons. It does FM, AM, TV audio channels, and VHF weather station monitoring.

So, this summer, take a special interest in your local weather conditions. Look for a stable high-pressure system between you and where you're trying to receive, and see what happens over an outside TV antenna on TV channels 2 through 13. Look to those channels that you normally receive snow on, and see what happens on an outside antenna when conditions begin to form up for the tropospheric duct. With a VHF weather monitor – such as the CC Radio – try tuning in distant weather stations, and see how far away you can pick them up.

You will notice that FM is just as effective over long tropospheric paths as weak signal modes like SSB and CW. Although SSB and CW can get through when conditions are marginal, most tropospheric ducting periods will lead to exceptionally strong signals, more than adequate to handle 5 kHz of frequency modulation.

If you are a ham just getting started and have only a little handheld radio, you, too, could work over several thousand miles this summer via the atmospheric enhancement from tropospheric ducting leading to crystal-clear, long-range, FM calls. You will be very surprised how far just a couple of watts may go. **NV**

Just a mere 2,500 miles to Hawaii – author West in California works Hawaii on a portable SSB two-meter transceiver.

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by Don L. Powrie

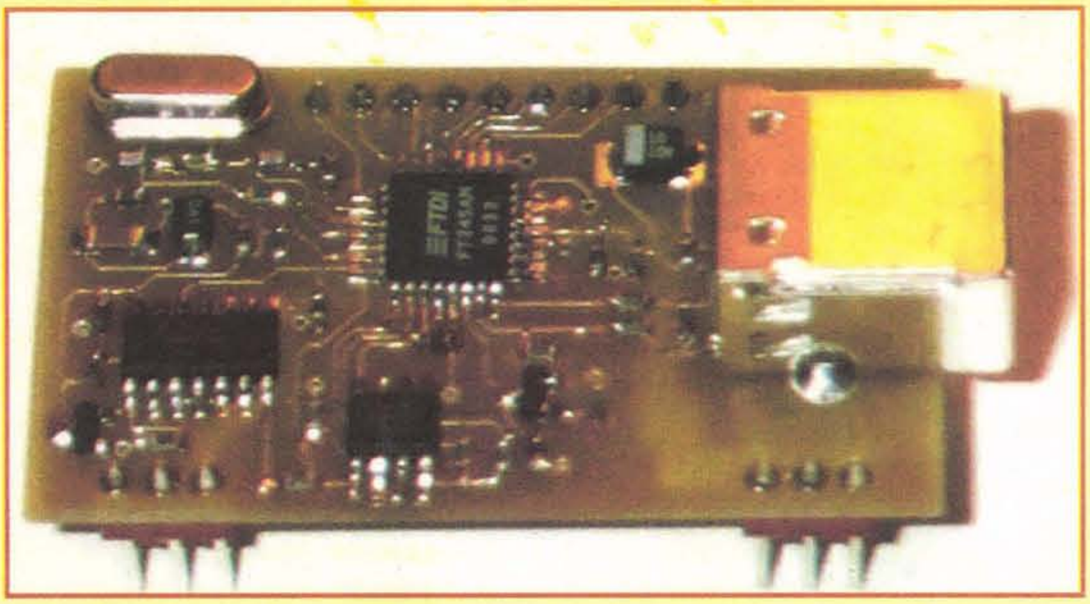


FIGURE 1 — DLP-USB1 from www.dlpdesign.com

If you can write Windows application software that can open, read from, and write to the PC's RS-232 serial ports, then you already know enough to incorporate Universal Serial Bus (USB) into your next hardware design!

Until now, interfacing a new hardware design to a PC meant connecting it to either the serial or parallel port. Serial ports offer a maximum data rate of about 230K bits per second. Parallel printer port interfaces are faster, but tie up the much needed printer port and present a bit of a programming challenge. Now, with the introduction of a nifty little chip and driver software developed by FTDI of Scotland (www.ftdi.co.uk), hobbyists needing a fast, easy connection to the PC with a data rate of up to eight megabits per second can use USB.

FTDI's FT8U245AM makes designing a USB 1.1 compliant hardware interface easy. But, as some of you well know, the hardware design for most USB interfaces is trivial when compared to the effort that goes into developing the Windows driver software. This is where FTDI rises above the rest of the USB silicon manufacturers with their virtual COM port drivers.

As stated in the FT8U245AM datasheet, "By using FTDI's virtual COM port drivers, the peripheral looks like a standard COM port to the application software. Commands to set the baud rate are ignored — the device always transfers data at its fastest rate regardless of the application's baud rate setting."

Once an FT8U245AM is connected to your system and the drivers are loaded, you select which COM port you want to use by going to the Device Manager via the System Properties page. Next, open the "Ports" selection, right click on USB Serial Port (COMx), select Properties, select the Port Settings tab, click on Advanced, and there you can change the COM port number. Note, however, that you cannot change the COM port number until an FT8U245AM is connected to the system. Windows will not allocate a resource to a USB device until it is connected.

Device Drivers

A Device Driver is a highly complex piece of software that serves as a mediator between the Windows operating system, an application program, and a piece of hardware. A driver defines a communications protocol that is used to access the functionality of a hardware device in a well-defined manner.

For example, many of the new webcams available at your local computer shop come with a USB interface. When you connect the webcam's cable to the PC's USB port for the first time, Windows has no idea how to pass data between the webcam's electronics and its application program running on the host PC.

Since the application program cannot "talk" directly to the PC's USB hardware, a Device Driver is required. When the webcam is plugged in, Windows will ask the unknown piece of hardware for identification. The webcam responds with its PID and VID (more on these later), and Windows will then search for the correct driver assigned to that particular camera.

If Windows cannot find the appropriate driver (as it would, say, for a standard keyboard or mouse), it will request that the user provide a driver (typically found on a floppy disk that came with the webcam). Once the driver is installed, the application program can then be run, and the webcam puts your smiling face on the screen.

A Device Driver is much more complex than you might imagine. A poorly written device driver can easily crash the most stable of operating systems. No effort is made by the operating system to protect itself from a poorly written device driver. Once loaded, a device driver becomes an integrated part of the operating system's kernel.

Due to this level of complexity, only a very small percentage of programmers have the knowledge and experience necessary to write Device Drivers. Thanks to FTDI's virtual COM drivers and the FT8U245AM, all you have to know to use USB on your next project is how to open, read, and write to the RS-232 ports.

Implementation

The FT8U245AM is only available from FTDI in surface-mount form. Soldering the device is a bit tricky in that it requires a steady hand and a fine tipped soldering iron. Even my best attempts at soldering the chip by hand resulted in some clean-up work with de-soldering braid. Another easy way to add this device to your project is to buy the DLP-USB1 module (Figure 1) from www.dlpdesign.com.

Four basic hand-shaking lines and eight data lines D[7..0] are provided to interface with the chip. The FT8U245AM's internal FIFO is comprised of two buffers which can hold 128 bytes of received data coming from the host PC and 384 bytes of data to be transmitted to the host.

RD# (input) When pulled low, RD# takes the eight data lines from a high impedance state to the current byte in the FIFO's receive buffer. Taking RD# high returns the data pins to a high impedance state and prepares the next byte (if available) in the FIFO to be read.

WR (input) When taken from a high state to a low state, WR# reads the eight data lines and writes the byte into the FIFO's transmit buffer. Data written to the transmit buffer is immediately sent to the host PC and placed in the RS-232 buffer opened by the application program.

TXE# (output) When high, the FIFO's 384-byte transmit buffer is full or busy storing the last byte written. Do not attempt to write data to the transmit buffer when TXE# is high.

RXF# (output) When low, at least one byte is present in the FIFO's 128-byte receive buffer and is ready to be read with RD#. RXF# goes high when the receive buffer is empty.

Connection to a microcontroller is made with these 12 lines. A quad NAND gate can be used to detect when the FT8U245AM is in sleep mode (suspend) and provide a reset line. Refer to DLP-USB1's Schematic (Figure 2) for the SLEEP# and RESET# signals.

Be careful not to use any power provided via the USB cable from the host unless you are fully versed in the USB specification. The maximum current available from the upstream port (or hub) when active is 500 milliamps, and this drops to only 500 microamps when in the suspend state. If the FT8U245AM does not observe bus activity for three or more milliseconds, then it is required to enter suspend mode.

If your target electronics are getting power from the USB port, then they must be shut down when the FT8U245AM enters suspend mode. Your best bet here is to not take any power from the USB port for your target electronics. The DLP-USB1 adapter includes a connector pin that provides power for target electronics, but I really must discourage the use of USB port power unless you can ensure your design meets the power requirements.

USB Implementers Forum (USB-IF)

As stated on their website (www.usb.org), USB Implementers Forum, Inc., is a non-profit corporation

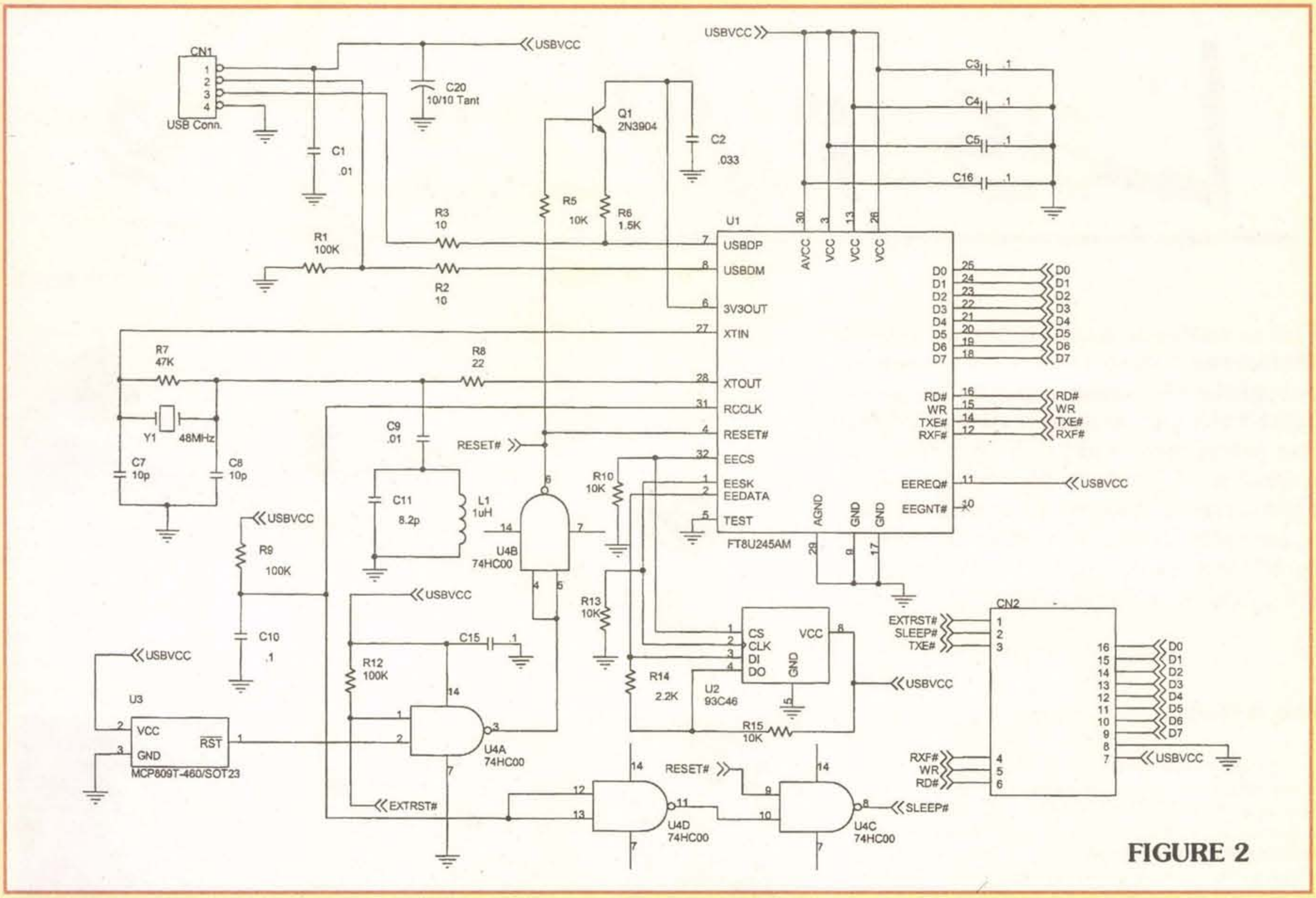


FIGURE 2

founded by the group of companies that developed the Universal Serial Bus specification. The USB-IF was formed to provide a support organization and forum for the advancement and adoption of Universal Serial Bus technology. The Forum facilitates the development of high-quality compatible USB peripherals (devices), and promotes the benefits of USB and the quality of products that have passed compliance testing. Some of the many activities that the USB-IF supports include:

- USB compliance workshops
- USB compliance test development
- www.usb.org website
- USB pavilions at Comdex, PC Expo, World PC Expo, and other events
- Marketing programs and collateral materials, such as retail newsletters, retail salespeople training, store end-caps, etc.
- USB 2.0 Developer Conferences
- and many more ...

Becoming a member of the USB-IF costs $2,500.00 for a one-year membership. An application for membership can be found at www.usb.org/developers/data/usbifapp.pdf.

USB 1.1 Specification

You should know that for every minute detail mentioned in this article about the USB specification, there are dozens of other details that have not been mentioned. The spec is daunting at best, and should only be read when suffering the worst bouts of insomnia. That said, the Device Drivers from FTDI do a splendid job of hiding the details of the specification, and this article will only cover the ones you are most likely to encounter when using the FT8U245AM. For those interested in reading USB specifications, they can be found at www.usb.org/developers/docs.html.

The FT8U245AM is compliant with version 1.1 of the USB spec. By definition, version 1.1 allows for two speeds of communication: "Low Speed" which is 1.5 megabits per second, and "Full Speed" which is 12 megabits per second.

The new USB specification 2.0 is rated at 480 megabits per second and is being termed "High Speed." The FT8U245AM communicates at up to eight megabits per second, somewhat less than Full Speed due to the behind-the-scenes handling of all the details associated with USB communication.

The FT8U245AM is designed to interface directly with a 93C46 EEPROM for storing configurable parameters which include the PID (Product ID), VID (Vendor ID), device description, and manufacturer name.

Users of the FT8U245AM can use their own VID and PID or FTDIs. If you are planning to commercialize a product with a USB port, you must register your own PID and VID with the USB-IF. This registration is included with the $2,500.00 membership fee, or you can become a non-member USB-IF Logo Licensee for $1,500.00.

Once registered, your VID and other configurable parameters can be written to the EEPROM using the program 232PROG.EXE which can be downloaded from FTDI's website. This program will also generate a serial number and write it to the EEPROM.

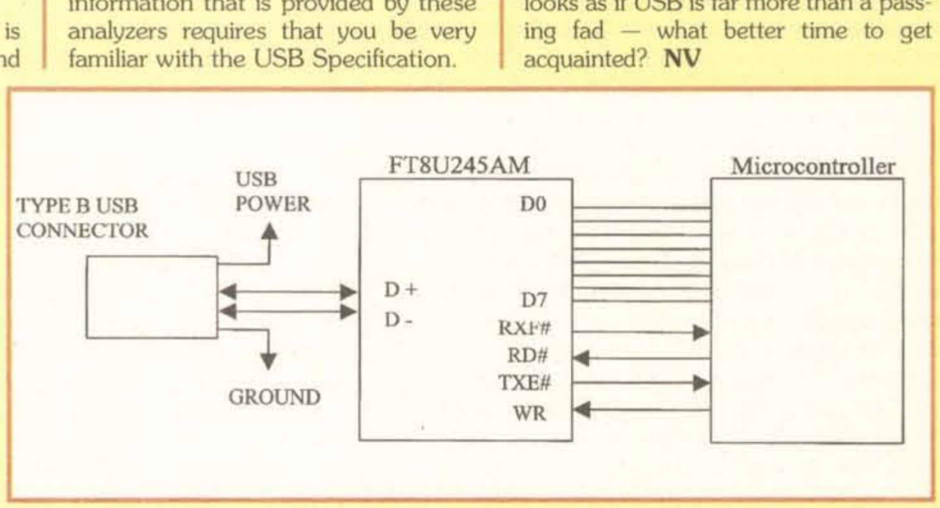
USB analyzers are available from a number of companies and tend to be rather pricey, but can be worth the money if you are attempting to isolate an elusive software bug. The level of information that is provided by these analyzers requires that you be very familiar with the USB Specification.

At this level of understanding, you will probably want to write your own drivers.

Conclusion

The Universal Serial Bus is slowly changing the way we connect to personal computers. Several manufacturers are now selling USB-based computers that do not have serial or parallel ports. The ability to connect and disconnect peripherals without having to shut down the computer, as well as the elimination of ambiguity over where and how to connect a device, can be extremely attractive to consumers.

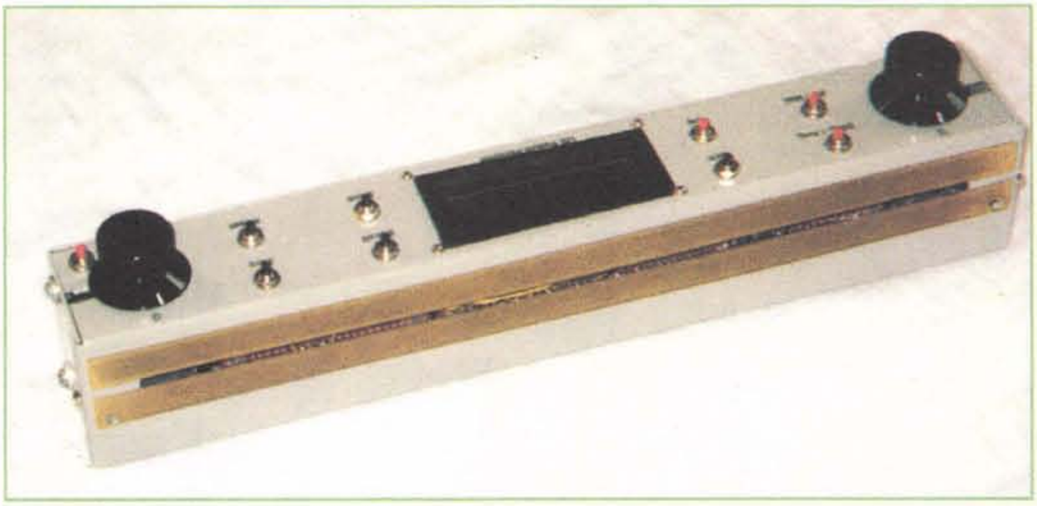
Legacy ports will be around for some time to come but, eventually, the lower cost of USB-based peripherals will choke them out of existence. It looks as if USB is far more than a passing fad — what better time to get acquainted? **NV**

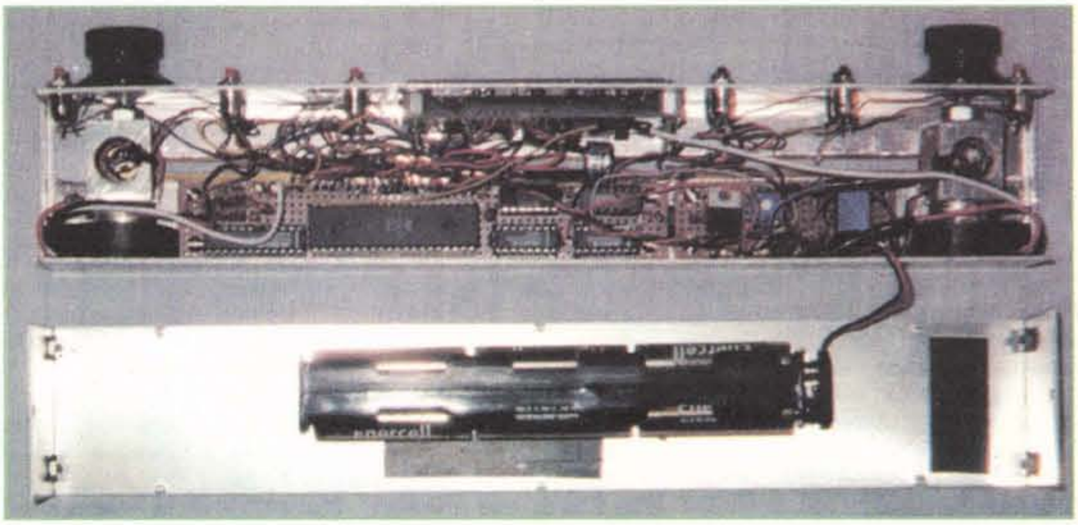


Laser Measure

by John Boyd

The standard method for measuring distances using lasers has been to calculate the time a pulse of laser light takes to travel a distance from the pulse generator to the distant object and back to the instrument. This article describes a different approach that relies on the visibility of two laser spots to measure lengths as opposed to distances.





How it Works

The device essentially measures one side of two different triangles. The side of the first triangle is the distance of the front of the unit to the surface of the length to be measured. The side of the second triangle is the actual length being measured. The separation (S) of the two laser diodes on the unit represents the base of a right triangle for measuring the distance (D), and the distance (D) then becomes the base of a second right triangle for measuring the length (L) or distance between the two points a and b. See Figure 1(a).

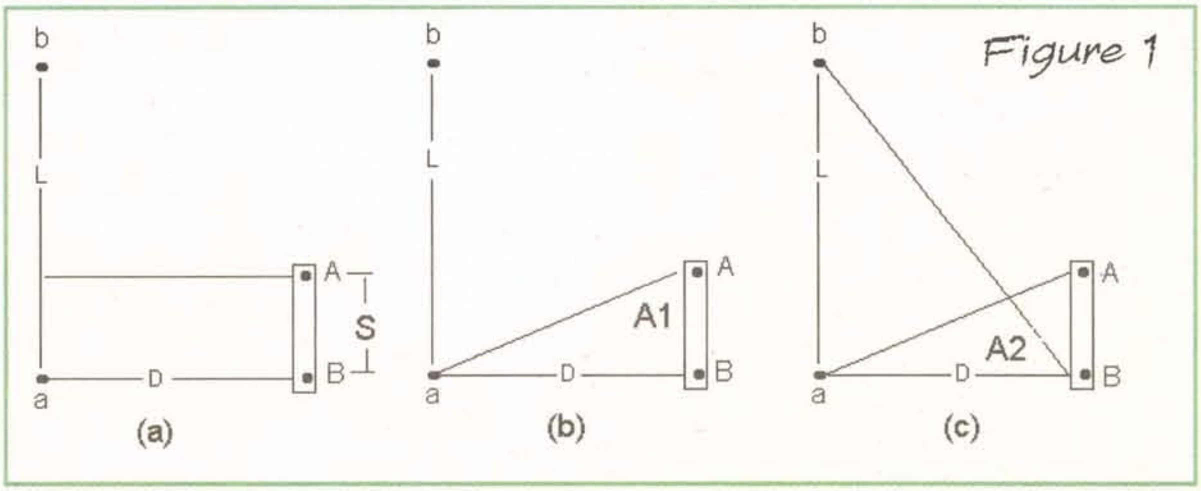
Taking a Measurement

The following applies to either laser. Refering to Figure 1(a), to measure lengths, the user initially rotates each laser to the zero position. The device now projects two laser spots, hence referred to as laser spot A and laser spot B, each one at right angles to the front of the device. Next, laser spot B is placed at one end of the length to be measured. The laser spot A is now rotated to coincide with the laser spot B.

This effectively forms a right triangle with the laser separation distance (S) as the base of the triangle. See Figure 1(b).The laser spot A transducer senses the amount of rotation by producing a proportionate output voltage to the internal analog-to-digital (A/D) converter. The internal microcontroller uses this digital value to calculate the rotation angle (A1).

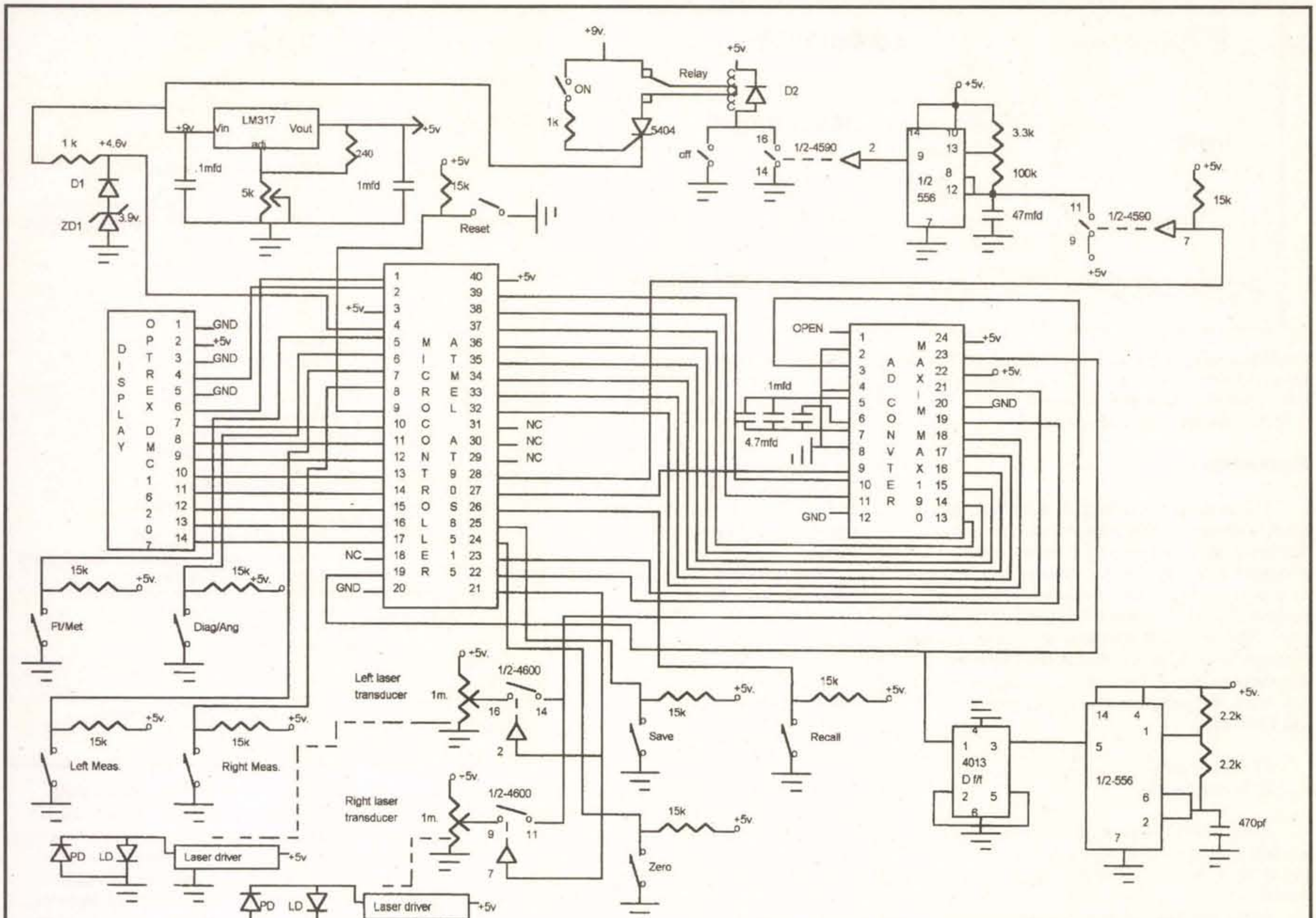
The internal microcontroller can now calculate the distance from the front of the apparatus to the laser spots using the formula for the tangent of the rotation angle as equal to the height divided by the base; the height being the distance (D) and the base being the laser separation (S). This distance (D) now becomes the base of a second right triangle.

Laser spot B is now rotated to the other end of the length to be measured, as in Figure 1(c). The laser B transducer senses the amount of rotation by producing a proportionate output voltage to the internal A/D converter. The internal microcontroller uses this digital value to calculate the rotation angle (A2). The previously calculated distance (D) to the spots is used as the base of a right triangle. The unknown length (L) is the height of the triangle. The internal microcontroller calculates the unknown length (L) using the formula for the tangent of the rotation angle as equal to the height divided by the base.



To measure angles, the two lasers are first rotated to the zero position. Either laser spot can then be used to measure the acute angle of a right triangle.The laser spot is placed at the base of the height of a right triangle formed by the projected laser beam and the side opposite the acute angle. Next, the laser is rotated to the vertex of the right triangle, and a measurement is taken.

The laser transducer senses the amount of rotation by producing a proportionate output voltage to the internal A/D converter. The



Laser Measure Circuit Diagram

internal microcontroller uses this digital value to calculate the rotation angle.

Hardware

The processing of data is accomplished by the Atmel AT90S8515 microcontroller. It is a low power CMOS eight-bit microcontroller. It has 8k bytes of reprogrammable flash, 512 bytes of EEPROM, and 512 bytes of internal SRAM. Input is in the form of 12 bits from a Maxim MAX190BCNG 12-bit A/D converter. Data is read into the CPU in a two-byte read. The lower eight bits are read in when a control signal is low, and the upper four bits are read in when the control signal is high. The analog signal is obtained from one of two position sensors. The term "position sensor" is just a fancy word for a high-quality potentiometer that has been manufactured to rotate from 0 to 90 degrees. The microcontroller selects which sensor by applying a control signal to one of two analog switches, the Maxim MAX 4600.

The laser diodes are mounted to the rotating part of the sensor using a 1/4-inch, aluminum rod epoxied to a square aluminum bracket. The laser diodes are two keychain-type laser pointers with the rear portion "hack-sawed" off to expose the laser driver for connections to the +5 volt power supply and to shorten their length for mounting into the square aluminum brackets with epoxy (Figure 2).

Other inputs are 1) On; 2) Off; 3) Reset, resets system; 4) Zero, pressed before each measurement to tell the microcontroller that the lasers are at zero degrees; 5) Save, saves current measurement; 6) Recall, recalls previously-saved measurement; 7) Diag/Ang, displays the length of the diagonal of the right triangle and the acute angle; 8) Ft.-Met., toggles the display from feet to meters and meters to feet; and 9) Measure, signals the microcontroller to calculate a measurement. See Figure 3.

Output is an Optrex DMC16207 liquid crystal, two-line display. Voltage regulation is accomplished using an LM317-adjustable, IC voltage regulator. Diodes D1 and ZD1 form a reference voltage to tell the microcontroller when battery voltage is low. The system clock is generated using half of an 556 timer. The output of this timer is input to a 4013 D-type flip-flop. The output of this flip-flop generates a squarewave with a 50% duty cycle. Power is applied to the device by triggering a 5404 SCR.

The device is turned off by opening the anode of the SCR through a normally closed relay. The relay is activated by 1) the Off switch or by 2) closing the analog switch or half of a MAX4590. The analog switch is connected to the other half of the 556 timer. This timer has a cycle of one minute. If the unit is not used for a period of one minute, then the timer will turn the relay on and the anode of the SCR will open, turning the unit off.

All the components fit nicely into an alu-

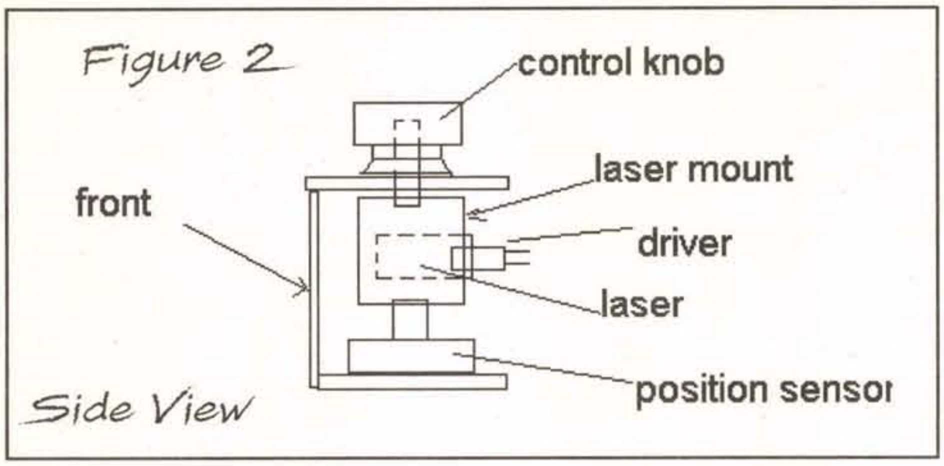


Figure 2 Side View

Parts

Quantity	Description
1	Atmel AT90S8515 -8PC microcontroller
1	Maxim MAX190BCNG A/D converter
1	Optrex DMC16207 liquid crystal display
1	Intersil 556 dual CMOS 555 timer
1	Maxim MAX4600, dual SPST, CMOS analog switch
1	Maxim MAX4590, dual SPST, CMOS analog switch
1	National LM317 voltage regulator
1	CD4013BE dual D-type flip-flop
1	3.9V zener diode
2	1N914 switching diode
9	15 Kohm, 1/4 watt, 10% resistors
1	240 ohm, 1/4 watt, 10% resistor
2	1 Kohm, 1/4 watt, 10% resistor
1	3.3 Kohm, 1/4 watt, 10% resistor
1	100 Kohm, 1/4 watt, 10% resistor
2	2.2 Kohm, 1/4 watt, 10% resistors
3	.1 mFd, 20-volt disk capacitors
1	1 mFd, 20-volt Mylar capacitor
1	47 mFd, 20-volt electrolytic capacitor
1	470 pF, 20-volt disk capacitor
1	5 Kohm trimmer potentiometer
1	5404 SCR or silicon controlled rectifier
1	1 SPDT miniature five-volt relay
10	momentary push-button switches, N.O.
2	1" square, aluminum angle or equivalent laser mount
1	1" x 10" vector board and hook-up wire
1	Battery holder for six AA alkaline batteries
1	Snap connector for nine-volt battery
1	Strong, high-quality epoxy glue
2	Rotational postion sensor

Clarostat part # 640ES106D06NAAY
90-degrees travel, 1/4" through shaft, linear taper
Clarostat, 12055 Rojas Drive, Suite K, El Paso, TX 79936,
phone 1-800-874-1874

minum, LMB15 chassis. It measures 12 inches long, 2 inches wide, and 1-3/4 inches deep (see photo). The unit is powered by six, 1.5-volt AA-size alkaline batteries.

Software

The software is written in assembly language using the AVR Assembler. The user applies power by pressing the On button. The program first initializes constants and sets specific pins on the microcontroller for input or output. The LCD display is initialized for display. The battery is checked for proper voltage through a comparator that is built into the microcontroller. If the battery voltage is above 4.5 volts, the program then displays the following message:

1) Zero lasers
2) Press Zero

1) Instructs the user to rotate the laser control knobs so that they point to the zero position. 2) Instructs the user to press the Zero button.

When the Zero button is pressed, the program saves the values for the analog voltages from the position sensors. These values are converted to digital form by the A/D converter. The values represent the zero position and are later subtracted from the rotated values in order to produce a true reading.

Next, the program displays the following message:

3) Align spots
4) Press measure

3) Instructs the user to rotate either the left or right (but not both) laser knobs so that one laser spot coincides with the other laser spot. The point at which the two spots merge is the starting point of the length that is to be measured. To establish the end point, rotate the knob that was not rotated to set the laser spot at the end of the length.

These two rotations determine the two angles needed to determine the unknown sides of the triangles.

4) Instructs the user to press the measure button next to the laser control knob that was rotated first. The program now saves the digital value of the analog voltages of the two-position sensors which represent the rotation angle of each laser. These two values combined with the laser separation (S) are all that is needed to calculate the distance from the instrument to the surface being measured and the unknown length along the surface.

The distance (D) is calculated using the formula:

D = S X tan(A1).

The length L is calculated using the formula:

L = D X tan(A2).

The tangent is calculated by first calculating the sine of the angle and storing this result. Next, the cosine of the same angle is calculated and stored. Finally, the sine of the angle is divided by the cosine to give a tangent.

After the calculation is finished, the values are displayed as:

D = XX.X feet
L = XX.X feet

If the Diag/Ang button is pressed, the length of the diagonal from laser B to point b is displayed and the angle A2:

Ang = XX.X deg.
Diag = XX.X feet

The assembly language source file for Laser Measure can be downloaded from the following web site: http://laser_measure.homestead.com/laser_measure.html.

Measurement Accuracy

Two factors limit the accuracy of the device. The first is the separation (S) of the two laser diodes. A large separation means the base of the first triangle is wide and this increases accuracy because the first angle (A1) is smaller, and calculating the tangent is done with greater accuracy. The second is the tangent calculation.

Calculating the tangent of angles that approach 90 degrees must be done to high precision. This is needed when measuring very long lengths. The unit works best when the rotated angle is between 30 and 60 degrees. This restriction is due to the current state of the software. As it is now, the unit can measure with an accuracy of ±1/10 of a foot for lengths up to about 15 feet. This also means the user should stand from two feet to no more than six feet from the surface of the length to be measured.

A more accurate determination of the tangent by the software will produce significantly better results of 30 to 40 feet for the current laser separation of 10 inches.

There is nothing to prevent one from designing a unit with laser separations of two or even three feet. I have not experimented with these lengths, but I assume that this will allow significant accuracy and very long lengths or heights to be measured. The software will have to be modified if a laser separation is greater than 10 inches. This merely amounts to changing a value to the new separation distance.

This device has advantages over the traditional method of time measurement. Measuring the height of a building is difficult if not impossible with the time method whereas this method is fairly simple. Measuring inaccessible ceilings and support beams is also simplified. Environmental factors such as air temperature and humidity do not affect measurements although bright sunlight can make the lasers difficult to see. **NV**

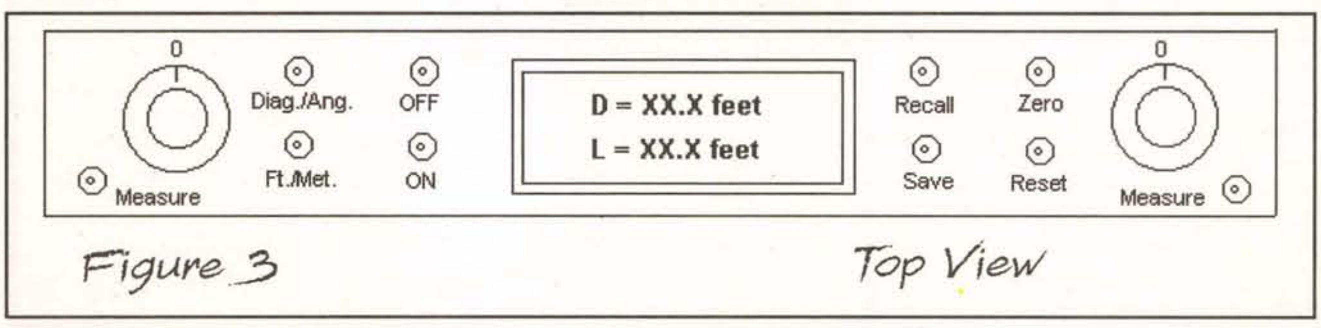


Figure 3 Top View

Author bio — Self-employed, currently writing software for the Palm PDA. John O. Boyd, email: jboyd45@hotmail.com

Small Logic Gates Spawn Big Dreams — Part 1

Yes, Michael, there is such a thing as a generic logic chip.
Learn how to turn your junk box orphans into a construction project or replacement part treasures.

by TJ Byers

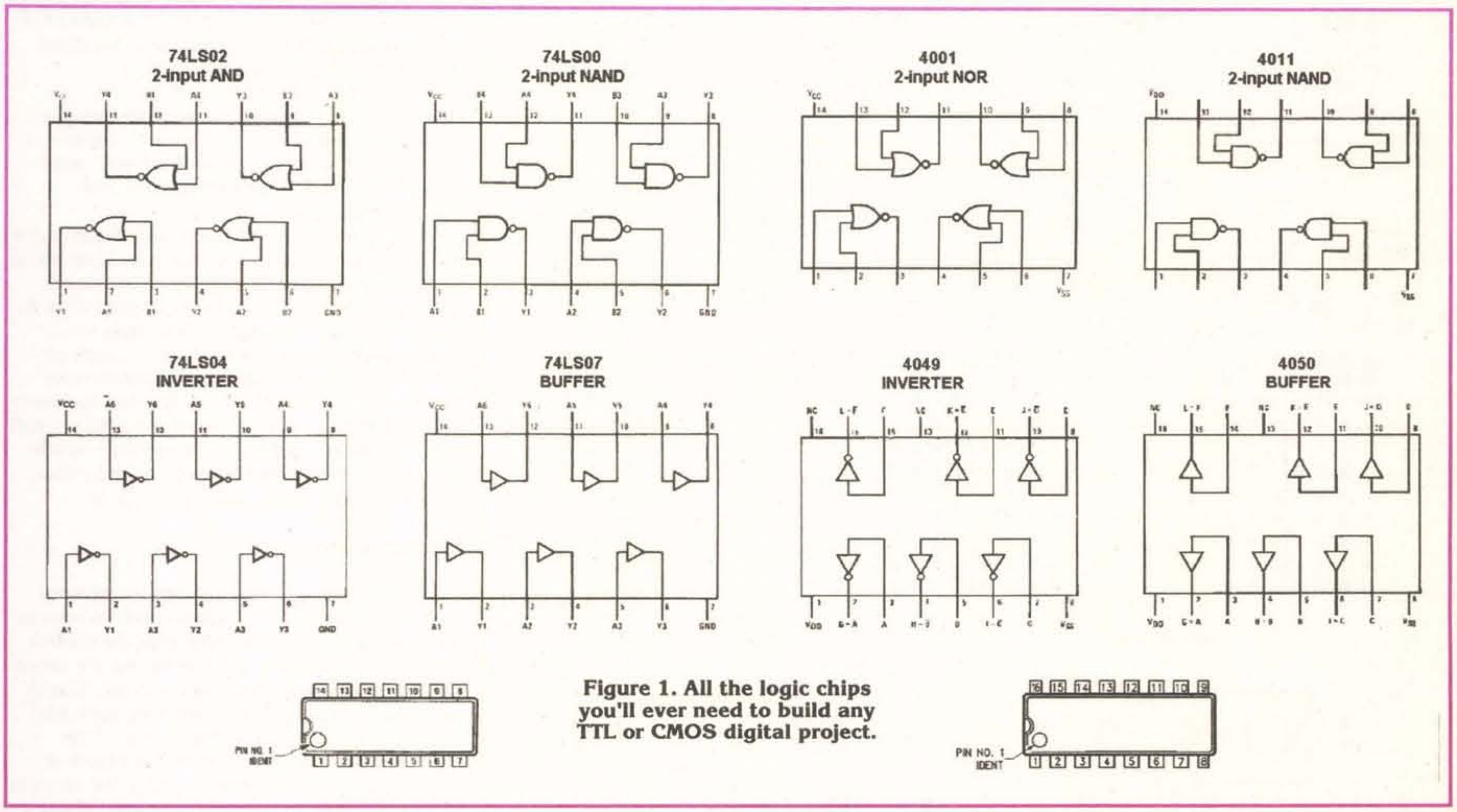


Figure 1. All the logic chips you'll ever need to build any TTL or CMOS digital project.

Straight from the "It never fails" files. Ten o'clock Saturday night. You're putting the finishing touches on your mindboggling new robot steering controller. Visions of Bot Wars games numb your senses. Just one more step, a simple RS flip-flop, and your beast will roar into action. But wait! The IC cupboard is ... well, bare. Not a flip-flop in sight!

Not to fret, though. If you have just a single NOR or NAND chip in that rat's nest, you have the makings of an RS flip-flop. In fact, you probably have more logic functions in there than you're aware of.

All logic circuits — no matter how complex (including that BASIC Stamp microcontroller) — are based on two elementary propositions: AND and OR. Throw in an inverter gate (NOT), and you can solve any logic equation.

In this article, I'll show you how to use these basic building blocks to get you out of a parts jam, whether it be for a new project or as a replacement device. You will also learn about the subtle differences between seemingly similar logic functions, so that you can choose the flavor that best suits your pet project.

The Basics

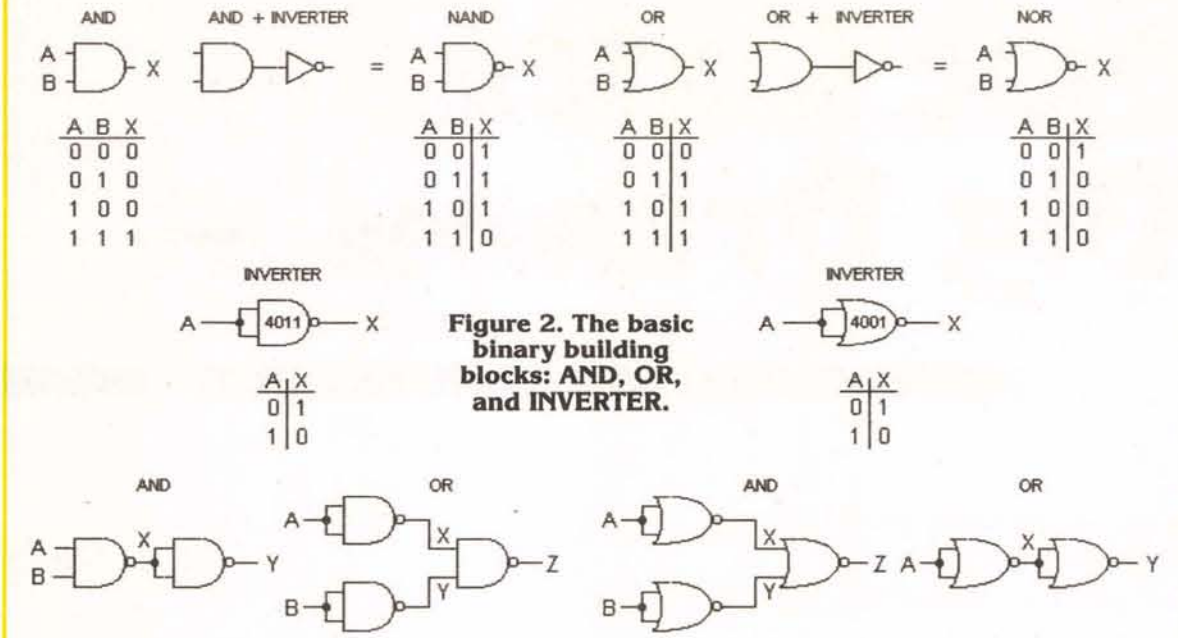
Boolean algebra is the basis for all computer logic. Originally formulated by George Boole, an English mathematician (1815-1864), Boolean algebra describes propositions whose outcomes are either true or false. In computer work, the true and false statements are represented by the output state of an electronic circuit, whose state can be either 1 (true) or 0 (false). We perceive these logic changes as voltage levels. That is, when the logic level is supposed to represent a 1, the output voltage will typically measure five volts. Conversely, a logic 0 is represented by — what else? Zero volts. This is important. Logic 1 is five volts and logic 0 is no volts. (Okay, you nitpickers. Before you pluck my pupils out, let me say that voltages other than five volts can represent a logic 1, with 3.3 volts being the newest inductee.)

The basic operators are AND, OR, and NOT. AND is the product of the two arguments; that is, if both propositions are true, then the statement is true. If either of the propositions is false, then the statement is false. OR is the sum of the propositions. If either proposition is true, or both are true, then the statement is true. NOT is the inverse or complement of a statement. If the statement is true, then its complement is false.

Expressed algebraically, the Boolean equations are:

Expression	Proposition	Statement
x • y	x AND y	true
x + y	x OR y, x AND y	true
/x • /y	NOT x AND NOT y	true
/x + /y	NOT x OR NOT y, NOT x AND NOT y	true

The inverse function is an important logic operator because it can be used to simplify otherwise complex functions, and is sometimes the



AND

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

NAND

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

OR

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

NOR

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

INVERTER (4011)

A	X
0	1
1	0

INVERTER (4001)

A	X
0	1
1	0

AND

A	B	X	Y
0	0	1	0
0	1	0	0
1	0	0	0
1	1	0	1

OR

A	B	X	Y	Z
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

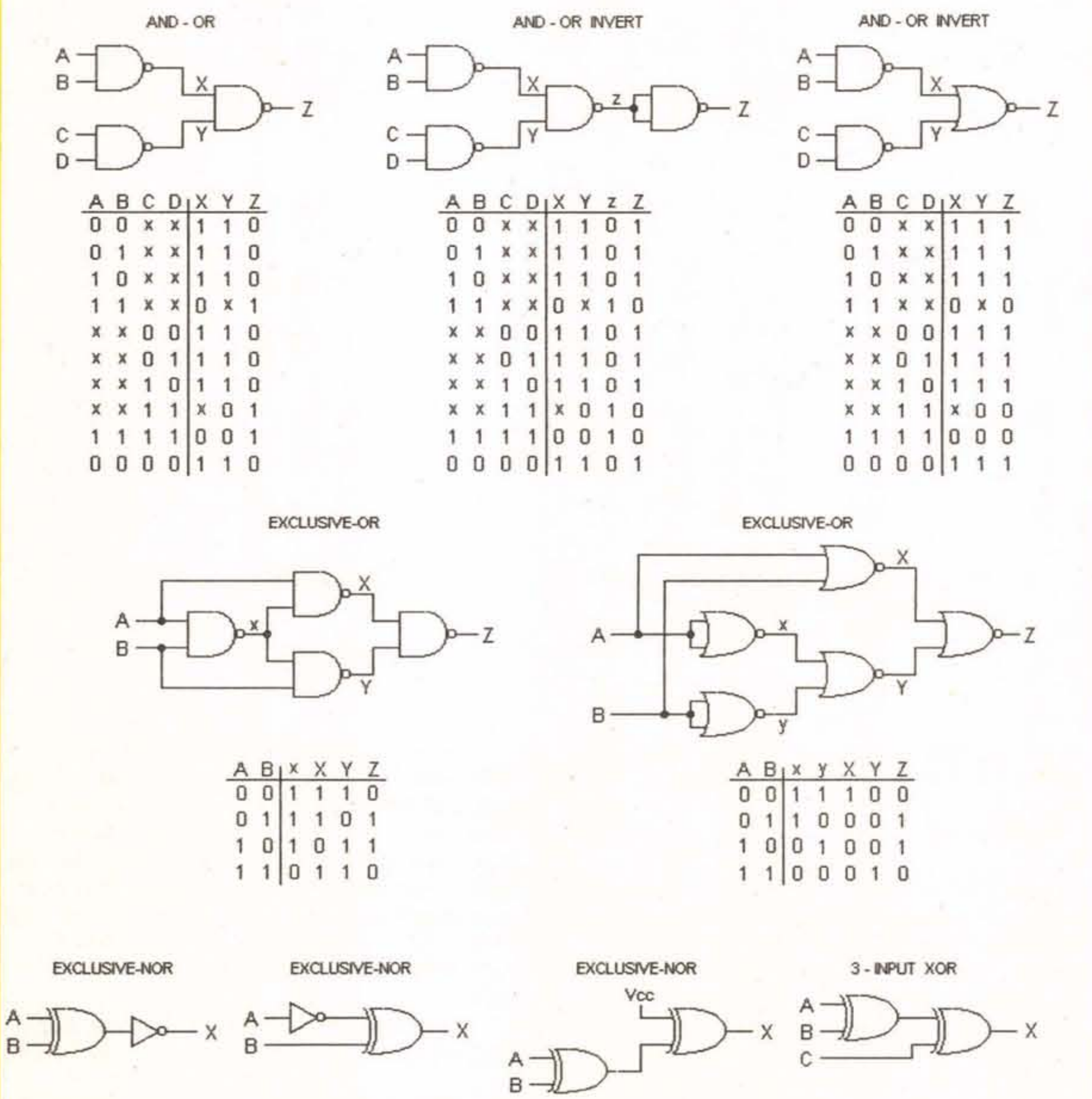
AND

A	B	X	Y	Z
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

OR

A	B	X	Y
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

Figure 2. The basic binary building blocks: AND, OR, and INVERTER.



AND - OR

A	B	C	D	X	Y	Z
0	0	x	x	1	1	0
0	1	x	x	1	1	0
1	0	x	x	1	1	0
1	1	x	x	0	x	1
x	x	0	0	1	1	0
x	x	0	1	1	1	0
x	x	1	0	1	1	0
x	x	1	1	x	0	1
1	1	1	1	0	0	1
0	0	0	0	1	1	0

AND - OR INVERT

A	B	C	D	X	Y	z	Z
0	0	x	x	1	1	0	1
0	1	x	x	1	1	0	1
1	0	x	x	1	1	0	1
1	1	x	x	0	x	1	0
x	x	0	0	1	1	0	1
x	x	0	1	1	1	0	1
x	x	1	0	1	1	0	1
x	x	1	1	x	0	1	0
1	1	1	1	0	0	1	0
0	0	0	0	1	1	0	1

AND - OR INVERT

A	B	C	D	X	Y	Z
0	0	x	x	1	1	1
0	1	x	x	1	1	1
1	0	x	x	1	1	1
1	1	x	x	0	x	0
x	x	0	0	1	1	1
x	x	0	1	1	1	1
x	x	1	0	1	1	1
x	x	1	1	x	0	0
1	1	1	1	0	0	0
0	0	0	0	1	1	1

EXCLUSIVE-OR

A	B	x	X	Y	Z
0	0	1	1	1	0
0	1	1	1	0	1
1	0	1	0	1	1
1	1	0	1	1	0

EXCLUSIVE-OR

A	B	x	y	X	Y	Z
0	0	1	1	1	0	0
0	1	1	0	0	0	1
1	0	0	1	0	0	1
1	1	0	0	0	1	0

EXCLUSIVE-NOR

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

3 - INPUT XOR

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

Figure 3. The AND-OR and exclusive-OR gates are a perfect example of complex logic functions, made from negative logic gates, that find widespread use in the computer industry.

only way to arrive at a solution. For example, it's virtually impossible to solve the equation of

x OR y, but not x AND y

(the logical reasoning of an exclusive OR gate) without the NOT operator. And without the exclusive-OR gate, computers wouldn't be smart enough to add or subtract. Figure 1 shows the logic chips that we'll use for the rest of this discussion, and Figure 2 shows their elementary structures.

Early logic gates were built on RTL (resistor-transistor logic) technology, which was plagued by noise, blatantly cantankerous, and downright slow. RTL construction techniques of the time also limited the gate types to the simpler AND, OR, and inverter functions. It wasn't until the advent of TTL (transistor-transistor logic) that more complex designs could be successfully fabricated.

The advances included multiple inputs beyond four propositions, stable edge triggering, and increased fan-out capability. But none were more important than the paradigm shift from positive (AND/OR) logic to negative (NAND/NOR) logic thinking (Figure 3). Negative logic simplifies many Boolean equations, which leads to a reduced gate count — which results in very sophisticated logic products like embedded microcontrollers and Pentium processors.

Negative logic isn't hard to understand, but it takes a nimble mind to implement it efficiently. In this discussion, there is a heavy emphasis on negative logic and the clustering of gate types to reduce IC count. Most logic ICs contain two or more identical gates, many of which might go unused if you don't know how to wire them to perform operations other than for what they were intended. For example, an unused NAND or NOR gate can easily substitute for an inverter, which could possibly eliminate an extra IC and make the product less costly and more reliable.

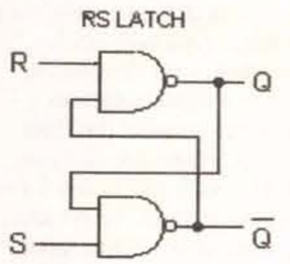
I Remember, Too

Logic gates can also be used as memory elements. In order for a logical circuit to remember and retain its logical state after the controlling input stimulus has been removed, it's necessary to include some form of feedback. This is easily done using a pair of inverters, each having its input connected to the output of the other, like the cross-linked circuit in Figure 4.

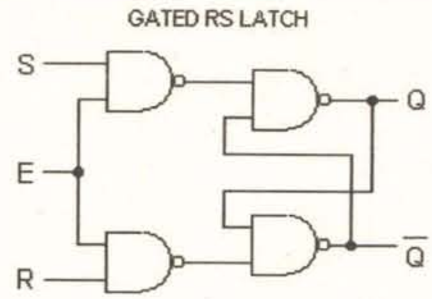
Because the gates are inverting, the outputs will always have an opposite logic level of the input. Depending on which gate assumes control on power-up, this circuit will latch up in one of two states. To toggle between these states, an extra input is added to the cross-linked inverters, like the NAND latch shown in Figure 5a.

The inputs are traditionally designated S and R for Set and Reset, respectively, and the outputs are designated Q and /Q The designations S and R are a logical evolution, but what prompted the use of Q for an output? Legend has it that the early memory gates weren't totally reliable, and so researchers labeled the predicted outcome as Questionable (so the story goes). In a commercial latch circuit, either or both outputs may be available for use by other circuits.

For the NAND latch circuit, both inputs should normally be at logic 1. Pulling the top gate's input low (logic 0) forces its output high (logic 1). This logic 1 is also applied to the input of the bottom NAND gate, forcing that output low (logic 0). This, in turn, feeds back to the second input of the original gate, thereby clos-

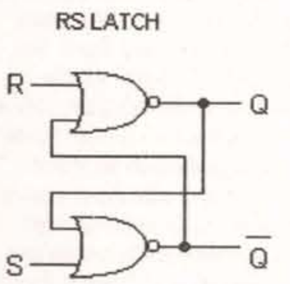


R	S	Q $\overline{Q}$
0	0	not allowed
0	1	1 0
1	0	0 1
1	1	no change

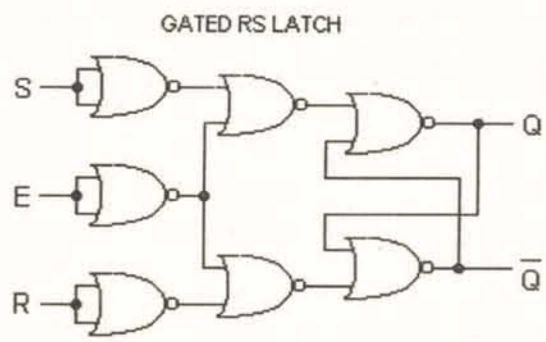


E	R	S	Q $\overline{Q}$
1	0	0	not allowed
1	0	1	1 0
1	1	0	0 1
1	1	1	no change
0	x	x	no change

Figure 6. The RS NAND latch is created by adding a pair of NAND gates to the input circuits of a basic RS latch.



R	S	Q $\overline{Q}$
0	0	no change
0	1	1 0
1	0	0 1
1	1	not allowed



E	R	S	Q $\overline{Q}$
1	0	0	no change
1	0	1	1 0
1	1	0	0 1
1	1	1	not allowed
0	x	x	no change

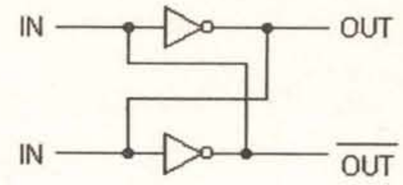


Figure 4. In order for a logical circuit to be used as a memory cell, it's necessary to include some form of feedback. By cross-linking the outputs of two inverters to its opposite inputs, the circuit forms a stable memory retention element.

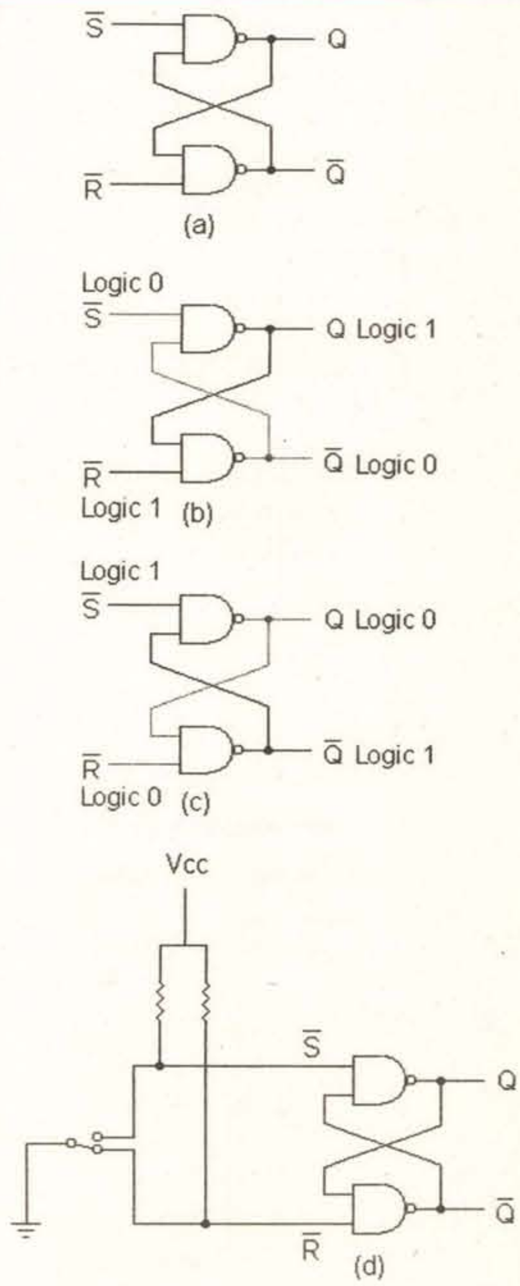


Figure 5. An RS latch can be used to debounce mechanical switches, sending a single, clean digital pulse to the next circuit.

ing the feedback loop. The gates are now locked (Figure 5b), even if the /S input signal is removed. Applying logic 0 input to the top gate will have no further effect on this circuit. However, applying a logic 0 to the bottom gate will cause the same reaction in the other direction, thus changing the state of the latch (Figure 5c). If you need to switch states on a positive note, pulling the inputs high (logic 1) instead of low (logic 0), a NOR gate may be substituted for the NAND gate.

Note that it's forbidden to have both NAND inputs at a logic 0 level at the same time (the opposite occurs in the NOR latch configuration). That state will force both outputs to a logic 1, overriding the feedback latching action. In this condition, whichever input goes to logic 1 first will lose control, while the other input (still at logic 0) controls the resulting state of the latch. If both inputs go to logic 1 simultaneously, the result is a "race to the finish line" frenzy, and the final state of the latch cannot be determined ahead of time.

Pardon My Hiccups

RS latches are the most simple-minded of the flip-flop family — but that doesn't prevent them from contributing to the digital community. RS latches are often used to eliminate contact bounce in mechanical switches. When you press the button or change a switch's position, the physical contacts flex a little, causing them to make and break several times before settling down. You don't notice this when turning on a light in your home, but digital circuits are fast enough that they do notice this behavior and mimic it faithfully.

The solution is to insert an RS latch between the mechanical switch and the following circuitry, as shown in Figure 5d. Notice that the unconnected input is held at a logic 1 via a pull-up resistor, while the switched input is held at logic 0 by a direct connection to ground. (The resistor prevents the switch from shorting Vcc to ground.) When the switch is moved to its alternate position, the gate toggles to its opposite state and latches in place; additional bounces will have no effect on the output. This eliminates the contact bounce and sends a single, clean digital pulse to the next circuit.

While RS latches are useful devices, they have their limitations. One problem is how to control when the latch is allowed to change state, and when it's not. This is necessary if we have a group of latches and want to be sure they all change state (or not) at the same time. By adding a pair of NAND gates to the input circuits of the RS latch, we accomplish two goals: normal rather than inverted inputs, and a third input common to both gates which we can use to synchronize this circuit with others of its kind.

The gated RS NAND latch (Figure 6) circuit is very similar in operation to the basic latch. The S and R inputs are normally at logic 0, and must be changed to logic 1 to switch the state of the latch. However, with the third input, a new factor has been added. This input is typically designated clock or CLK, because it's typically controlled by a clock circuit of some sort, which is used to synchronize banks of these latch circuits with each other. The output can only change state while the CLK input is a logic 1. When CLK is a logic 0, the S and R inputs have no effect.

Flip-Flops, Not Pop-Tops

Although the gated RS latch solves some of the problems of basic RS latch circuits, and allows closer control of the latching action, it's by no means the last word. The RS latch circuit could easily experience a change in S and R input levels while the CLK input is still at a logic 1 level. This allows the circuit to change state many times before the CLK input returns to logic 0.

A good way to make sure that the latch can only change its outputs exactly on the clock cycle trigger is to sample the inputs on the transition, or edge, of the clock signal. To adjust the gated RS latch for edge triggering, we must use two identical gated latch circuits, each of which operates on opposite halves of the clock signal. The resulting circuit is commonly called a flip-flop, because its output can first flip one way and then flop back the other way. The two-section flip-flop is also known as a master-slave flip-flop, because the input latch operates as the master section, while the output section is slaved to the master during half of each clock cycle.

The edge-triggered RS NAND flip-flop is shown in Figure 7. As previously described, the circuit actually consists of two identical RS latch circuits, with an inverter connected between the two CLK inputs to ensure that the two sections are enabled during opposite half-cycles of the clock signal. The inverter is the key to the operation of this circuit.

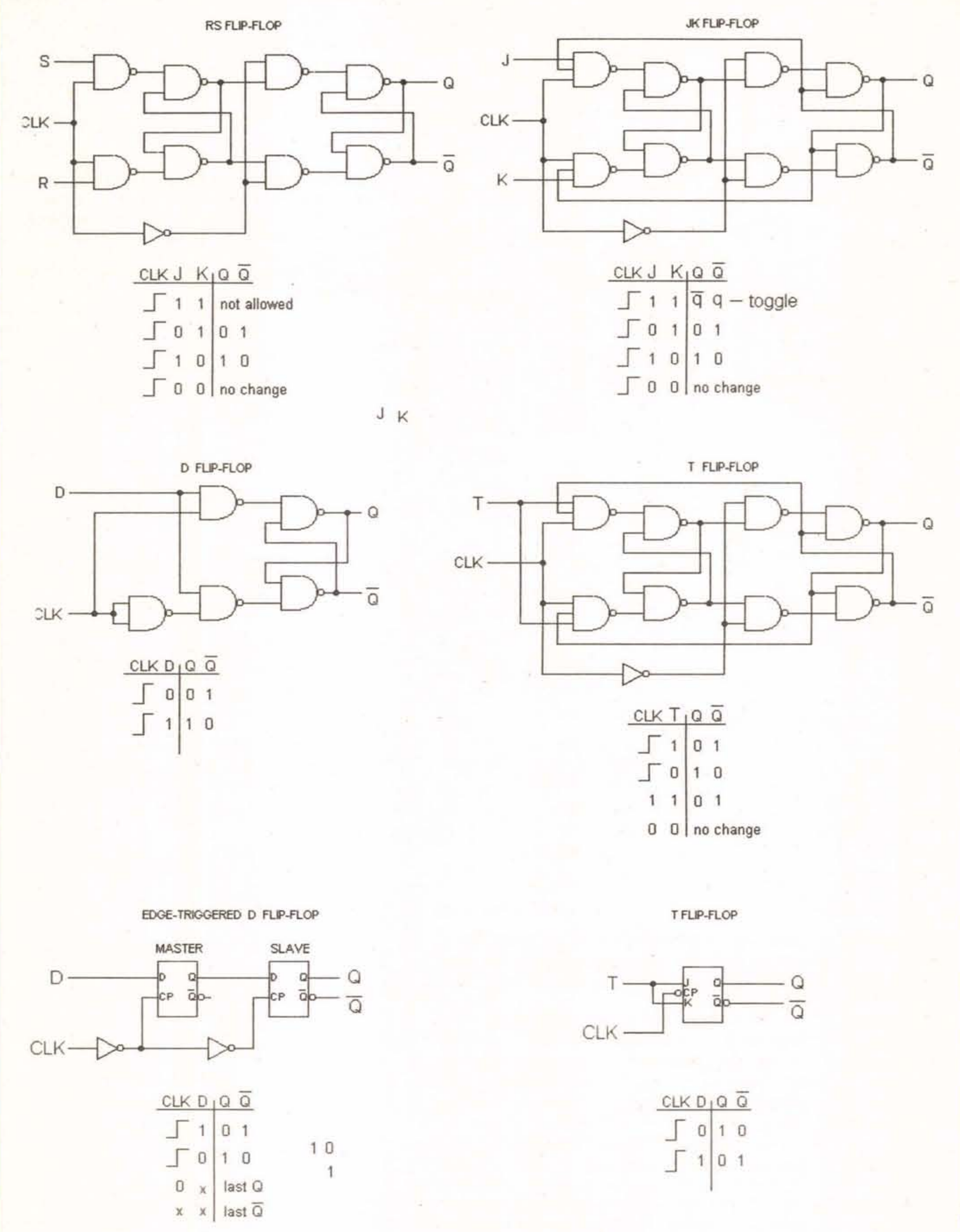


Figure 7. Flip-flops come in a wide variety of sizes, shapes, and features.

If we start with the CLK input at logic 0, the S and R inputs are disconnected from the input (master) latch. Therefore, any changes in the input signals cannot affect the state of the final outputs. When the CLK signal goes to logic 1, the S and R inputs are able to control the state of the input latch, just as with the single RS latch. At the same time, though, the inverted CLK signal is applied to the output (slave) latch and prevents the state of the input latch from having any effect here. Therefore, any changes in the R and S input signals are tracked by the input latch while CLK is at logic 1, but are not reflected at the Q and /Q outputs.

When CLK falls again to logic 0, the S and R inputs are again isolated from the input latch. At the same time, the inverted CLK signal now allows the current state of the input latch to reach the output latch. As a result, the Q and /Q outputs can only change state when the CLK signal falls from a logic 1 to logic 0. This is known as the falling edge of the CLK signal; hence the designation "edge-triggered flip-flop."

By making the flip-flop edge-triggered, we can precisely control the moment when all flip-flops will change state. This arrangement also allows plenty of time for the master latch to respond to the input signals, and for those input signals to change and settle down following the previous change of state.

JK Flip-Flop

Still, there is one problem left to solve: the ambiguous output condition which may occur if both the S and R inputs are at logic 1 when the CLK falls from logic 1 to logic 0. In the example above, we automatically assume that the master latch will end up in the logic 1 state — but this isn't always a certainty with real components. Therefore, we need a way to prevent a race between the two gates to see which one reaches logic 1 state first.

The solution is to add extra feedback from the slave latch to the master latch. This modified latch is called a JK flip-flop. To prevent any possibility of a "race" occurring between the R and S inputs when both inputs are at logic 1, we must somehow prevent one of the inputs from having an effect on the master latch. At the same time, we still want the flip-flop to be able to change state on each falling edge of the CLK input if the input logic calls for it. Whether the S input or the R input is to be disabled depends on the current state of the slave latch outputs. If the Q output is a logic 1 (the flip-flop is in the

Set mode), the S input can't be any more set that it already is. Therefore, the S input can be disabled without disturbing the flip-flop under these conditions. In the same way, if the Q output is logic 0 (the flip-flop is Reset), the R input can be disabled without causing any harm. We have thus prevented a foot race to logic 1.

Feedback control of the RS flip-flop inputs is attained by adding two new inputs from the Q and /Q outputs. (Remember that NAND and NOR gates may have any number of inputs.) To prevent confusion, the designations of the new flip-flop inputs are designated J (instead of S) and K (instead of R).

In most ways, the JK flip-flop behaves just like the RS flip-flop. The Q and /Q outputs will only change state on the falling edge of the CLK signal, and the J and K inputs will control the future output state pretty much as before. However, there are some notable differences.

Since one of the two logic inputs is always disabled, the master latch can't change state back and forth while the CLK input is at logic 1. Instead, the enabled input can change the state of the master latch once. This isn't true of the RS flip-flop. The Q and /Q outputs can only change state with each falling edge of the CLK signal, with the master latch circuit changing state with each rising edge of CLK.

We can use this characteristic to our advantage in a number of ways. A flip-flop built specifically to operate this way is typically called a T flip-flop (Toggle flip-flop). The lone T input is, in fact, the CLK input for other types of flip-flops.

The operation of the T flip-flop is identical to that of an RS flip-flop with joined S (set) and R (reset) inputs. Every T input pulse triggers switching of the latch to the opposite state. When it's in logic 0, a CLK pulse changes the T flip-flop to the logic state 1. When the latch is in logic 1, a clock pulse changes the flip-flop to logic state 0. Note that the frequency of the output pulses is exactly half of the frequency of the input pulses.

D Flip-Flop

One very useful variation on the RS latch circuit is the Data latch, or D flip-flop, as it's generally called. The D flip-flop is constructed by using the inverted S input as the R input signal. The single remaining input is designated D to distinguish its operation from other types of latches. It makes no difference that the R input signal is effectively clocked twice, since the CLK signal will either allow the signals to pass both gates or it won't.

When the CLK input is logic 1, the Q output will always follow and reflect the logic level present at the D input, no matter what course it may take. However, when the CLK input falls to logic 0, the state of the D input at that instant is trapped and held in the latch for use by whatever other circuits may need this signal. Because the single D input is also inverted, this latch circuit can't experience an ambiguous state condition caused by all inputs being at logic 1 simultaneously, making it safe to use in any circuit.

Although the D flip-flop doesn't have to be edge-triggered, there are some applications where an edge-triggered D flip-flop is desirable. This can be accomplished by using a D latch circuit as the master section of an RS flip-flop. Both types are useful, and both are commercially available.

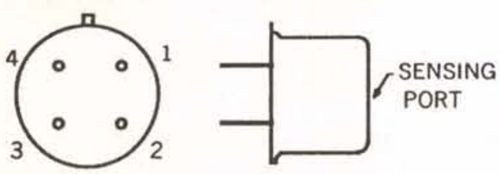
With all of these different types of latches and flip-flops, the logic diagrams we've been using have gotten rather large, especially for the edge-triggered flip-flops. Fortunately, it really isn't necessary to follow and understand the inner workings of any of these circuits when they are used in larger applications. Instead, we used a set of very simple symbols to represent each type of latch or flip-flop in larger logical circuits, as shown in the two bottom circuits of Figure 7.

That's all for this installment. Coming next month is a look at the brainier side of binary logic. Here is where we put the above logic gates and memory cells to work on mathematical problems. **NV**

BUILD THE BREATH-O-METER

by Anthony J. Caristi

SIMPLE BUT SOPHISTICATED ELECTRONIC TESTING DEVICE CHECKS BLOOD ALCOHOL CONCENTRATION



BOTTOM VIEW **FIGURE 1**

ALCOHOL SENSOR SHOWING TERMINAL IDENTIFICATION

Everyone knows the importance of not driving after drinking, and if you like to host parties, the Breath-O-Meter is just what you need. Not only will this easy-to-build project be useful, it is sure to be a hit at your next gathering.

....

Many people are aware of the growing movement towards making 0.08% blood alcohol concentration (BAC) the legal limit for driving in all 50 states. In fact, anyone with a BAC of just 0.02% should never get behind the wheel of a vehicle.

Measurement of blood alcohol is a reliable indication of the impairment of human senses due to alcohol. Law enforcement agencies are permitted to use BAC to determine if a person is legally drunk, and the results of such tests are admissible in court.

This is where the Breath-O-Meter comes in. It is a high-quality, portable electronic measuring device that is able to provide reasonably accurate BAC measurements, simply by having a subject blow through a straw into a sensitive alcohol breath sensor. Three levels of BAC can be detected: 0.02%, 0.05%, and 0.08%. Calibration of the circuit is easily performed using a technique similar to that employed on law-enforcement breath analyzers.

While this project can provide some amusement at your party, it is a serious device that belongs in any home where alcoholic beverages are served to guests. At the very least, it will increase awareness of the importance of not driving when impaired by alcohol.

BLOOD ALCOHOL CONCENTRATION FUNDAMENTALS

When an alcoholic beverage is consumed, the human body absorbs the alcohol into the blood stream. About 1/2 ounce of alcohol per hour can be metabolized, or burned off. If several drinks are consumed in an hour, the BAC level will reach concentrations that will cause impairment. This level will be different for different people, depending mostly upon the individual's weight. Table 1 illustrates typical BAC levels after ingesting one or more alcoholic drinks containing 0.5 ounces of pure alcohol.

Table 1 represents typical values of BAC. Males tend to develop lower levels of BAC than females for the same number of drinks consumed in a given time. Note that just one drink consumed per hour will result in some impairment, and one should not drive a vehicle until the BAC level is less than 0.02%.

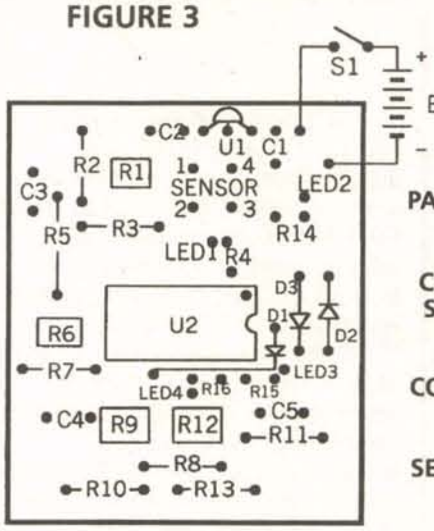
When alcohol is present in the blood stream, the exhaled breath will contain alcohol vapor. The ratio between blood alcohol level and breath alcohol concentration is a known quantity that was discovered almost 200 years ago. It is this factor that permits BAC levels to be determined by measuring the concentration of alcohol vapor in the breath.

THE ALCOHOL SENSOR

The alcohol sensor (Figure 1) used in the Breath-O-Meter was developed by Figaro, Glenview, IL, and the part number is TGS2620. It is composed of a metal oxide semiconductor layer formed on an alumina substrate, together with an integrated heater that is powered by a five-volt DC supply. A mesh protects the element while allowing vapor to enter the chamber. The sensor's conductivity is relatively low in the presence of air, and increases significantly when alcohol and other organic solvent vapors are present.

An initialization period of several minutes is required when the sensor is first operated. This clears out any contaminants that have accumulated in the sensor since it was last used. After initialization,

FIGURE 3



PARTS LAYOUT SHOWN FROM THE COMPONENT SIDE OF THE BOARD. NOTE THE CONNECTIONS TO THE ALCOHOL SENSOR, LEDs, S1, AND BATTERY.

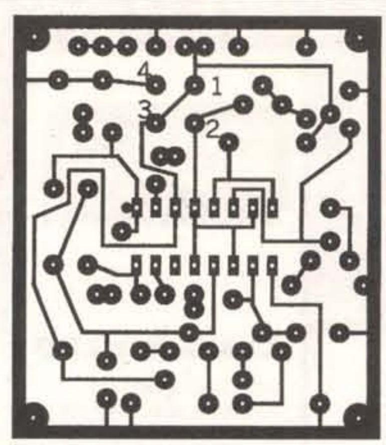


FIGURE 2

PRINTED LAYOUT SHOWN FULL SIZE AS SEEN FROM THE COPPER SIDE OF THE BOARD

the resistance of the sensor is high, possibly 25,000 ohms or more.

When an alcohol gas concentration of 50 parts per million (PPM) or more is introduced into the sensor, its resistance decreases rapidly depending upon the concentration of the gas. By driving the sensor with the five-volt supply and connecting a load resistor in series with it, the voltage developed across the resistor will then be an indicator of the concentration of the alcohol gas.

ABOUT THE CIRCUIT

Refer to the schematic diagram. Power to operate the circuit is provided by a set of six "C" or "D" cells connected in series. (A 7-to 12-volt DC wall adapter transformer may also be used if portability is not required.) Total current draw is about 60 milliamperes.

In order to preserve circuit calibration and ensure that the heater voltage for the sensor is held within tight tolerances, a fixed five-volt regulator chip, U1, provides the regulated voltage that supplies the entire circuit.

The heater terminals of the sensor — pins 1 and 4 — are driven by the five-volt supply. The sensor electrodes — pins 2 and 3 — are connected in series with a load resistor (R1 and R2) and driven by the five-volt supply. The sensor resistance depends upon the alcohol concentration in the breath sample, and the voltage across R1 and R2 represents the electrical equivalent of the gas concentration.

U2 is a four-section voltage comparator chip that includes a stable 1.18 volt reference. A voltage comparator acts as an op-amp without feedback so that its gain is extremely high. It compares the magnitude of the voltages fed to the input terminals, and the output terminal goes either high or low, depending upon which of the two input voltages is greater.

U2A is used to determine when the sensor is ready for a measurement. Upon turn-on, the voltage across the load resistor is high as the sensor conditions itself. When that voltage is reduced to below a volt or so, U2A output terminal goes high. This illuminates LED1 to indicate that the Breath-O-Meter is ready.

U2 sections B, C, and D operate as voltage comparators that compare the voltage across the sensor load resistor to a predetermined level as set by the calibrating potentiometers R6, R9, and R12.

When a breath sample containing alcohol vapor representing 0.02% BAC or more is introduced into the sensor, the voltage across the load resistor increases from its standby level of less than a volt. Depending upon the alcohol concentration, any or all of the comparators will change state. This will cause the appropriate comparator to go high, lighting its LED.

To obviate ambiguity when the BAC is great enough to cause more than one LED to light, a diode network (D1, D2, D3) is used to prevent more than one LED to light at a time. This is accomplished by using the output terminals of U2B and/or U2C to pull the appropriate negative input of U2C and/or U2D high, negating its comparator function. This forces a lower BAC indicator to be extinguished when a higher one is illuminated.

CONSTRUCTION

Most of the circuitry of the Breath-O-Meter is contained on a small printed circuit board measuring about 2" x 2-1/4". The circuit is not critical and may be hardwired on a perfboard if you do not wish to etch your own, or obtain one from the source given in the parts list.

Figure 2 illustrates the printed layout shown full size as seen from the copper side of the board. Figure 3 depicts the component layout. Also shown are the connections to the external components such as the battery, S1, and LEDs.

Pay strict attention to all polarized components such as semiconductor devices and electrolytic capacitors. Any such part placed backwards in the circuit will render the circuit inoperative, and may cause damage to itself or other components. Double-check before soldering these parts in place. The use of a socket for U2 is optional.

Be sure to use metal film type resistors where specified, to ensure circuit accuracy and stability. Carbon resistors are not temperature stable and should not be used in place of metal film types where specified.

Refer to Figure 1. The builder has the option of soldering the sensor directly into the top side of the PC board as high as possible, and mounting the board directly to the top of the enclosure with suitable spacers and hardware so that the sensor protrudes through. An alternate method of mounting the sensor is to drill a suitable sized hole in the enclosure and use silicone rubber to hold the sensor in place. Then use flexible insulated wire to make the connections to the PC board.

Whichever option is chosen, be sure to follow Figures 1 and 3 — and the wiring depicted in the schematic — exactly as shown.

When finished stuffing the board, check all components for correct value and orientation. Check for short circuits between closely spaced conductors. Are the solder joints shiny and smooth? If not, correct them by removing the old solder, cleaning the joint, and resoldering. It is much easier to correct any problems now rather than later on if you discover that your Breath-O-Meter does not work.

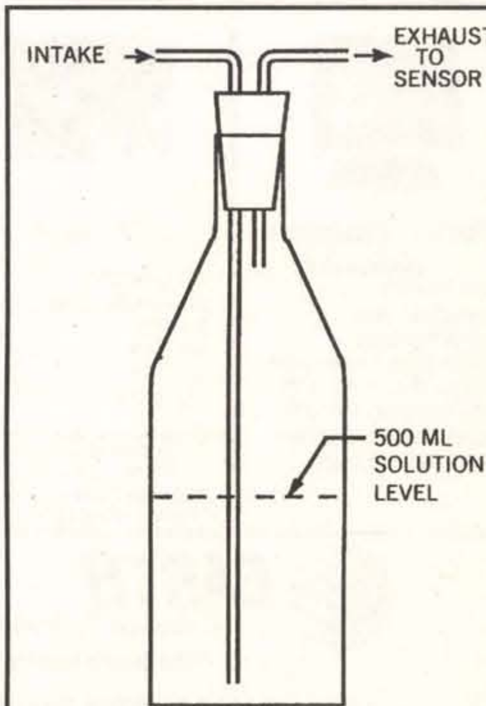


FIGURE 4

STOPPERED BOTTLE CONTAINING DILUTED STOCK SOLUTION TO SIMULATE ALCOHOL BREATH

Set the board aside while preparing the enclosure.

FINAL ASSEMBLY AND WIRING

Select a suitable enclosure that will be large enough to house a set of six C or D cells. Use appropriate battery holders. Either alkaline batteries or Ni-Cads may be used for this circuit. **CAUTION**: Fully or partially charged Ni-Cads can deliver many amperes of current into a short circuit. Wires can melt and PC board traces can vaporize. Be extremely careful not to cause an inadvertent short circuit when using these cells.

NUMBER OF DRINKS PER HOUR

Body Wt.	1	2	3	4	5	6	7	8
100 lbs	.04	.08	.11	.15	.19	.23	.26	.3
120 lbs	.03	.06	.09	.13	.16	.19	.22	.25
140 lbs	.03	.05	.08	.11	.13	.16	.19	.21
160 lbs	.02	.05	.07	.09	.12	.14	.16	.19
180 lbs	.02	.04	.06	.08	.10	.13	.15	.17
200 lbs	.02	.04	.06	.08	.09	.11	.13	.15
220 lbs	.02	.03	.05	.07	.09	.10	.12	.14
240 lbs	.02	.03	.05	.07	.08	.09	.11	.13

TABLE 1. BLOOD ALCOHOL CONCENTRATION

BREATH-O-METER

An alternate power supply, using a 7-to 12-volt DC wall adapter transformer, is optional. Current draw of the circuit is about 60 milliamperes, so use a wall adapter rated at 100 ma or more. Be sure the output of the adapter is well filtered DC, not AC.

Determine the location of the alcohol sensor, which must be assessable for sensing the subject's breath when blown through a straw. The remaining components include four LEDs and the power switch. LEDs are easily secured to the enclosure by drilling an accurate sized hole, then using silicone rubber to hold them in place.

Follow Figure 3 and the schematic when completing the circuit. Use stranded insulated wires, #22 gauge or so, for the connections. Do not use solid wire — it will break.

Be sure the battery connections have the proper polarity. If in doubt, use a DC voltmeter to verify which lead is plus and which is negative. Do not install the batteries until the final calibration is completed.

INITIAL CHECKOUT

It is recommended that a 7-to 12- volt, well-filtered DC power supply be used for the checkout. This will avoid depleting batteries as the sensor is initiated for the first time, and as the calibrating procedure is performed. A DVM will be required for the test.

Apply DC power to the circuit and measure the voltage at pins 1 and 3 of the sensor, with respect to circuit common. Normal indication is 4.75 to 5.25 volts DC. If you do not obtain the proper voltage, check the power supply voltage to be sure it is delivering at least seven-volts DC to the regulator. Check the orientation of C1 and U1. Remove power and check the resistance between the five-volt bus and ground for any possible short circuit. Do not proceed with the checkout until the fault is located and repaired.

Set R6, R9, and R12 to mid position. Apply power to the circuit and measure the voltage at pin 2 of the sensor, with respect to ground. When power is first applied, this voltage will rise from zero, and then slowly decrease as the sensor conditions itself.

This may take a couple of minutes. Adjust R1 over its range and note that LED1 (green) will be illuminated when the voltage at pin 2 of the sensor is less than 1.1 volts, and extinguished when the voltage is more than 1.3 volts.

If you do not obtain these results, check the orientation LED1 and U2, and check the connections to the sensor. Check pin 8 of U2 to verify the presence of the reference voltage, 1.18 volts DC. Do not proceed until the fault is located and corrected.

When the voltage at pin 2 of the sensor stabilizes, adjust R1 for a reading of 0.9 volts. Adjust R12 so that the voltage at pin 12 of U2 is 1.5 volts. Adjust R9 so that the voltage at pin 10 of U2 is 2.0 volts. Adjust R6 so that the voltage at pin 6 of U2 is 2.5 volts.

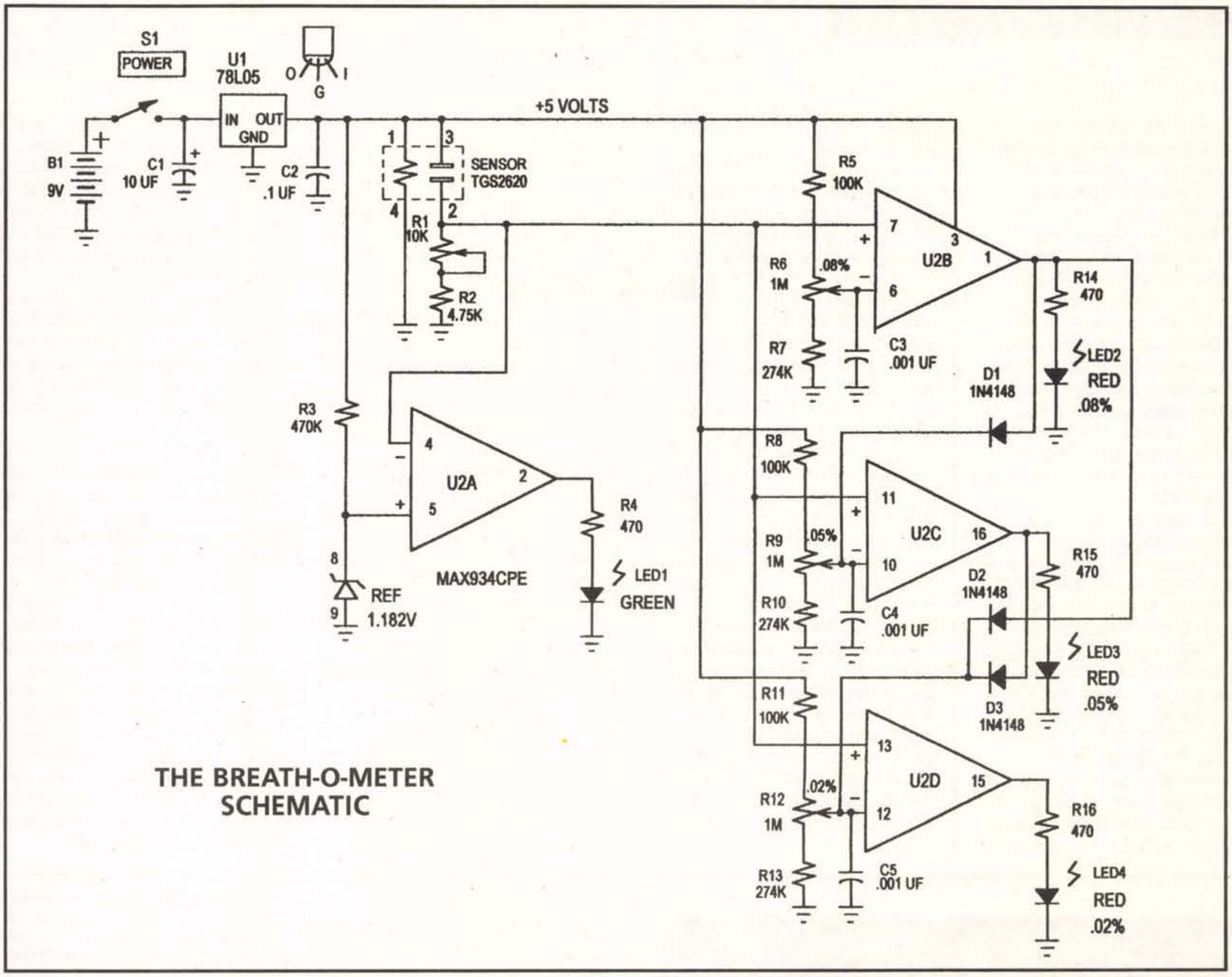
All red LEDs should be extinguished. Check circuit operation by exposing the sensor to the open end of a bottle of ordinary rubbing alcohol. **CAUTION**: Do not allow any liquid to enter the sensor.

The green LED should extinguish and the red LEDs will light, in rapid succession, as the sensor reacts to the alcohol vapor. When the alcohol bottle is removed from the vicinity of the sensor, the LEDs will extinguish in reverse order. Finally, the red LEDs will be out, and the green LED will be lit.

If the red LEDs do not light as described, check the wiring to them, and check their polarity. Check the orientation of D1, D2, and D3. Replace the LEDs, if necessary.

CALIBRATION

The principle by which the Breath-O-Meter operates is based on a discovery in 1803 by British chemist William Henry. He stated there is a fixed ratio between the



THE BREATH-O-METER SCHEMATIC

concentration of a volatile compound such as alcohol, in water, and its concentration in air.

This ratio is constant for a given temperature and pressure. In this case, the concentration of alcohol in water is represented by the blood, and the concentration in air is represented by the subject's breath. Henry's Law provides the means by which the Breath-O-Meter can be calibrated to a reasonable accuracy.

Calibration of the Breath-O-Meter is performed in three discrete steps by simulating human breath with BAC levels of 0.02%, 0.05%, and 0.08%, and feeding the air sample to the sensor. This is accomplished using a few readily obtainable materials, plus properly prepared alcohol solutions.

Figure 4 illustrates the calibrating apparatus to be used, which is similar to professional breath alcohol simulators. It consists of a clear wine or soda bottle, a length of plastic tubing, and a cork or rubber stopper drilled for a tight fit for two hoses. A thermometer is required to measure the temperature of the solution which must be warmed to the average temperature of the human mouth, 34 degrees Celsius (93 degrees Fahrenheit).

In accordance with Henry's Law, simulation of human breath is accomplished by blowing through the plastic tube that is submerged in the warmed solution so that the alcohol/air mixture in the head space of the bottle is forced out the exhaust tube and directed to the sensor.

The accuracy of the calibration is a function of the accuracy of the procedure. First, a "stock" solution is prepared and stored in a well-stoppered bottle. From this, three different calibration solutions are prepared by diluting the stock solution with water.

If possible use graduated beakers or cylinders, available from laboratory supply houses. Use the following procedure:

1. First, pour exactly 500 milliliters (16.9 ounces) of pure

PARTS LIST

B1 — Four C or D alkaline or Ni-Cad cells connected in series
C1 — 10 uFd 25-volt radial electrolytic capacitor
C2 — .1 uFd 50-volt ceramic disc capacitor
C3, C4, C5 — 0.001 uFd 50-volt ceramic disc capacitor
D1, D2, D3 — 1N4148 silicon diode
LED1 — Green light emitting diode
LED2, LED3, LED4 — Red light emitting diode
R1 — 10K cermet potentiometer PC mount
R2 — 4.75K 1/4 watt 1% metal film resistor
R3 — 470K 1/4 watt carbon resistor
R4, R14, R15, R16 — 470 ohm 1/4 watt carbon resistor
R5, R8, R11 — 100K 1/4 watt 1% metal film resistor
R6, R9, R12 — 1 Megohm cermet potentiometer, PC mount
R7, R10, R13 — 274K 1/4 watt 1% metal film resistor
S1 — SPDT toggle or slide switch
Sensor — Figaro TGS2620
U1 — 78L05 five-volt regulator
U2 — Quad comparator, Maxim MAX934CPE
Misc. — Battery holder, enclosure, hook-up wire

SOURCES OF SUPPLY

Sensor: **Figaro USA**, Glenview, IL; 847-832-1701
Other parts: **Digi-Key**, 800-344-4539
Mouser, 800-346-6873

Note: The following parts are available from **A. Caristi, 69 White Pond Road, Waldwick, NJ 07463**

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water into a clean bottle that can be capped or stoppered. Set the bottle on a level surface and carefully mark the level attained. Discard the water.

2. Next, pour water into the bottle, halfway to the marked level. Then add 95 milliliters (3.2 ounces) of ordinary 80 proof vodka. Be sure the label on the vodka bottle says 80 proof. Add sufficient water to bring the level in the bottle to the 500 ml level previously marked. Cap or stopper this bottle, and label it "stock solution." This solution will keep for several months if kept sealed and in a cool place.

3. To make a working solution for the simulator bottle depicted in Figure 4, take a clear wine or soda bottle that can be stoppered with the drilled cork, and fill it with exactly 500 milliliters of clean water. Mark the level attained, as done previously with the stock solution bottle. Discard the water.

4. Pour in enough water to half the marked level. For 0.02% BAC, add 2 milliliters (0.068 ounces) of stock solution, and then add sufficient water to bring the level up to the 500 milliliter mark. Seal the bottle with the previously prepared stopper or cork containing the tubing.

5. The solution in this bottle must be warmed to 34 degrees Celsius. This can be done by soaking the bottle in a large pan containing water, and gently heating it on the stove while monitoring the temperature of the water bath. It may take a soak time of 15 or 30 minutes for the solution in the bottle to attain the temperature of the water bath.

6. To calibrate the Breath-O-Meter, connect the voltmeter to pin 2 of the sensor. Turn power on, and wait until the voltage reading is stabilized and the green LED is lit. An assistant will be useful to help with the procedure.

7. Place the open end of the exhaust tube near the open end of the sensor. Take a deep breath and blow very gently but steadily into the open end of the submerged tube to force the head space air out of the exhaust tube. A steady flow of air, for 15 seconds or more, will be required to attain a peak reading of the voltmeter.

8. Record the highest voltage reading that is obtained with a steady stream of air. Discard the solution.

9. For the 0.05% and 0.08% measurements, make new working solutions (step 4) containing 5 milliliters (0.17 ounces) and 8 milliliters (0.27 ounces) of stock solution, respectively.

These solutions must be warmed as before. Repeat steps 6, 7, and 8 as done for the 0.02% measurement, and record the peak meter readings obtained. Note that the voltmeter reading for 0.05% will be higher than that for 0.02%, and 0.08% will be higher than 0.05%. Discard each of the solutions after use.

10. Connect the voltmeter to pin 12 of U2. Set R12 so that the measured voltage is equal to that recorded from the 0.02% procedure. In a similar manner, check the voltage at pins 10 and 6 of U2 and adjust R9 and R6, to attain the voltage readings recorded in the 0.05% and 0.08% procedures, respectively. This completes calibration of the Breath-O-Meter.

USING THE BREATH-O-METER

For an accurate measurement of BAC, the subject should not have smoked or ingested alcohol for at least 15 minutes before the test. Be sure the batteries are fresh.

Turn on the instrument and wait until the green LED is lit, which may take 30 seconds or more. If the green LED does not remain extinguished for this period, the batteries may need replacement.

Have the subject take a deep breath, and blow steadily but gently through a straw for at least 15 seconds while directing the air flow to the open end of the sensor. Be sure no liquid or saliva enters the sensor.

If any of the red LEDs illuminate, the BAC level of the subject is equal to or greater than the threshold of the illuminated LED. To repeat the test, allow sufficient time for the sensor to stabilize and illuminate the green LED.

Although a BAC level of 0.02% or 0.05% is not sufficient for a person to be declared legally drunk, such a person should never attempt to drive a motor vehicle. The body will metabolize about 1/2 ounce of alcohol an hour. Wait an hour, then repeat the test.

If the instrument was calibrated with care, believe its results and don't drive with a BAC level of 0.02% or greater. **NV**

Continued from page 56

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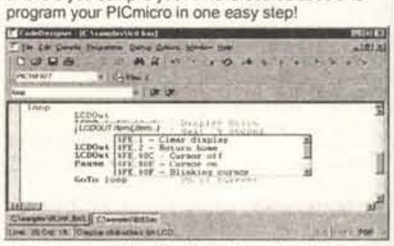

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Continued on page 84

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:

This month, it's back to class. You'll learn how to create hard-to-find and esoteric parts using simple devices you probably have in your junk boxes. A keypad encoder, slick Internet tips, tutorial web sites, and everything you ever want to know about coils and inductors (but were sorry you asked).

Multi-Layer Coils: A Dumb Q?

Q. I recently ran across a project that called for a multi-layer RF choke. It would seem to me that placing layers in parallel, one atop the other, would decrease the inductance, not increase it. I'm referring to the parallel inductor formula, which states

$$LT = \frac{L1 \times L2}{L1 + L2}$$

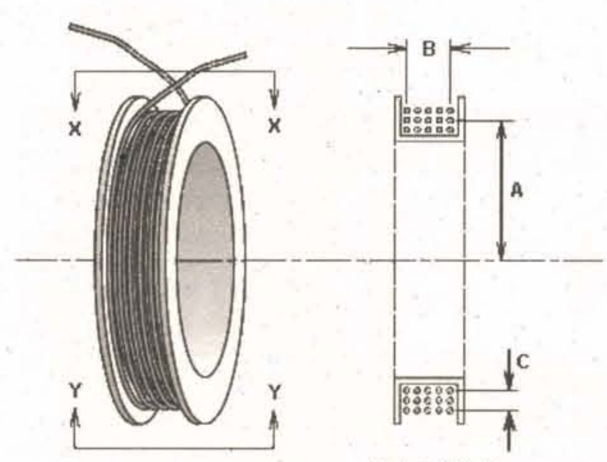
For example, if both inductors are 5uH, then the combination would equal 2.5uH. But when I wind these coils, I see no reduction in inductance no matter how many layers I add. In fact, the inductance hardly changes at all! Why is this so? If it's true, as my test show, what's the advantage or purpose of having a multi-layer coil over a single-layer coil? It uses more wire and takes more work to wind. I don't get it.

Stephen Hart
via Internet

A. If these were separated single layer solenoids connected in parallel, then yes, the result would be reduced inductance. But they're not separate coils; they are, instead, mutually coupled coils which behave differently. Unlike resistors and capacitors, which are two dimensional, inductors carry with them a magnetic field. When magnetic fields interact, they change the properties of the current and voltage that produces them. This is the case of a multi-layer coil. The coupled inductance can be determined by the formula

$$LT = \frac{1}{\frac{1}{L1 + M} + \frac{1}{L2 + M}}$$

where:
LT is the total inductance
L1 and L2 are inductance of the individual coils
M is the mutual inductance.



$$L = \frac{0.8\,(N \times A)^2}{6A + 9B + 10C}$$

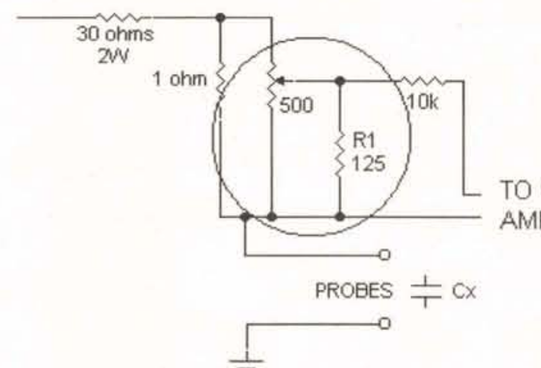
Without going into a lot of detail, take my word for it: The total inductance doesn't change as layers are added. So why do they do it? It increases the Q of the coil — the "figure of merit" or "quality" of an inductance coil. A circuit with a high Q has good efficiency, a narrow bandwidth and low loss.

Linear To Log

Q. In a recent column (Aug. 2000), you gave a schematic for a capacitor ESR tester. I am having a difficult time finding a slider log pot of about 100 ohms. Can I use a 200, 500, or even a 1000-ohm pot?

Irv Barb W4DHU
via Internet

A. The 100-ohm pot is part of an empirical formula for this design. The ESR value is proportional to the value of the potentiometer resistance, which means you can use a linear taper pot if you change the dial to a linear scale. If you do this, though, ESR values under 0.5 ohm are harder to read accurately. A solution is to add a padder resistor to the potentiometer, as shown in the highlighted area below.



Placing a fixed resistor across the tap of a linear potentiometer approximates a log-taper potentiometer. It's not actually log, but it's close.

This trick can be used to convert any linear pot into a pseudo log taper potentiometer. I used this formula to calculate the value of the padder resistor.

$$R = \frac{R1 \times R2}{R1 + R2}$$

$$100 = R1 \times 500 / R1 + 500$$
$$400R1 = 50{,}000$$
$$R1 = 125$$

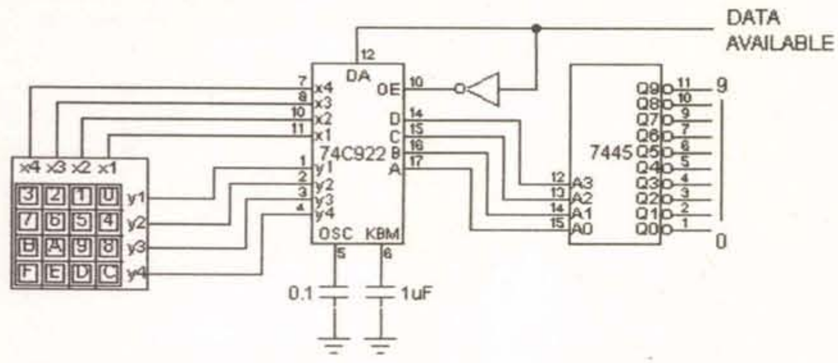
Going through the calculations: I knew R had to be 100 ohms, the value of the original pot. Then I selected 500 ohms, a standard off-the-shelf item, for R2. Solving for R1 produces a value of 125 ohms for the padder resistor; a 121 ohm, 1% resistor is close enough. Here's a rule of thumb for converting a linear sweep into a logarithmetic sweep: R1 is approximately 25% greater than R (R1 = 1.25 x R), and the ratio between R1 and R2 should be 1:4 (R2 = 4 x R1 — about 5 x R).

Keypad Encoder/Decoder

Q. I have a neat diagram for an electronic combination lock that uses a handful of small SCRs. To enter the combination, the circuit detects a separate input from each key of a small keypad. However, all the keypads I can find seem to have a matrix type output, typically in rows and columns of 3 by 4. Is there an IC that will decode the matrix from one of these keypads and output a single pulse or ground connection for each key?

Alan May
Houston, TX

A. What you need is a keypad encoder, like the 74C922. This IC takes the cross-point signals from the keypad and converts them into BCD (binary-coded decimal) format, which is then decoded using a BCD-to-decimal decoder, typically a 7442 or a 7445. When a key is pressed, one of the outputs will go low (7442) or high (7445), representing a digit between 0 and 9. The outputs are in tri-state until a valid key-press is detected, at which time the DATA AVAILABLE output line goes high. These outputs can now be used to trigger your combination sequence.



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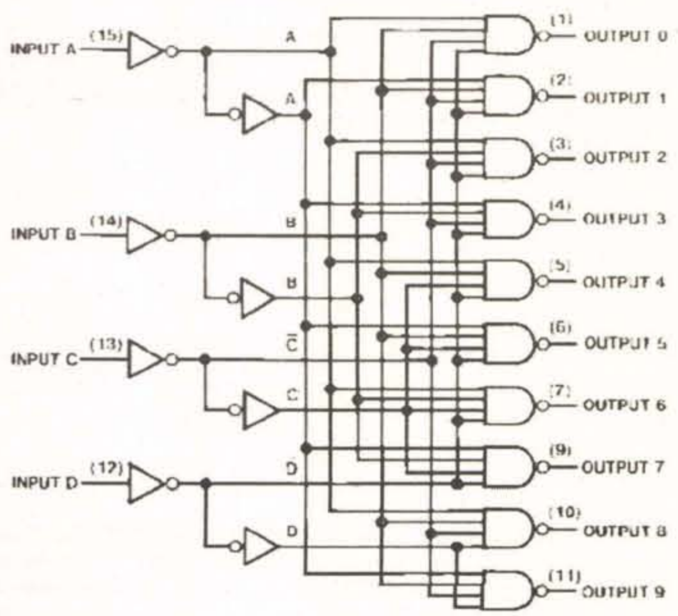


Troublesome Triac

Q. I have been searching for a Siemens TXD10K40 triac, or at least data on it, with no success. I found Internet references to surplus inventory, but no place that's willing to sell less than $100.00 worth. Apparently, it was never sold in the US, so it doesn't show up in the usual places, and Siemens was no help at all.

The triac is mounted on a control board for a MIG welder. This welder is about 30 years old and was probably made in Europe. I tried to track down the vendor (Detroit Autobody Equipment), but they disappeared three or four years ago. At some point in my search, I found a description that indicated the triac was 12 amps. It has a flat case with a tab, a TO-220 I believe. I don't know its operating voltage, but the welder runs off 240 VAC.

Ed Palazzo
via Internet

A. When confronted with a parts situation like this, the best thing to do is fall back 15 yards and punt. In other words, give up the parts search and launch a reverse-engineering procedure. You have already supplied two very important parameters: case style and operating current. All that's missing is the blocking voltage, which is easily calculated using

Vpeak = 1.414 x Vrms
Vpeak = 1.414 x 240
Vpeak = 339 volts

To be on the safe side, I'd use a 600-volt device rated at 12 amps or better. Thumbing through the Digi-Key catalog reveals a 12-amp, 600-volt triac (listed as an Alternistor) by Teccor (Q612LH5-ND). Another substitute is the NTE56008.

Metrics, Metrics Everywhere

Q. In your Dec. 2000 column, you show a circuit that lets you send 9 volts DC through a coax cable ("Sending DC Volts Through Coax"). I'd like to build this circuit, but I can't find the inductors specified. Is that a 56nH (nanohenry?) coil, and where can I buy a 1.2mH coil? Both are hard to find.

Robert Trompeter
San Jose, CA

A. Yes, Bob, that is a 56nH coil. What's a nanohenry, you ask? It's 1/1000 of a uH (microhenry), or .056uH. While all electronic component values are expressed in "simple" decimal metrics, the prefixes are sometimes puzzling to the hobbyist. Let's see if these tables help clear the confusion. The upper table shows the common usage of electrical values and the bottom table describes how to convert from one value to another.

				Value				
pico	nano	micro	milli	unit	kilo	mega	giga	tera
10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{0}	10^{3}	10^{6}	10^{9}	10^{12}
—	—	1μΩ	1mΩ	Ohm	1k	1M	1G	1T
1pF	1nF	1μF	—	Farad	—	—	—	—
1pH	1nH	1μH	1mH	Henry	—	—	—	—
1pV	1nV	1μF	1mV	Volt	1kV	1MV	1GV	1TV
1pA	1nA	1μA	1mA	Ampere	—	—	—	—
1pW	1nW	1μW	1mW	Watt	1kW	1MW	1GW	1TW
1pS	1nS	1μS	1mS	Second	—	—	—	—
—	—	—	—	Hertz	1kHz	1MHz	1GHz	1THz

To:	pico- p	nano- n	micro- μ	milli- m	units	kilo- k	mega- M	giga- G	tera- T
From:									
pico- p	—	← 3	← 6	← 9	← 12	← 15	← 18	← 21	← 24
nano- n	3 →	—	← 3	← 6	← 9	← 12	← 15	← 18	← 21
micro- μ	6 →	3 →	—	← 3	← 6	← 9	← 12	← 15	← 18
milli- m	9 →	6 →	3 →	—	← 3	← 6	← 9	← 12	← 15
units	12 →	9 →	6 →	3 →	—	← 3	← 6	← 9	← 12
kilo- k	15 →	12 →	9 →	6 →	3 →	—	← 3	← 6	← 9
mega- M	18 →	15 →	12 →	9 →	6 →	3 →	—	← 3	← 6
giga- G	21 →	18 →	15 →	12 →	9 →	6 →	3 →	—	← 3
tera- T	24 →	21 →	18 →	15 →	12 →	9 →	6 →	3 →	—

To convert from one value to another, move the decimal point left or right as shown above. Example: 50nA = .05μA — .0012μF = 1200pF

The prefix set from kilo- down to milli- was introduced in 1791. For the multipliers, values greater than 1, Greek prefixes are used and for the fractions, prefixes less than 1, Latin prefixes are used. In 1958, the International Committee on Weights and Measures added mega, giga, and tera to the multiplies and micro, nano, and pico to the fractions. As scientific instruments get better and better, smaller and smaller quantities can be detected. So, new fractional prefixes need to be added. When they are, new multipliers are added also, to keep the system symmetrical.

As for the inductors specified in the Dec. 2000 column, both are readily available from **Digi-Key (800-344-4539: www.digikey.com)**, part numbers M1185CT-ND (56nH) and M9252-ND (1.2mH). However, the 56nH inductor is a surface-mount device, which you may have trouble soldering in place. Fortunately, the value isn't critical and a 49nH inductor will work just as well (Digi-Key M7503-ND). Air wound coils may also be used. A 56nH coil can be made by winding five turns of #22 magnet wire around a wooden pencil, spread out to a length of 1/2-inch. See the next question, "Winding Single-Layer Coils," for more details on making your own coils.

Embedded Controller Has No Equal

Q. I'm troubleshooting a finicky Realistic PRO 2008 Scanner. When this scanner is operating for about 20 minutes, the unit won't lock onto any receiving frequency and may be accompanied by an erratic LED display. After turning it off for a while, it works okay for another 20 minutes then starts acting up again. Using freeze spray, I have isolated the bug down to IC 9, GRE 7831 (a 28-pin DIP). Unfortunately, I am unable to find any info on this chip — except, according to the block diagram, it's a "microprocessor initiate control." Could you please give me more info on the GRE 7831, especially a pinout and cross reference?

Chris Nalbone
Queens, NY

A. Unlike the two question above, there is no generic replacement for an embedded controller like the GRE 7831. While most proprietary controller chips are built around a generic device (e.g., a Motorola MC68HC908JK1), they contain custom software code (called firmware) that dictates the chip's function and actions. Parts lists for recent and many older Realistic models are available online at **http://support.tandy.com**. Parts may be ordered through **Tandy National Parts (800-241-8742)**, or through your local RadioShack store. You may be able to obtain some technical assistance from Tandy by calling **800-843-7422**, Option 2. The RSU (RadioShack Unlimited) phone number is **800-433-2024**.

(Mr. Nalbone replies: "Thank you for the good and/or bad news. I contacted RadioShack and they have the chip, but it's a high $36.00. I was hoping I could replace the IC cheaper, but I guess I was hoping for too much."

When The Logic Cupboard Is Bare

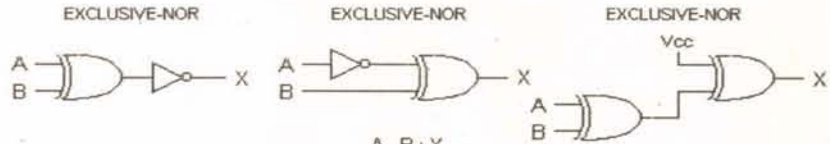
Q. I have a circuit that calls for a 74266 IC. I can't find this chip anywhere. What is it and where can I buy one?

Jack Lewis
via Internet

Q. I need a high-power flip-flop — something more robust than a 7474, with an output current of 100mA at 5 volts. Do they make such a device?

Grant Fletcher
via Internet

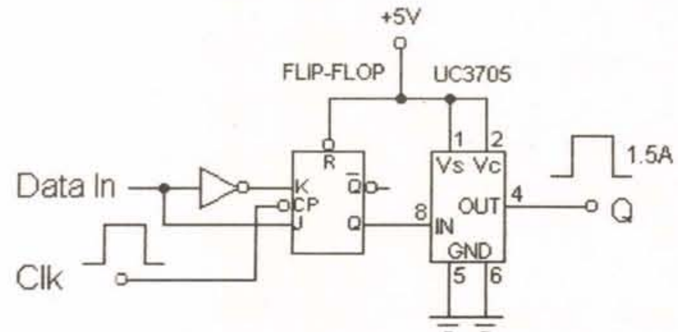
A. Rule #1: all logic chips are based on two functions, AND and OR. Throw in an inverter gate, and you can solve any logic equation. The 74LS266 chip Mr. Lewis is puzzled about is an XNOR (exclusive NOR) gate — a strange breed, indeed. However, it's easily made by adding an inverter to the output of a standard XOR gate, like a 74LS86, which is readily available. Here are other ways to create an XNOR gate.



A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

For further information on logic chips, their functions and how to make them work in your own complex logic designs, check out the article "Small Logic Gates Spawn Big Dreams" on page 65 of this issue.

As for Mr. Fletcher's high-power flip-flop, output drive current can be increased by paralleling gates. Unfortunately, it takes 25 TTL drivers to equal 100 mA. A better solution is to use a half-bridge driver, like the UC3705 from Unitrode (now a division of Texas Instruments).



The UC3705 family of power drivers is made with a high-speed Schottky technology to interface between low-level logic and high-power switching devices — particularly power MOSFETs. These devices are an optimum choice for capacitive line drivers where up to 1.5 amps may be switched in either direction. With both inverting and non-inverting inputs available, logic signals of either polarity may be accepted. Supply voltages can range from 5V to 40V.

Winding Single-Layer Air Coils

Q. Why does the inductance get bigger as the diameter of the coil grows larger? It would seem that the larger the coil, the weaker the magnetic field, hence the smaller the inductance ... wouldn't it? I'm trying to wind a 250uH coil for a project I'm building, and all this is getting very confusing.

Dennis Friedman
via Internet

A. Of all the disciplines associated with electronics, inductance is probably the most perplexing. Unlike Ohm's Law and, which contains just two variables, inductance is a mixture of physical sizes, shapes, and voodoo magic. To answer your question, all we have to do is look at the equation for calculating inductance.

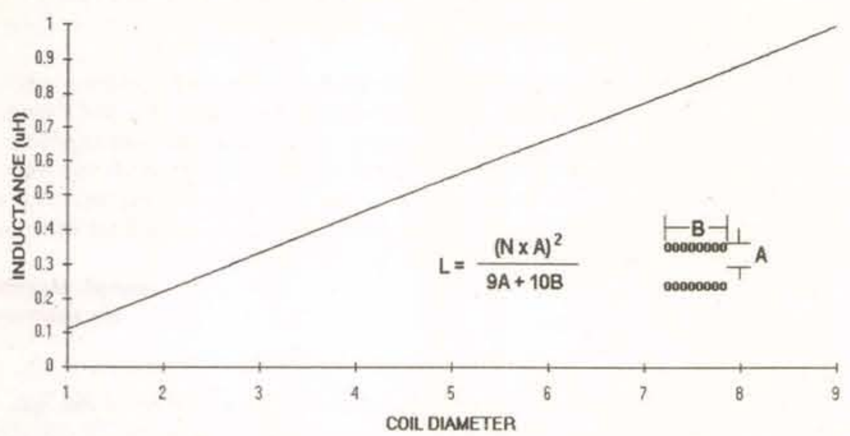
$$L = \frac{(N \times A)^2}{9A + 10B}$$

where:

L is the inductance in microhenrys (uH)
L is the number of turns
A is the radius of the coil in inches
B is the length of the coil in inches

If we plot this equation on a graph, it looks like this.

COIL INDUCTANCE



As you can plainly see, inductance increases as the diameter increases. Strange but true. Now as for winding a 250uH coil, the formula for this is

$$N = \frac{\sqrt{L(9A + 10B)}}{A}$$

If A equals 1 inch (2 inches dia.), B equals 4 inches, and L equals 250uH, then you need 111 turns of wire. The next step it to determine what size (AWG) wire. This is done by looking up the Turns Per Linear Inch ratings for enamel covered magnet wire. For 250uH you need 111 turns spread over 4 inches.

Table 1. Wire Resistance and Turns Per Linear Inch

Wire Gauge	Ohms Per 1000 ft.	Turns Per Linear Inch
14	2.52	15.2
16	4.02	19.0
18	6.39	23.9
20	10.1	29.9
22	16.2	37.5
24	25.7	46.8
26	41.0	58.8
28	65.3	73.3
30	104.0	91.7
34	261.0	145

Cross referencing the table shows us that 111 turns of 20-gauge wire (or thinner) suits our needs exactly. If this is more math than you care to deal with, use the handy-dandy coil calculator at **www.vwlowen.demon.co.uk/java/coil.htm**. This is a JavaScript utility written for metrics, so you have to convert from inches to millimeters. (Hint: 1 inch ≈ 25mm; conversely, 1mm = .04 inches.)

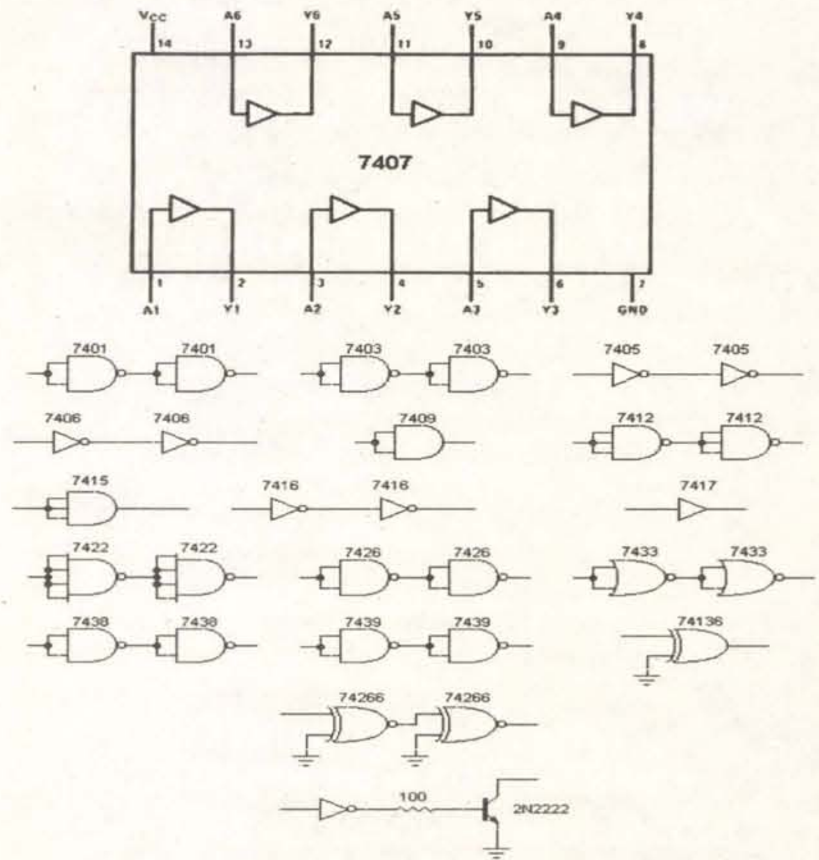
More Than One Way To Kin A Gate

Q. I am in need of a SN7404 IC chip, but for some reason all the local jobbers are fresh out of them. They are either not in stock or are on back order. The problem is that I'm in dire need of this chip because others are depending on me to deliver this project on time. Do you know of a substitute that will work? I'm only using two of the six gates.

Larry Fostano
via Internet

A. Of course, there's always the ubiquitous NTE series (NTE7407), but they are several times more expensive than the original chip. Fortunately, the 74SN7407 — a TTL, hex buffer/driver with high-voltage open collector — is easily replaced with several logic chips or discrete components. Exact replacements include 7417, 74LS07, 74LS17, and 74F07A. If high voltage isn't a requirement on the open collector (7 volts or less), the 7407 can be replaced with a number of gates and gate combinations.

INVERTER OPEN-COLLECTOR SUBSTITUTES



The next time you're at wits end because you can't find a specific IC, make one. With a little bit of imagination and ingenuity you can duplicate any logic function using other logic gates. If all else fails, a 7407 gate can be made using an inverting buffer or gate and an NPN transistor.

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Did you ever cut and paste something into word only to see embedded URLs? It looks like plain text except that it's blue, underlined, and makes Word turn into a quasi-browser when you click on it.

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T. Goodwin
via Internet

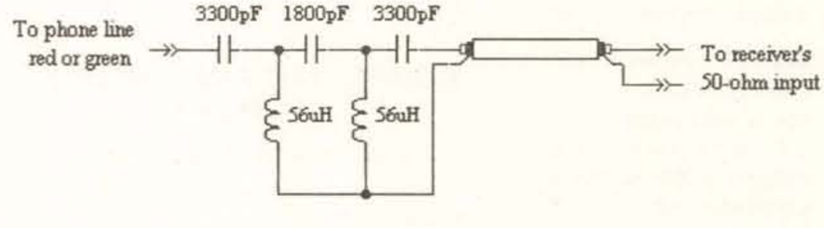
Correction

I have noticed that in the April 2001 issue on page 23, there is a schematic diagram that should be of a telephone line LF antenna, but instead it is a diagram of an electric beverage cooler.

Steven Mieland

Sorry about that. It was a rough month. Here's the correct diagram.

NV Editor



Mailbag

Dear Mr. Byers:

In a recent Q & A column, you comment on the problem of mixing TV Channels 3 and 4 for distribution over the same coax. Rather than use those grossly expensive agile modulators, I accomplished the same thing using the

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http://tm0.com/sbct.cgi?s=118417869&i=309095&d=1111011

cruddy modulator in my VCR by running it through a Channel 3 narrow-pass filter I got from Channel Master before combining it with the rest of TV land.

The bad news is, I bought this filter years ago, and I haven't see anything like it since. Surely someone still makes these. (Note: Don't confuse this filter with Channel Master's Join-Tenna products. One might get the impression that they are perfect for the job when, in fact, no attempt is made to filter out the "single channel" side. Thus, it won't work for our purposes.)

Joseph Haefeli
via Internet

Dear TJ:

Regarding the motorcycle battery charger circuit on page 85 of the Feb. 2001 issue (Tech Forum), response no. 2, as a Safety professional (CSP #5120) I strongly advise against the use of the circuit because of the potential for a potential electrical shock hazard.

Cleve Svetlik
Cleveland, OH

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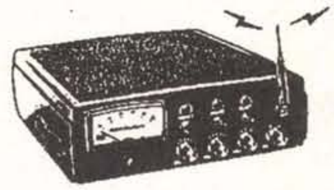

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Events CALENDAR

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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
MD - FREDERICK - Hamfest. Frederick ARC, Carolyn Moroney N3VOK, 301-831-5060. Email: n3vok@erols.com Web: http://www.qsl.net/k3erm
MI - MONROE - Hamfest. Monroe County Radio Communications Assn., Fred VanDaele KA8EBI, 734-587-2250 days or 734-242-9487 eves. Email: ka8ebi@arrl.net

June 23-24

CA - FERNDALE - State Convention. Humboldt ARC, Redwood ARC, Farwest Repeater Assn., & Southern Humboldt ARC, Marci Campbell K36IAU, marcidon@quik.com Web: http://www.geocities.com/clem95501

JULY 2001

July 1

PA - WILKES-BARRE - Hamfest. 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. 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
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

MA - WORCESTER - Convention. Utah Hamfest Committee, Kathy Rudnicki N7JSH, 801-547-9218. Web: http://www.utahhamfest.org

July 14

GA - GAINESVILLE - Hamfest. Lanierland ARC, Terry Jones W4TL, 770-967-6364. Email: w4tl@arrl.net Web: http://www.mindspring.com/~w4tl/hamfest.htm
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
PA - KIMBERTON - Hamfest. 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

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
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
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
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. BRATS, Mayer Zimmerman W3GXK, 410-786-6839. Email: w3gxk@arrl.net Web: www.bratsatv.org
NC - WAYNESVILLE - Hamfest. Western Carolina ARS, Pat Kelsey WA4OLA, 828-236-0181. Email: wa4ola@arrl.net Web: http://wcars.org
OH - RANDOLPH - Hamfest. 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

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

MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. Email: ka8aip@centurytel.net Web: http://www.oscoda.net/icare/
NY - ITHACA - Hamfest. 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

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

August 11

IL - QUINCY - Hamfest. Western IL ARC, Bob Crockett N9KUT, 217-222-4467. Email: w9awe@arrl.org Web: http://www.qsl.net/w9awe
MI - JACKSON (VANDERCOOK LAKE) - Hamfest. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058. Email: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn
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
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 - 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

by ***Robert Nansel***

Amateur Robotics

This past six weeks, ravening hordes of nano-scale clogger robots have been laying siege to the Robot Ranch. We managed to repel the first two waves, though at some personal cost: our boys Yonatan and Nadav both got clogged twice in those first three weeks, each barely recovered from the first onslaught when the second arrived.

Still, we beat the 'bots back. We licked our wounds and counted ourselves lucky. I mean, you can't even see these little devils without an electron microscope, so it's not exactly easy to fight them, even though these cloggers are dumber than dirt. Fast, cheap, and out of control, there's just too many of them. The fourth week was quiet, though, and we breathed sighs of relief.

Then the real attack came.

They used a double-pronged strategy. First, they clogged Yonatan, then Nadav, and while I was trying to help unclog the boys, the cloggers clogged me. This left only Shoshana to defend the rest of us. If that had been all, she would have polished them off handily – she's got stamina, she's resourceful, and she's a rabbi besides, so I figure she has some pull with God. It wasn't enough, though. A new type of 'bot entered the fray – eye gloopers – and we all went down.

We're mostly recovered now, though Shoshana is still a little wobbly from the gloopers. Someday, I hope nanotechnology will provide us with some real weapons to fight the cloggers and gloopers. Until then, cover your mouth when you sneeze; we've had more than our quota of colds around here.

SunSeeker

After three colds in six weeks and the generally crappy weather of March, believe me, I was eager to see the sun again, especially since I had a Solarbotics kit to build. The SunSeeker is a phototropic device that can be built as a self-contained, solar-powered robot, or as a head to control the behavior of a carrier robot, much as a rider controls a horse. It tracks bright light sources by comparing the amount of light seen by two photodiodes. Essentially, it's a Braitenberg Vehicle 2, except it has only one motor so it can only pivot in place.

The solar-powered version gathers energy with a Panasonic PV panel, stores it in a 3300 uF capacitor, and doles that energy out in bursts with two 1381-type solar engine triggers (see my March 2001 column for details on SEs). If the right photodiode sees a higher light intensity, the Sunseeker pivots clockwise, and vice versa. When both photodiodes are equally illuminated, the head blinks tiny LEDs, about once a second in direct sunlight.

Photo 1

Photo 1 shows all the components you get with the kit, including PV panel, servo motor, nifty springy brass whisker sensor thingies, and all the electronics to make it work. This being a BEAM robot, a 74AC139 serves as a motor reverser and H-bridge (what else would you use a dual two- to four-line decoder for?).

Photo 2 shows the kit as I built it. I left the whiskers off since I plan to mount the SunSeeker on my ScoutWalker 2, the four-legged walking robot kit I built last month. This will give the ScoutWalker eyes. The combination requires an adaptor kit (included when you buy the SunSeeker/ ScoutWalker combo kit) designed so the robot walks for several seconds, stops, looks around for several seconds, then continues. This avoids the problem of interpreting all the erratic light readings the SunSeeker would see while the robot was walking; the robot looks while standing still – an economical and straightforward strategy used by many insects.

By itself, the SunSeeker is priced at $80.00, a good value considering the quality of the parts and the instructions. If you get it with the ScoutWalker combo kit, Solarbotics knocks $36.00 off their separate prices, or $339.00 for both. I haven't yet had the chance to try the two together (thanks to battling cloggers and gloopers), so I will say more about that next month.

Now to update the Heavy Iron project.

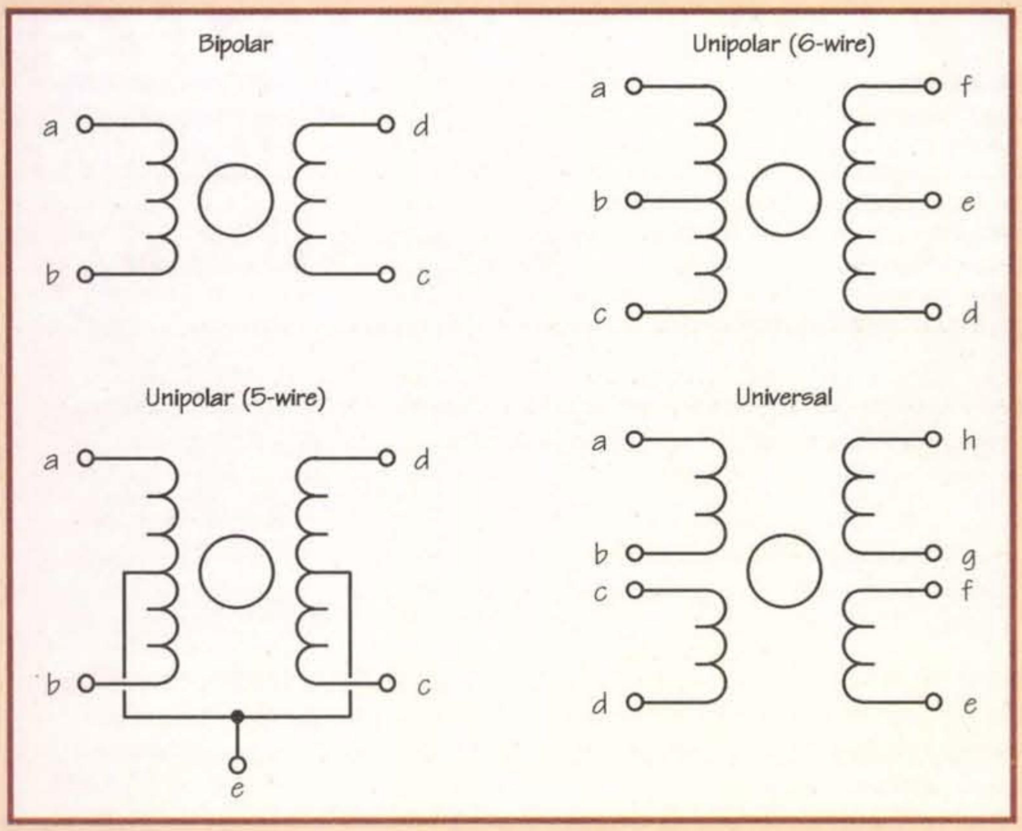


Figure 1. Basic PM stepper motor types.

Find Some Muscle

One of the keys to a low-cost home CNC system is low-cost stepper motors, and that most often means either salvaging stepper motors from used equipment or finding the motors on the surplus market. With a little luck, you can wind up with beautiful motors for about half the cost of new OEM motors – sometimes much less than that. However, unlike OEM motors, you'll almost never be able to get complete documentation for surplus motors. How can you tell, then, if a given stepper motor is up to the task? What do you look for?

The first thing you look for is torque. The more torque the better. At an absolute minimum, you need stepper motors rated for 100 in-oz torque for the Heavy Iron project; 200 in-oz would be better, especially if the dovetail slides of your mechanism are stiff. Because torque is so important, in most cases, you will want bipolar instead of unipolar steppers (I'll talk about exceptions later).

Robotics

For Heavy Iron, I am using standard XL toothed belts and pulleys to reduce the output speed of my steppers by a factor of two, thus doubling torque while sacrificing some high-end speed. Since my motors are rated for 140 in-oz, the belt reducers convert that to about 280 in-oz.

The second consideration in selecting a motor is resolution. With a leadscrew thread pitch of 0.100", a 200 step per rev motor would advance its translation axis 0.0005" per step, and with the above-mentioned 2:1 reduction, it would advance 0.00025" per step, which is plenty of resolution for drilling circuit boards – overkill, really. (For routing smooth arcs and oblique lines, though, the extra resolution will come in handy.)

Motors with 200 steps per rev are quite common, as are motors with 180 steps per rev. Both sorts will work fine. What you want to avoid are the motors that give you only 48 steps/rev or fewer. Generally, these 48 step/rev motors are on the smaller side anyway with less than 50 in-oz torque, but you never know what kind of oddball motor you might find.

The third consideration is current. This is usually given in surplus listings in terms of "amps per phase," though sometimes they will just list the phase resistance and voltage; use Ohm's Law to calculate the phase current in this case. Sometimes just the phase voltage will be given, and you'll need to measure the phase resistance with a VOM or DVM to calculate the current, again with Ohm's Law. The current range of interest here is around two amps per phase, since that is what the Camtronics three-axis chopper board will handle.

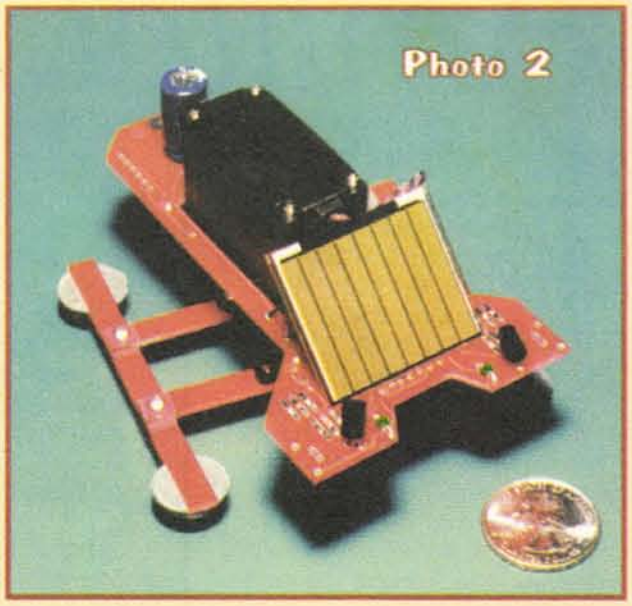


Photo 2

Stalking the Wild Stepper

The torque, resolution, current, and operating voltage ratings are commonly stamped on metal plates or labels attached to the stepper motor – but not always. Sometimes there will only be a manufacturer's part number, and sometimes not even that. It is the perverse nature of the surplus market that the part numbers of perfectly good steppers are for motors the company no longer makes (if the company is even still in business), or, more likely, for motors that were custom-designed for a specific customer. In either case, you are unlikely to be able to get a spec sheet. If the motor isn't labeled and you can't get spec sheets for it, you'll have to be more creative.

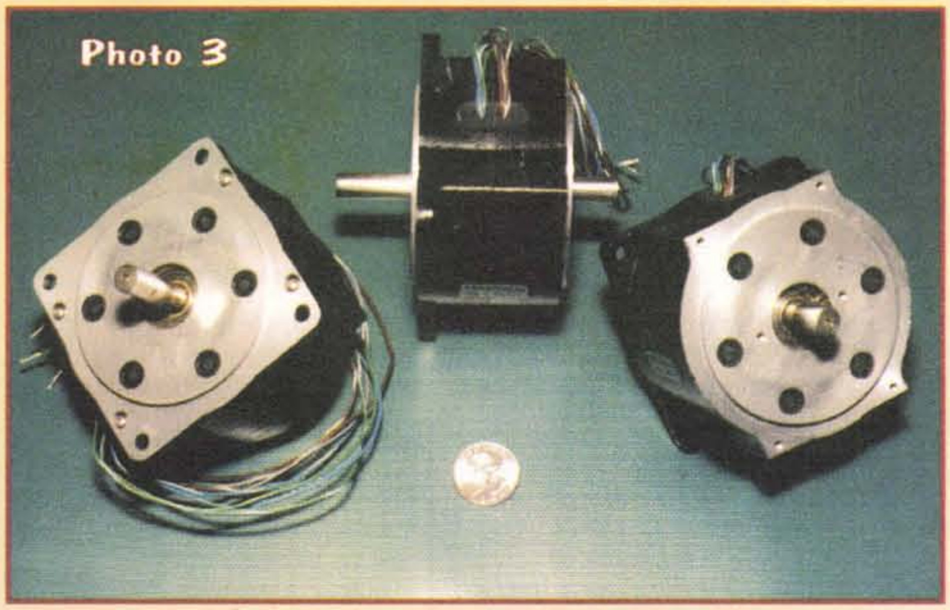


Photo 3

Photo 3 shows the steppers I bought from C&H Sales (check out their ad on page 28) for Heavy Iron. They are C&H stock #SSM9900, and from the catalog I know they are four-phase, 200 step/rev motors rated at 140 in-oz torque, 1.8A/phase. If I had come across these motors in a bin in a surplus shop, however, I might have been out of luck because there are no ratings plates on them and the part numbers are unrelated to anything the manufacturer currently sells.

When you have no other source of information, you have to depend on the physical characteristics of the motor itself to tell you whether or not it will do the job. This may seem overwhelming at first, since stepper motors come in many sizes and types. Some have four wires, while some have five, six, or eight wires. Then, too, steppers come in both variable reluctance and permanent magnet (PM) types.

Right away you can eliminate variable reluctance stepper motors; you want PM steppers. The way to tell the difference is to give the shaft a spin. If the shaft spins freely with little mechanical resistance, you've got either a brushless DC motor, a variable reluctance stepper, or something more esoteric like a synchro; set these aside. If the shaft has a definite cog-like resistance, this shows the motor is a PM type; it may be useable.

It may sound silly, but just hefting a stepper motor is not a bad way to guestimate its torque. For steppers in the range of 100 to 200 in-oz torque, you're looking for motors that weigh two to three pounds.

When evaluating salvaged motors don't forget your other senses, either; examine the motor closely, run your fingers over it, even give the motor a good sniff. If it smells like clean oil and metal, it's probably fine, but if it smells burnt and looks burnt, it probably is burnt. Pass it by.

How Many Wires?

Next, you need to notice how many wires come out of the motor. Figure 1 shows the common types of PM steppers. A four-wire bipolar is the ideal, but an eight-wire universal is also easily wired for bipolar operation, and even a six-wire unipolar can be made to work. All are "two-phase" motors, even though most PM steppers are manufactured with four independent windings inside.

For the five-, six-, and eight-wire types, two windings make up each phase. The windings are either bifilar wound or wound on separate stacked stators. The two windings of each phase are arranged to allow magnetic field reversal by selecting which of the two is energized. This is for unipolar operation where one lead of each winding is typically tied to a common positive voltage, and the remaining leads are sequentially pulled to ground. The drive circuitry for unipolar operation is thus quite simple, requiring only four low-side switching transistors, but that simplicity comes at a price: only half of the copper fill or ampere-turns of each phase can be used at one time to produce torque.

A bipolar driver, in contrast, reverses the magnetic field of a phase by reversing the current flowing through the phase. This requires a more complicated driver — an H-bridge — to drive each phase, but it allows all the ampere-turns of the windings to produce useful torque. Four-wire bipolar steppers must use bipolar drive, and six-wire unipolar and eight-wire universal steppers may use bipolar drive. Only the five-wire unipolar type can't be easily wired for bipolar operation, since the center taps of the windings are tied together inside the motor.

Figure 2 shows how a six-wire unipolar can be made to work in bipolar mode by simply leaving the center taps of each phase ("b" and "e" in the diagram) unconnected and driving the remaining leads as if the motor were a simple four-wire stepper. Likewise, an eight-wire universal stepper can be wired for bipolar operation, either by connecting the windings in series or parallel.

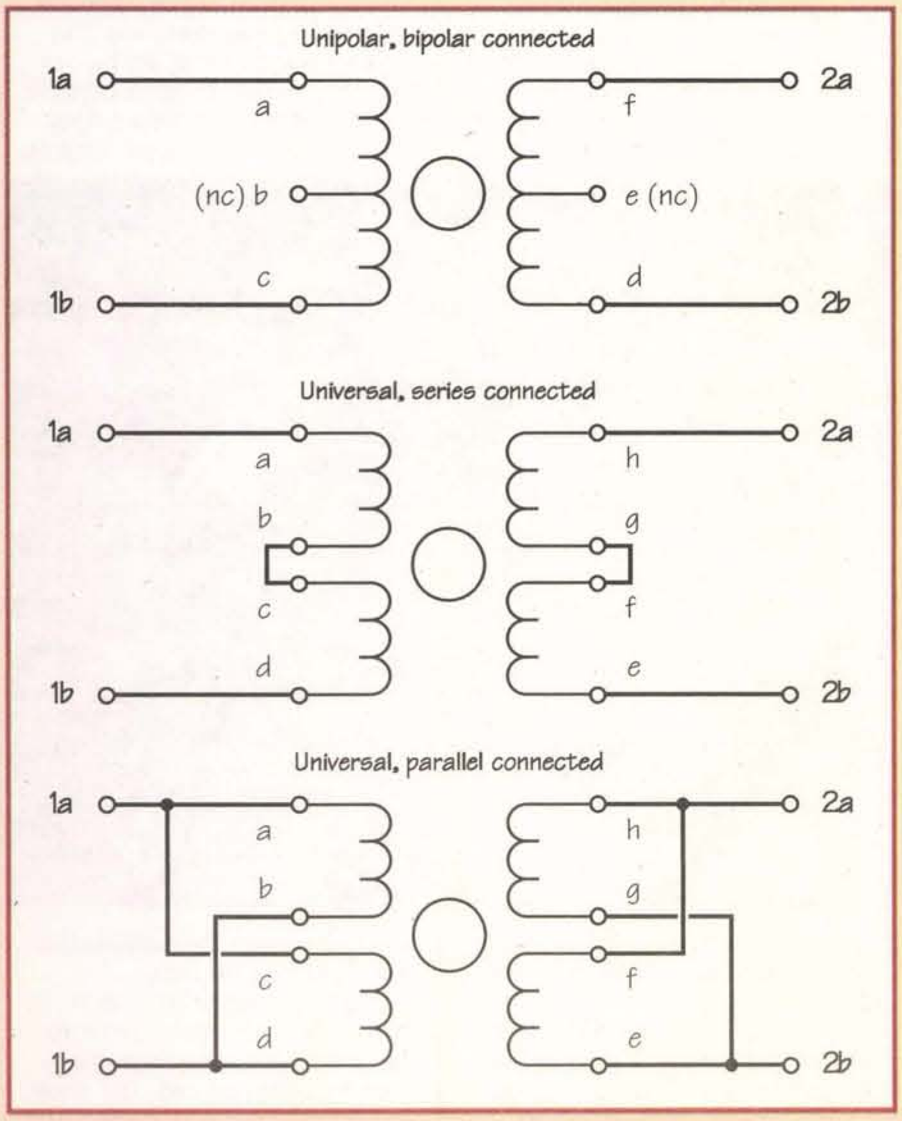


Figure 2. Wiring for six-wire and eight-wire stepper motors for bipolar operation.

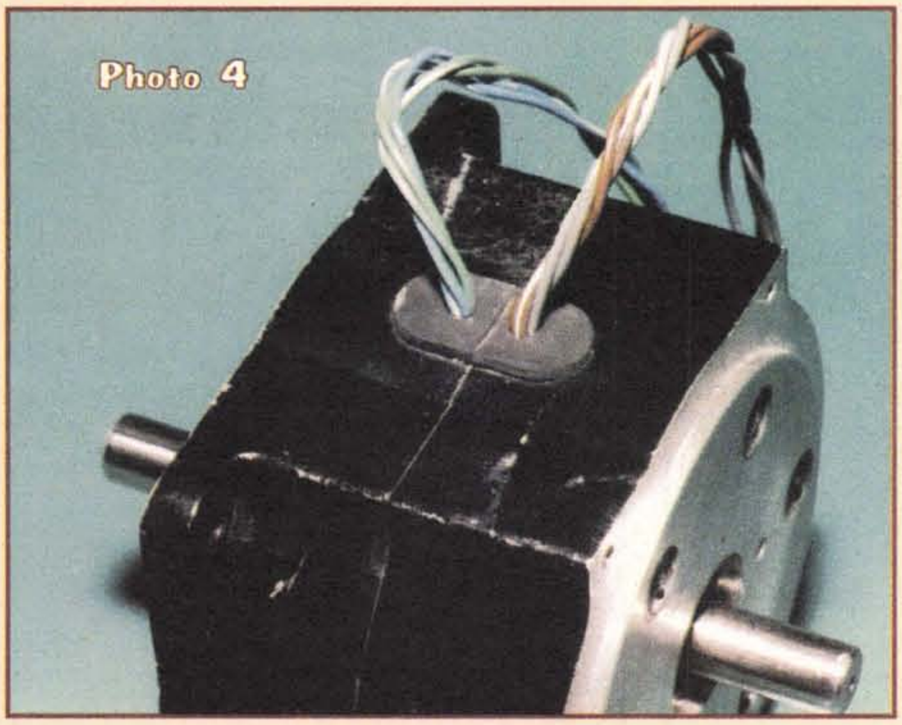
Series or Parallel?

A series-connected eight-wire universal is equivalent to the six-wire unipolar when driven in bipolar mode. The inductance of series-connected windings is four times that of parallel-connected windings for the same motor, however, because inductance goes up as the square of the number of turns. Simple addition would suggest that the inductance would only be doubled, but inductors in close proximity are magnetically coupled, so the usual formulas for how parallel and series-connected inductances combine do not apply.

Series and parallel-connected configurations of the same motor give the same low-speed torque, but high-speed torque is better for the parallel-connected configuration (because parallel-connected inductance is lower, the R/L time constant of the winding is smaller, thus increasing the average current each step pulse). Parallel connection will be preferred, then, for the sake of high-speed operation, but the driver must supply two times as much current as for series connection.

For my motors, using parallel connection would be double 1.8A/phase, or about 3.6A, much more than the chopper board's 2A nominal rating. Series connection would use only 1.8A, well within the board's rating, so series connection would appear to be what I should use for my motors. However, 3.6A/phase is the stall current of the parallel-connected stepper; the running current would reasonably be expected to be less. Perhaps it might be enough less to run my motors in parallel-connected mode?

When I asked Dan Mauch (the designer of the chopper board) about this, he told me his rule of thumb is to assume that the stepper will draw — on average — about 75% of the peak current. You could therefore use a stepper motor that draws perhaps as much as 2.7A peak with his 2A chopper — but not 3.6A. Even assuming just 2A continuous, you must aggressively heatsink the L298 driver chips and use fans to cool the heatsinks. (If all else fails, you can always adjust the



maximum current output of the chopper to operate your motor at lower than its rated current. Much more on this later, when I cover construction of the chopper board.)

But Which Wire is Which?

If you don't have a hook-up diagram, how can you sort out what wires are connected to what windings? A four-wire stepper is simple enough — a few resistance measurements will quickly show you which wires should be paired. In Figure 1, you should measure low resistance — about 1 ohm, give or take — between "a" and "b" or "c" and "d," and open-circuit between the phases. As for the polarity of each phase, you just have to experiment, either with the stepper driver board or manually with a power supply and clip leads; swap leads until the motor steps the direction you need it to step. A piece of tape on the motor shaft makes it easier to see steps.

If you don't know the motor voltage or ratings, for testing purposes, don't apply any more voltage to a phase than would give a few watts power dissipation. As a rule of thumb, most motors in the 100 to 200 in-oz torque range dissipate less than 10 watts per phase in ordinary operation.

(I'll ignore sorting out the wires of a five-wire unipolar since you can't use a five-wire motor in bipolar mode.)

A six-wire set-up is almost as easy to figure out as the four-wire. Methodically measure resistance between pairs of leads. Whenever you find two leads with low resistance between them, twist them together. After you've examined some subset of the possible pairing, you should have two sets of three wires twisted together, and you should measure open circuit between these two bundles.

Then take one bundle and, between two of the three wires, you should measure resistance R; from the third one to either of the other two, you should measure just R/2. The first pair of wires correspond with "a" and "c" and the third with "d." Repeat this procedure with the other bundle to label the "d," "e," and "f" terminals. Tuck "b" and "e" out of the way, making sure they are electrically isolated, and find the polarity as above for the four-wire motor.

Alternatively, you can tie "b" to a suitable positive voltage and then connect "a" or "c" to ground. Put a piece of tape on the shaft so you can see which way it steps; the shaft should be hard to turn. Try the same set-up, but with "e" tied high and "d" and "f" alternately tied to ground. You should be able to see the shaft step back and forth a tiny amount each time you connect "d" or "f" to ground. Note that if you connect both to ground at the same time, you shouldn't see any further movement and the shaft will be much easier to turn.

Taming the Universal

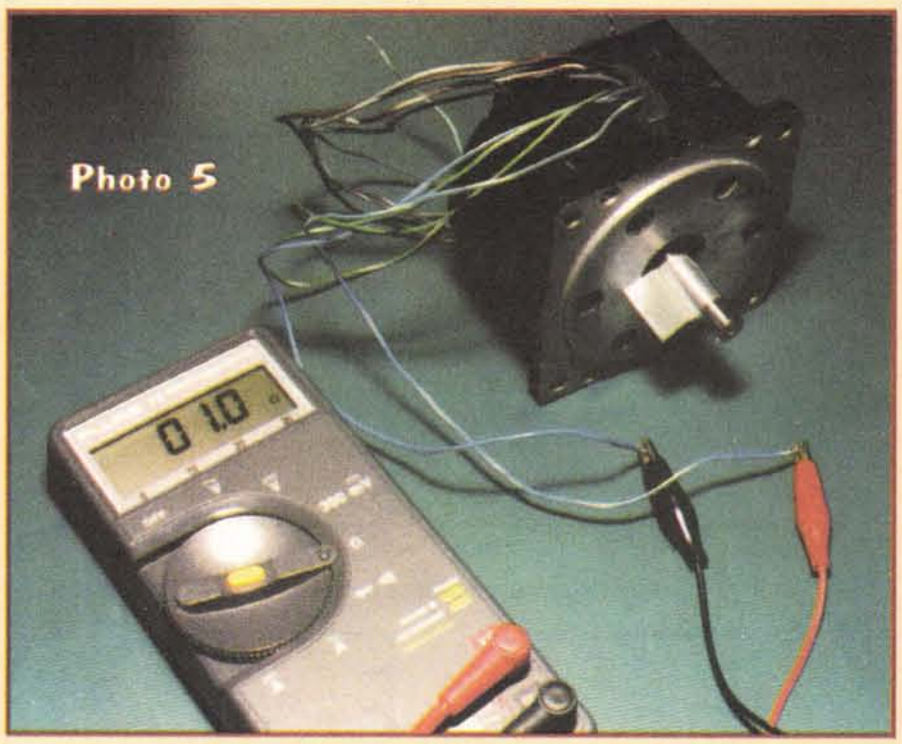
Sorting out an eight-wire universal set-up is the hardest, but using the same basic techniques as above, along with a few extra tricks and clues, you will get the job done.

First of all, before you start making resistance measurements, look at the wires themselves. There's usually some sort of color coding, though this varies wildly between manufacturers; be sure to note any regularities if they exist. Also note the mechanical arrangement of the wires.

Do they come out of the motor case in one bundle of eight or two bundles of four? Two bundles, especially if they are each associated with their own axial segment of the motor case, usually indicates that there are no connections between the bundles, so you can reduce the number of pairs you need to check (Photo 4).

Now begin to pair off wires using a DVM to establish which pairs have low resistance between them (Photo 5). Temporarily twist or tape each pair together and move them out of the way, and continue until you've got all the wires paired. You should wind up with four pairs with no connectivity between pairs.

Next, hook up your power supply to any one of the pairs you've identified, using clip leads so you have your hands free. The motor shaft may or may not step, but in any case, it should become notably harder to turn once the winding is energized (now is also a good time to measure the current through the winding; Photo 6 shows the set-up to do this). Turn off power, then hook another pair up in parallel with the first pair.



Now for a Little Ozone ...

When you re-apply power, one of three things will happen:

1) The motor shaft doesn't step, and it's now twice as hard to turn the shaft as before when just one winding was energized. This means these two coils are part of the same stepper phase and you've hooked them up with the proper polarity, which is what we want. Be sure to jot down the combination and mark the wire ends.

2) The motor shaft doesn't step, and it's now much easier to turn the shaft even though the windings are energized. This means you've connected one winding of the phase backward with respect to the other, so the two windings cancel each other's torque. If you now reverse the leads of one of the

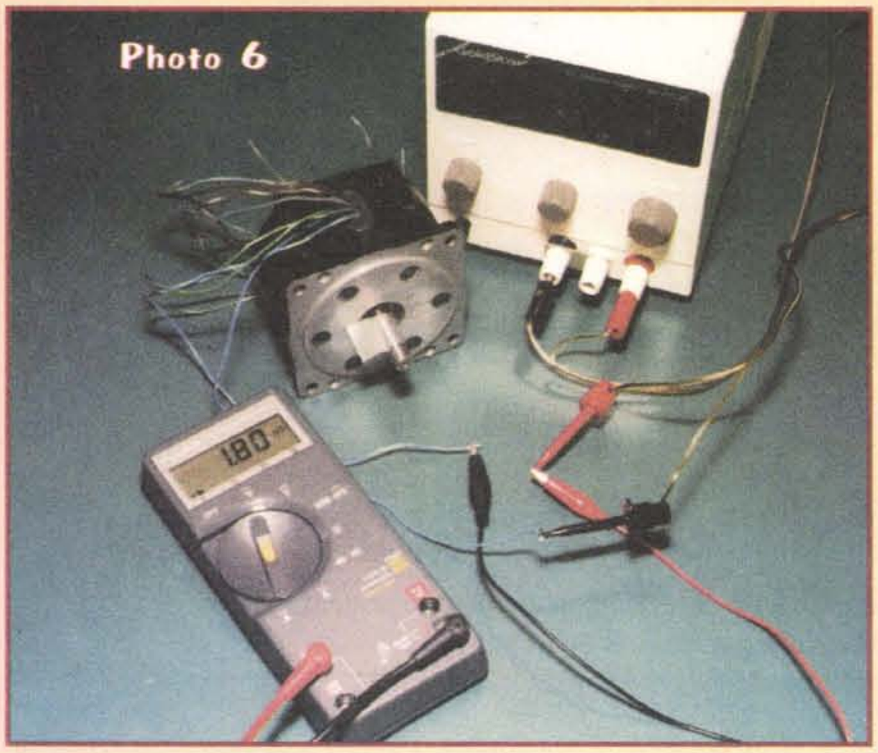


Photo 6

windings, you should get situation one above. The remaining untried pairs (if any) belong to the other phase.

3) The motor shaft steps, and it is still hard to turn the shaft when the windings are energized. This means you've hooked up a winding from each phase. If you make and break connection with the second winding, you should see the shaft step back and forth. Disconnect the second winding, tuck it out of the way and — one at a time — connect the remaining untried pairs in parallel with the first winding as above until you hit on the combination that gives you situation one or two above.

Once you've identified which windings belong with which phase and what their polarities are, you are done. If you have any trouble along the way, be sure to double-check your procedure and your set-up. Use a current-limited power supply with the current control set to a safe limit. If you don't have a power supply with adjustable current limiting, put a 1- to 5-ohm power resistor in series with the positive voltage supply; a 1/2W resistor is way too small; use a 10W resistor (or larger if you can find one).

One final note: When I was measuring my motors, I got unpredictable results no matter what I tried. The problem turned out to be not one, but two pairs of faulty clip leads. The lesson here is to test both your assumptions and your test gear.

Next Time

Ack! I'm out of room and I didn't even get to the book review (and you know I was reading while laid up by the cloggers and gloopers). Next month, next month. Until then, don't let those nanorobots bite you! **NV**

If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

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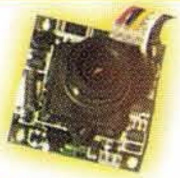

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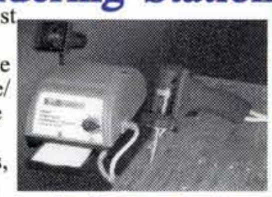

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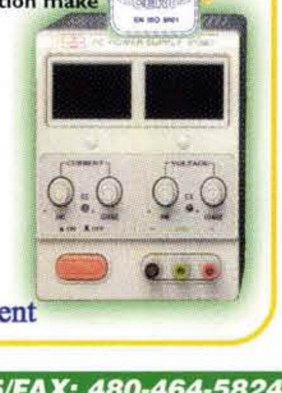

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Applications: PDAs, organizers, and laptops; handheld terminals; EPOS equipment, barcode scanners, belt clip printers; data loggers; audience response systems; in building environmental monitoring and control; high-end security and fire alarms; restaurant ordering systems; and vehicle data up/download.

Further information will be available imminently, however, BiM-433-F data sheets contains applications information that is equally applicable to the new BiM2.

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The BarrettHand BH8-series grasper was showcased on the recent cover of Machine Design Magazine (Feb. 2001), www.machinedesign.com for its unmatched versatility, programmability, and ease of integration with commercial robotic arms. The new BH8-262 will be demonstrated at the 2001 International Robots and Vision Show.

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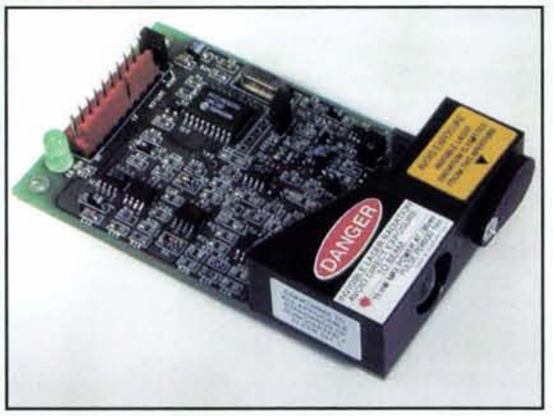

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