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Nuts & Volts

The Preferred Magazine Of The Electronics Hobbyist/Industry

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July 2002
Vol. 23 No.7

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COLUMNS

DEPARTMENTS

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by Edward B. Driscoll, Jr.

Micro Memories

Along with the TRS-80 (see May's Micro Memories column), the Apple II is what many personal computer users cut their teeth on in the late 1970s. A complex, extremely well-designed machine, housed in a deceptively simple-looking off-white case, it sold over two and a half million units based on its ease of use.

But the Apple II's name implies that there was an Apple I to precede it, and indeed there was. Far cruder appearing than its successor, the Apple I was based on a PC that Steve Wozniak designed in 1975 when he couldn't afford an Altair 8080, the first mass-produced personal computer.

Apple's First Three Stockholders

Wozniak, of course, would eventually team up with another Steve, Steve Jobs. 'Woz' and Jobs were buddies in high school, with a shared interest in electronics, and a mutual feeling of being outsiders. They kept in touch after graduation, and both ended up dropping out of college and getting jobs working for companies in Silicon Valley in the early 1970s, with Woz going to Hewlett-Packard, and Jobs to the nascent Atari, before its sales exploded in the late 1970s.

In early April of 1976, Jobs and Wozniak teamed up with Ron Wayne, a friend of Jobs from Atari, who was 20-odd years older than the two Steves. The three budding entrepreneurs formed the Apple Computer Company, with Woz and Jobs getting 90 percent of the company's stock and Wayne the remaining 10. The legend would eventually make the date of their partnership April 1st, but Wozniak claims that it was actually several days into April when the initial partnership documents were drawn up.

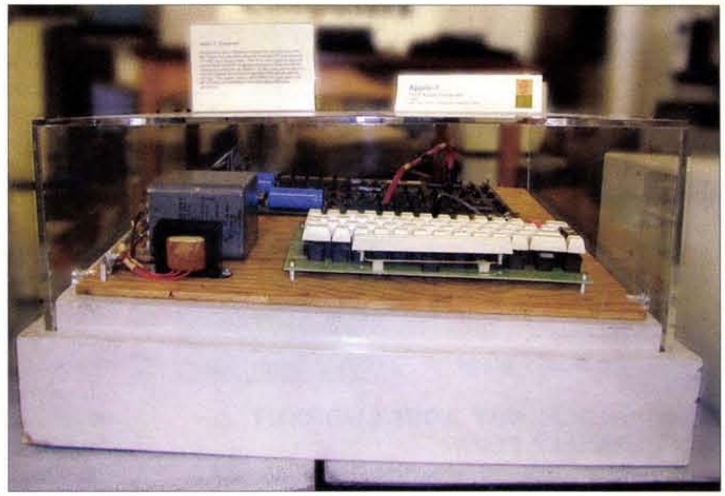
Their first product together was initially a kit. As Silicon Valley's Computer History Museum describes it in their catalog, for $666.66, the buyer of an Apple I received a printed circuit board, a bag of parts, and a 16-page assembly manual. The buyer then had to build his own case to house the circuit board in, and many Apple Is were housed in extremely crude-looking wood cases, or even briefcases.

The First Apple

Since the Apple I was initially designed because Wozniak couldn't afford the $179.00 Intel 8080 chip that powered the Altair, it used a $25.00 MOS technology 6502 chip, which worked at 1.023 MHz (compare that to the 1 GHz or more processor that may very well be inside your PC). While the manual said that the Apple I could handle 8K of RAM, and apparently clever hackers were able to boost that amount to 65K, only 4K of RAM was actually supplied. But unlike the early Altair and IMSAI PCs, the Apple I was a self-booting machine. Like the RadioShack TRS-80 and the early Apple IIs, the Apple I used a cassette interface to load programs. Apple's promotional literature said the interface was "very fast" (at 1,500 bits per second), and could "read or write 4K bytes in about 20 seconds." As with the microprocessor speed, compare that throughput to the speed of today's data interfaces, and compare how much data can be stored on a CD or DVD-ROM to see just how far home data storage has come.

While the $666.66 price tag sounded demonic, Wozniak later told interviewer Tom "Moose" O'Malley that it simply reflected the mark-up he felt the Apple I needed to make a profit, along with a love of identical numbers. "I simply like triple digit numbers with all the things I'm involved with, the cost of making the Apple I was around $540.00 or thereabouts and we agreed on the best mark-up, retail price above the cost of building it, which worked out to $666.00."

Jobs, in a bit of marketing whimsy, tacked on the extra 66 cents to make the full price an eye catcher in Apple's initial direct response style ads.



Chris Garcia, of the Computer History Museum, says that another reason for the price is that "it's two thirds of $1,000.00, so if they sold 30, which seemed likely, they'd make $20,000.00, meaning they could fund their next venture."

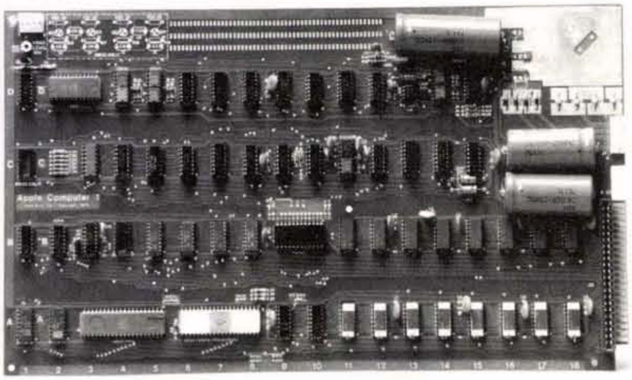
Taking A Byte Out Of Apple

Besides the two Steves, Paul Terrell was the man most responsible for the initial sales of the Apple I. Starting in December of 1975, he was the proprietor of The Byte Shop in El Camino, CA, which as a forerunner to today's CompUSA and MicroCenter computer stores, sold Altair 8080s, plus IMSAI 8800s, and other, smaller brands of equally Jurassic PCs.

Terrell ordered 50 Apple Is. Jobs reaction? "I saw dollar signs in front of my eyes," he told the authors of *Fire In the Valley* (McGraw Hill; ISBN: 0071358927). "But he said that he wanted them fully assembled and ready to go, which was a new twist to the story. So we spent the next two days visiting distributors and convincing them to give us net 30 days credit on thin air, built the computers in 20 days, turned them around, Paul paid cash, and we paid off the distributors. So we built the whole company on float. And we continued to do that. I quit my job at Atari and Woz continued at HP for another six months working in the evenings at Apple."

Where Are They Now?

Of the Apple I, Chris Garcia says that there were about 220 sold, although today there are less than 50 known in existence, because "many were traded back in on an Apple I for Apple II credit exchange program." Garcia says that among the places where Apple Is are on display are the Smithsonian in the Information Age exhibit, Fry's Electronics in Sunnyvale, and the Computer Museum of America in San Diego ("though theirs is a replica that was done for the film Pirates of



Silicon Valley," Garcia adds). The Computer History Museum has two Apple Is on display, one in a strange wooden box and one screwed to a piece of plywood with a power supply, keyboard and cassette interface. There's also an Apple I owner's club, in existence since 1977, and online at **www.applefritter.com/apple1/index.html**. It's filled with specs, data, and lots of tidbits about the world's first Apple.

As for the Apple I's builders, eventually of course, Woz and Jobs made millions when Apple went public. And what of Ron Wayne, their initial partner? He left Apple shortly after it delivered their first Apple I order, because Jobs planned to go deeply in debt to build the computer in quantity. Wayne had lost a fair amount of money in other investments with new computer start-ups, and rather than risk repeating this pattern, he resigned and returned his 10 percent of Apple stock. He received $500.00 in cash for the work he had done.

The Apple I was one crude personal computer, but it arrived at the right time, with the right name, and helped to provide Jobs and Wozniak with the initial funding, not to mention the initial impetuous, to get their business off the ground. It led to the Apple II, which would be one of the great personal computers of all time. But that's another Micro Memory. **NV**

Enter the MSP430 Gadget-O-Rama Design Contest!! Details on page 31!

Spice Up Your PC

By Al Williams

It just isn't always practical to build a circuit just to experiment with it. Luckily, with a PC, you can simulate nearly any circuit you can imagine with better results than you might expect.

There is an old saying: *Tell me something and I forget; show me something and I remember; let me do something and I learn.* This is very true of electronics for most people. You can read books until you are blue in the face and in six months, you'll be lucky to remember where you left the book. Demonstrations of real hardware are more effective. And nearly everyone learns better in the lab with a handful of parts.

Paradoxically, when you need to learn the most, you probably have less lab equipment, parts, and tools, than someone who has more experience. But no matter what your experience level, it just isn't always practical to build a circuit just to experiment with it.

Luckily, with a PC, you can simulate nearly any circuit you can imagine with better results than you might expect. The secret is in a software program known as SPICE. SPICE has long been a tool for professionals with access to big computers. However, with powerful desktop PCs and some free or low-cost software, you can simulate nearly any circuit before you actually build it. In the process, you can develop a lot of real-world intuition about how circuits work without having to heat up that soldering iron.

Free Spice

The first thing to do is get a copy of SPICE. SPICE originates at Berkeley, and is free to distribute. However, the plain Berkeley version isn't very friendly to use. You enter circuits using a special text file and the program reports its results as a table of numbers or a crude ASCII plot. However, there are several Windows versions that can simplify using SPICE.

One of the best is absolutely free from Linear Technology Corporation and is known as SwitcherCAD III/LTSpice. Linear offers this program to help you design switching power supplies using their products, but the program is really a very nice SPICE port with schematic capture and plotting functions built into it. What a great service for the electronics community and the fact that you'll think of them every time you use it seems fair enough. You can download the program at **http://LTspice.linear-tech.com/software/swcadiii.exe**.

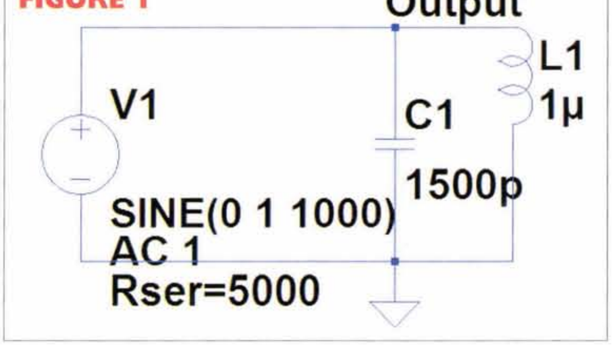
SPICE uses models that represent different types of electronic components. SwitcherCAD III/LTSpice has quite a few models, but you can also add other models (often available from the component's manufacturer). The program can also handle digital simulation. If you prefer a more traditional SPICE, you might check out Mike Smith's shareware WinSPICE **(www.willingham2.freeserve.co.uk/winspice.html)**. You can also find a list of inexpensive or free SPICE programs at **www.terrypin.dial.pipex.com/ECADList.html**.

If you use WinSPICE or another text-based SPICE, you might want to investigate a schematic drawing program that can automatically generate SPICE net lists (the text file that describes a SPICE schematic). Many schematic drawing programs can do this. For example, the popular EagleCAD **(www.cadsoftusa.com)** has an add-on user program that can export a SPICE net list (you have to download the add-on separately from their download page). In this article, I'll show you how to get started with SwitcherCAD III/LTSpice and I'll also show you a little about the more traditional usage of SPICE. In particular, I want to show you how you can gain intuition about circuits using your PC instead of a breadboard.

Getting Started

I'll assume you have SwitcherCAD/LTSpice installed. Start the program and use the File | New Schematic menu option. Draw the schematic shown in Figure

FIGURE 1



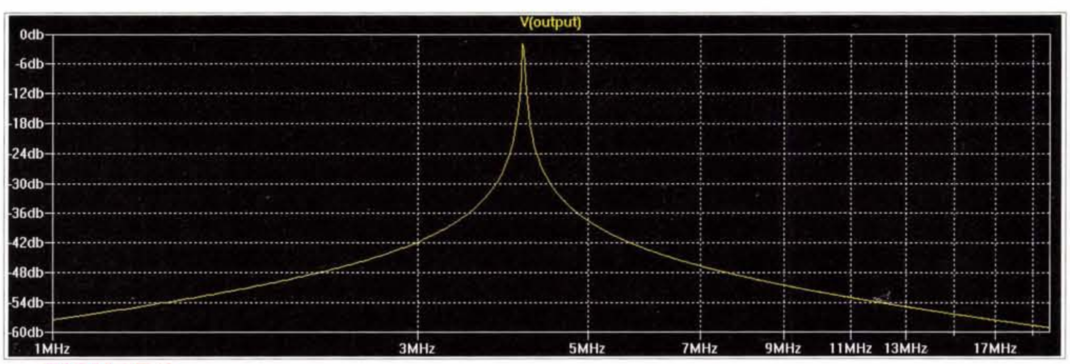
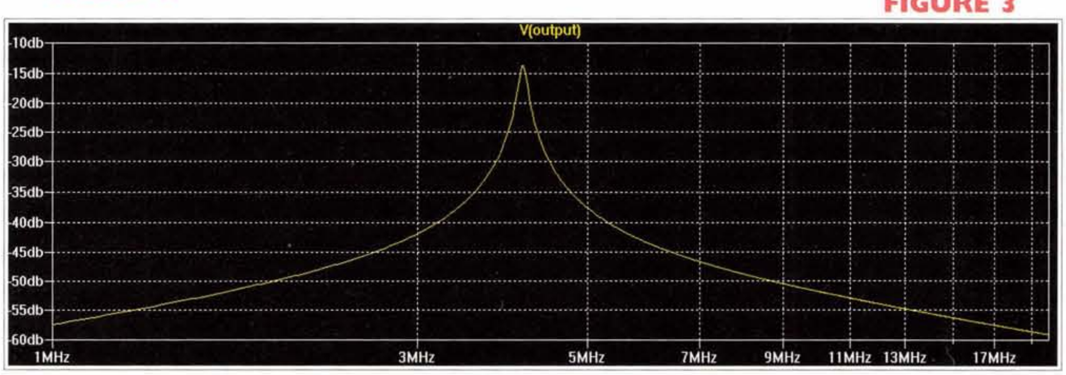


FIGURE 2

FIGURE 3



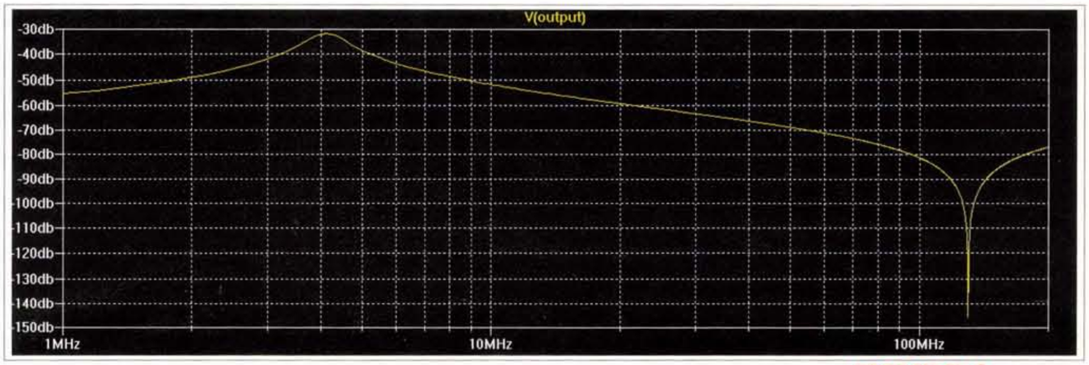


FIGURE 4

1. First, use the toolbar icon that looks like an AND gate to drop a voltage, capacitor, and inductor component on the schematic. Then use the wire tool (looks like a pencil drawing a wire) to connect them together. Use the ground icon on the toolbar to include the ground and connect it too. Once all the wiring is connected, you can right click on each component to set its properties. For the capacitor, set the value to 1500p (1500 picofarads). For the inductor, set the value to 1u. This is a common way to specify SPICE values (see Table 1). It is easy to forget that a 10M resistor is 10 milliohms not 10 megaohms (which would be 10Meg). For the voltage source, you'll need to right click and then click on the Advanced button. Select the sine voltage source and set the amplitude to 1 and the frequency to 1000. Also set the AC amplitude to 1 and the series resistance equal to 5000 (or 5k).

The next step is optional, but makes life a little easier. Use the toolbar button that looks like a letter A in a box. Type "Output" in the dialog box and then click on the wire going to the hot side of L1. This will label that wire as "Output" and you can refer to it as such in future work. If you don't do this, you have to use an internally-generated designator that the schematic drawing program arbitrarily selects.

Over Analysis

SPICE can perform many types of analysis. When you use the Simulate | Run menu, you'll get several choices:

- Linear AC Analysis — Sweeps an AC source and shows the resulting response.
- DC Sweep Analysis — Sweeps a DC source and shows the resulting response.
- Noise Analysis — Computes Johnson and Flicker noise.
- DC Operating Point Analysis — Computes the DC bias point (assumes capacitors are open and inductors are shorts).
- Non-Linear Transient Analysis — Provides an oscilloscope trace of the circuit as it operates.
- Small Signal DC Transfer Function Analysis — Computes the gain of the circuit.

For this example, pick Linear AC Analysis. The dialog box shows you that this is the SPICE .ac command and it also shows placeholders for the arguments the .ac command expects. You want to enter:

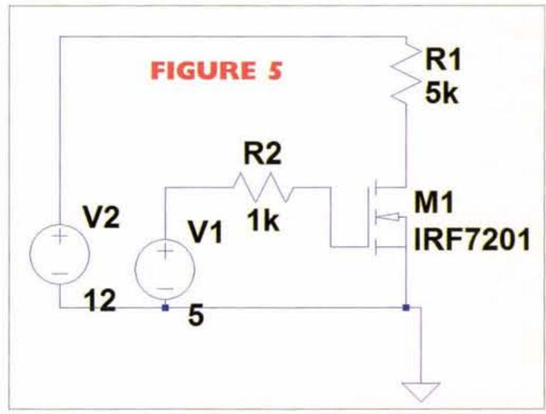
```
.ac lin 1024 1Meg 20Meg
```

This tells SPICE to sweep the AC voltage source from 1MHz to 20MHz in 1024 linear steps. The program places a special comment field on the schematic so you won't enter this again. After the analysis, you can right click on the comment to change the parameters. You can also delete it or use the .op toolbar button to insert a different command.

Once you enter the command, the program will prompt you for what you want to view. Pick V(output). This corresponds to the wire you labeled while drawing the schematic. You can also select different options. For this example, select Plot Magnitude and Magnitude Decibel and Frequency Logarithmic. Leave the other options unchecked. Figure 2 shows the results. You can click on a wire to see the voltage through that wire. Clicking on a component shows the current through that component. Since this is a parallel LC circuit, V(output) has a large spike at the resonant frequency. Away from that frequency, the network exhibits a good deal of loss rather quickly. If only that were true!

In real life, the sharpness of this spike de-pends on the circuit's Q. The Q depends on the internal resistance of the components and their reactance.

Capacitors typically have very high Qs, so let's focus on the inductor. Right now, the inductor is perfect. But in real life, we can't find perfect inductors. So right click on the inductor and set the series resistance to 0.5 Then run the simulation again (see Figure 2).



Notice the spike is not as sharp. Repeat the exercise with a series resistance of 5. The spike gets even broader. You can experiment with other effects (such as the capacitance inherent in the inductor). In particular, set the capacitor's series inductance to 1n and change the SPICE command to:

```
.ac lin 1024 1Meg 200Meg
```

Now when you run the simulation, you'll see a self-resonant notch above 100MHz and a slight effect on the spike (see Figure 3).

That Was Too Easy!

If you prefer to use SPICE the old-fashioned way, you can do that too. Here is the net list for the circuit:

```
* D:\SwCADIII\lcpar.asc
V1 Output 0 SINE(0 1 1000) AC 1 Rser=5000
C1 Output 0 1500p
L1 Output 0 1<B5> Rser=5
.AC lin 1024 1Meg 200Meg
.end
```

The first line is simply a comment. The V1 line tells SPICE that there is a voltage source from node Output to node 0 (which is always ground). The C1 line shows a capacitor and the L1 line shows an inductor. The .AC command is the same as the one you plugged into the schematic editor. Of course, .end finishes the file.

Although it is tedious to make a circuit like this, many SPICE books and tutorials will use this format so it pays to know about it. Also, if you use a different SPICE, you may have to use this net list format (or use a schematic program to generate them automatically). LTSpice can process these files directly if you don't want to use the schematic editor.

A Switch

Next, try entering the circuit in Figure 5. The FET is a NMOS FET. You can right click on it to choose the exact type (an IRF7201, in this case). Place the output label on the drain of the FET (the terminal con-

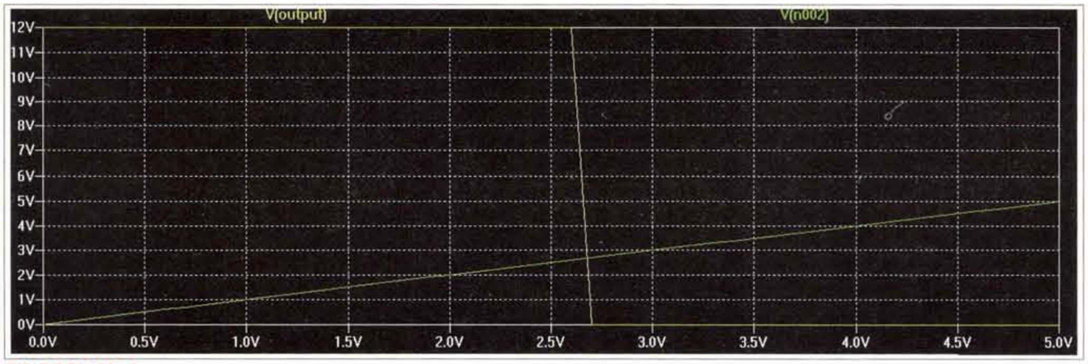


FIGURE 6

Table 1. Suffixes recognized by SPICE

Suffix	Multiplier	Common prefix
T	1e12	Terra
G	1e9	Giga
Meg	1e6	Mega
K	1e3	Kilo
mil	25.4e-6	
m	1e-3	Milli
u (or µ)	1e-6	Micro
n	1e-9	Nano
p	1e-12	Pico
f	1e-15	Femento

nected to R1).

In this circuit, V1 represents the output from a logic gate (perhaps the output pin of a BASIC Stamp). To see what would happen, you need to perform a DC sweep analysis. In particular:

```
.dc v1 0 5 .1
```

This tells SPICE to sweep V1 from 0 to 5 volts in .1 volt steps. The output of the analysis appears in Figure 6. Notice that around 2.7V, the FET switches on hard and the output voltage falls to about 0 volts.

If you want to see a "real world" simulation, right click on V1 and select Pulse. You'll enter the following parameters:

```
VInitial = 0
VOn = 5
TDelay = .5
TRise = 1n
TFall = 1n
TOn = .1
```

This creates a 100mS pulse. Now run a .TRAN simulation with an argument of 1 (this runs the circuit for one second). You can see an excerpt of the simulation's output in Figure 7. You can see the effects of gate capacitance and switching times very clearly. This type of simulation is the closest to an ordinary oscilloscope display. You can even ask for an FFT of the data using the View | FFT command.

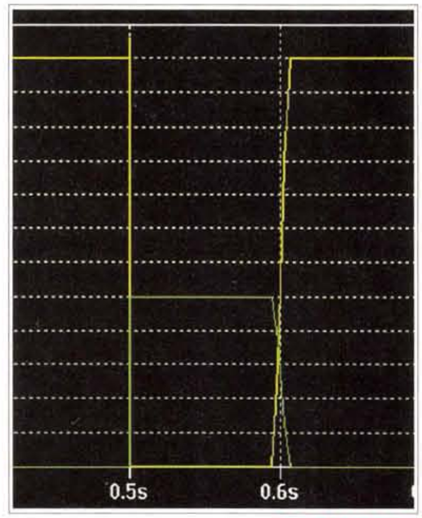


FIGURE 7

More About Spice

There are a few things that may not be obvious about using SPICE. For example, if you want to leave a node "hanging," just connect a current source with a 0 current between the node and ground. Similarly, if you want to measure a current in a path, you can put a 0V voltage source in the path which will allow you to measure the current.

Be sure to check out the help file to learn more about SPICE. You can download more models from many places on the web (for example, look at **www.intusoft.com/slinks.htm**). You can do many sophisticated analysis and modeling jobs with SPICE. But for all of its complexities, it is easy enough to use to model simple circuits. **NV**

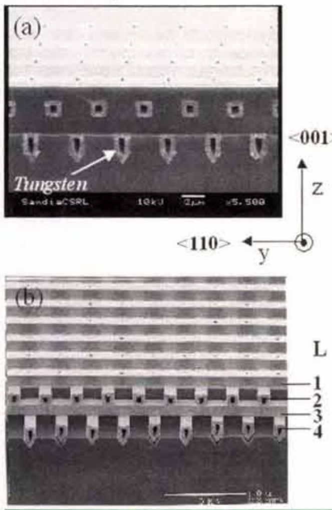
Events, Advances, and News From the Electronics World

by Jeff Eckert

TechKnowledgy 2002

Advanced Technologies

New Filament Design May Boost Bulb Efficiency 12x



Images of a Sandia 3-D tungsten photonic crystal, taken by a scanning electron microscope, (a) with oxide and (b) without oxide. Frequencies of light transmitted vary according to the spacing of the rods. Photo courtesy of Sandia National Laboratories.

You may not think of a light bulb as an advanced technological device, and present-day units are not much different from the one Edison patented in 1879 (or, for that matter, the one that Joseph Swan patented in England a year earlier). Tungsten filaments are only about five percent efficient in converting electricity into light and, in fact, are better generators of heat. However, a "tungsten lattice" structure (that is, a filament with an internal crystalline pattern) has been developed at the US Department of Energy's Sandia National Laboratories **(www.sandia.gov)** that can convert much of the wasted infrared energy into visible light. This could raise the efficiency of an incandescent electric bulb to greater than 60 percent, thereby, partially solving the world's most common power problem: the excess electrical generation capacity and unnecessary costs that result from inefficient lighting.

The concept of photonic crystals was proposed a decade ago by Eli Yablonovitch, of the University of California, Los Angeles. The structures consist of tiny bars that sit astride each other at regular, preset distances and angles that have the effect of forming an artificial crystal. Spacing of the bars allows passage of only certain wavelengths. The original idea was to use silicon crystals to transmit light beams at selected frequencies and bend their paths with no energy loss. But, more recently, researchers began to wonder what would happen to the lower-frequency energies in a tungsten crystal. They could merely generate excessive heat and melt the structure. But instead, the thermally excited tungsten atoms somehow reinforce higher-frequency emissions in the visible range. How this happens is not known, but "Possible explanations may involve variations in the speed of light as it propagates through such structures," according to Sandia scientist Jim Fleming.

Fabrication of the Sandia device was accomplished by an extension of common microelectromechanical systems (MEMS) techniques that are derived from mature semiconductor technologies. As a result, fabrication of such devices could be simple, cheap, and not so far off in the future.

Computers and Networking

Breakthrough in Disk Drive Density

Fujitsu **(www.fujitsu.com)** has announced development of a new hard disk drive technology, based on both improved read heads and improved media, that promises to deliver storage density of up to 300 Gbits per square inch. In practical terms, that translates into more compact drives (2.5-inch rather than the present 3.5-inch format) with capacities of up to 360 Gbytes.

The technology is based on the new "current-perpendicular-to-plane" mode used by the playback head, which generates three times the playback output levels of today's "current-in-plane" drives by allowing a perpendicular current flow. This is coupled with Fujitsu's "synthetic ferrimagnetic media," which uses longitudinal recording for increased density. Together, they achieve six times the storage capacity available from standard drives. The only drawback at this point is that the company doesn't expect to have the devices on the market for another two to four years.

Bargain-Priced Office Software

If you're thinking about buying or upgrading Microsoft® Office software, but are aggravated by the price ($450.00 for the full version, $150.00 for the upgrade, based on recent catalog offers) and increasingly restrictive licensing terms, you might consider StarOffice 6.0, recently released by Sun Microsystems, Inc. **(www.sun.com)**. The suggested retail price is only $75.95, and enterprise customers can get it for $25.00 to $50.00, depending on the number of copies purchased. Education customers can buy it for just the media cost plus shipping.

StarOffice is described as a full-featured office suite that includes word processing, a spreadsheet, and presentation software. It runs on Linux, Solaris, and Windows platforms and shares files among these operating systems. It also works with a variety of file formats, allowing users to open, modify, and share files with other office suites, including Microsoft Office. Based on the open Extensible Markup Language (XML) format, StarOffice files are also compatible with other applications. The package is available in 10 different languages, including Chinese. According to Sun, the new version will be available through Linux vendors, PC manufacturers, software retailers, and Sun's direct sales force.

Virus Update

In May, David L. Smith, of Aberdeen, NJ, was fined $5,000.00 and sentenced to 20 months in federal prison for unleashing the "Melissa" virus in 1999. The sentence is relatively minor, given that the virus infected thousands of computers and caused more than $80 million in damage. You may recall that Melissa was launched when a user opened an infected Word document that was attached to an email. When opened, the virus sent itself to the first 50 names in the user's address book.

A somewhat similar virus that is making the rounds as of this writing is several variations of the WORM_KLEZ. This one also propagates via email. If you find your machine infected with this or another virus, you can get more information and download a fix from Trend Micro at **www.antivirus.com**.

Circuits and Devices

2.4 GHz Transceiver Chip Has Wide Application Range

The MC13190 2.4 GHz transceiver chip, recently introduced by Motorola **(www.motorola.com)**, is an integrated transmitter/receiver that is aimed at simplifying the design process for complex, low-cost wireless applications. Intended uses include wireless toys and short-range wireless data applications such as two-way remote control and telemetry. In addition, because it offers a data rate of up to 5 Mbits/second, it is suitable for streaming audio functions.

The device can interface to many types of devices, including microcontrollers, microprocessors, and digital signal processors. The receiver includes a low-noise amplifier, an AM demodulator, a bandpass filter, and a limiter. The transmitter provides modulation control, baseband filtering, and an AM modulator. The total number of external components required for the RF function is typically between 10 and 20. The operating range is said to be 10 to 15 meters, which can be extended with an optional off-chip amplifier.

The MC13190 is housed in a 5 mm square, 32-pin QFN surface mount package. The projected price is $3.05 in quantities of 10,000, with single units from your local dealer costing somewhat more. The devices should be in full production during the third quarter of this year.

How to Defeat CD Copy Protection

When Sony Corp., developed the Key2Audio copy protection technology, the intent was to prevent consumers from making unauthorized copies of music CDs. It also is designed to prevent you from playing the music on your PC or Macintosh CD drive. (Why Sony would care what you play it on remains a mystery.) It appears, however, that you can defeat this high-tech system via the use of a one-bit digital input stylus, more commonly known as a felt-tipped marker. Apparently, all you have to do is draw a straight line over the ring that separates the audio portion of the CD from the data track created by Key2Audio.

The music industry has blamed home CD recording for declining sales of music CDs, but it may need to find a better solution than Key2Audio. (Dare we suggest that the industry's current reliance on superficial formula music and prepackaged performers might be a contributing factor?)

Cheap Mine Detector Developed

The Mine Rover, developed at Johns Hopkins University's Applied Physics Laboratory, provides sophisticated, inexpensive mine detection. Photo courtesy of Johns Hopkins APL.

An estimated 110 million land mines presently lie hidden in 68 countries, and several thousand people are killed by them every year. Finding and disposing of the things using human beings is dangerous to say the least, and automated mine detection systems basically consist of just a robot with a metal detector attached, which is expensive and relatively inefficient. But a physicist at the Johns Hopkins University Applied Physics Laboratory has developed a low-cost mine detector that can be backpacked to a suspected minefield and operate autonomously or by remote control.

According to Carl Nelson, the inventor, "Today's mine detectors are just metal detectors and give between 100 and 1,000 false-positive returns for every real land mine. Our Mine Rover significantly reduces the number of false alarms due to metal clutter in the environment."

The device can be configured to carry sophisticated sensors such as chemical and biological agent detectors, TV cameras, and devices that neutralize the mines. Infrared sensors and ground-penetrating radars can also be added for improved detection capability. The Mine Rover even detects mines that are made mostly of plastic. In the process, it marks their location to remove any threat to the operator. Reportedly, the machine has passed proof-of-concept tests and is now ready for the production of an advanced technology prototype for a full field test.

Industry and the Profession

RIP, Boyce McDaniel

Boyce D. McDaniel, pioneer nuclear physicist. Photo copyright Cornell University, reprinted with permission.

Boyce D. McDaniel, the Cornell University physicist and Manhattan Project scientist who gave the atomic bomb its final check before the first test at the Trinity site in July 1945, died of a heart attack May 8 in Ithaca, NY at the age of 84.

McDaniel's faculty career at Cornell spanned 56 years. In 1943, McDaniel was hired (at $250.00 a month, working 10- to 15-hour days at a secret facility in Los Alamos, NM) to conduct nuclear physics research on a device nicknamed "the gadget." The device was the atomic bomb. The young McDaniel would play a critical role on physicist Robert Wilson's cyclotron research team, which helped identify the amount of the isotope uranium-235 (U-235) needed to create the atomic fission to detonate the world's first nuclear weapon.

In 1946, McDaniel joined the Cornell faculty as an assistant professor and became a full professor in 1955. With Cornell physicist Robert Walker, he invented the pair spectrometer, an important tool used to measure gamma ray energies.

He was a leader in establishing the Cornell Laboratory of Nuclear Studies (LNS), and had a major role in designing and building the 300 MeV electron synchrotron, one of the first such accelerators in the world. McDaniel became director of the LNS in 1967 and remained in that position until he became an emeritus professor in 1985.

McDaniel was a Fulbright Research Fellow in 1953 at the Australian National University, Canberra, and a Fulbright Research Fellow and a Guggenheim Fellow at the University of Rome and the National Laboratory, Frascati, Italy, in 1959. He was a member of the National Academy of Sciences, a trustee of the Associated Universities, a member of the governing board of Brookhaven National Laboratory and of the Department of Energy High Energy Advisory Panel, a trustee of the Universities Research Association, a governing board member of Fermilab and chair of the Superconducting Supercollider Board of Overseers.

Comcast Sued for $1 Billion

Last February, it was revealed that Internet and TV cable service provider Comcast Corp. **(www.comcast.com)** had illegally tracked the web surfing habits of its subscribers for a few weeks. A representative told irate customers that Comcast had not linked any of the collected data to individual customers and that the company purged the information in the interest of privacy. Nevertheless, a class action lawsuit has been filed on behalf of at least 1 million Internet service customers, seeking damages of $100.00 per customer per day that the information was collected. When you add legal fees to that, the total could be as high as $1 billion. Not surprisingly, Comcast intends to fight the suit. **NV**

by Jon Williams

Stamp Applications

Multi-bank Programming

If program space becomes the issue, that can certainly be solved with one of the multi-bank BASIC Stamps (BS2e, BS2sx, or BS2p). But how do we take advantage of all those program banks? Well, there are a lot of ways, really. In this issue, I'll show you a strategy that has worked for me and that you can apply to your own projects.

If you work with BASIC Stamps long enough, there will come a time when you either run out of space or wish you could change some part of your program (usually the user interface device) without impacting all the hard work you applied to your control code. Or both. Welcome to the club.

Plan Your Work, Work Your Plan

Yeah, yeah, I know I harp on it a bit, but I sincerely believe that we get into trouble with our projects when we don't plan them. You know the saying: "We don't plan to fail, we fail to plan." I think that's particularly the case when we start to work across program banks with the BS2e, BS2sx, or BS2p. Since talk (theoretical talk) is cheap, let's dive into a project and learn by doing.

Our project this month is a simple thermostat simulation. The goal is to manage the temperature and control code in one bank and then display the output in another. Why? Well, this version will use a standard 2x16 LCD display. But what if, two months from now, we decide we want to use one of Scott Edwards' nifty graphics LCDs instead? By keeping the display code in a separate module, we don't have to tear-up the control code module to use it.

In the BS2e, BS2sx, and BS2p, there are three keywords that apply to the use of multiple program banks: **PUT**, **GET**, and **RUN**. **PUT** will write a byte variable to a specific location in a shared RAM space called the Scratchpad. **GET** will retrieve a byte. **RUN** will execute the target program bank.

What we're going to do is use the Scratchpad as a mechanism to store program variables and to pass commands and data between program banks. Here's where some of the planning comes into play. Program design will also play a big role in making all of this work easily.

I've long advocated the use of a "task manager" approach to writing PBASIC programs. I like this style because it allows programs to become very flexible without overusing **GOTO**. In this case, it really helps because we can save our current task to the Scratchpad, go run code in another module, then come back and retrieve the task to run. It'll probably make more sense as we get into the code.

Let's define our program: The main module will monitor a temperature sensor (DS1620), a mode switch (Off, Cool, Heat), and a couple of buttons (Up and Down) to change the current setpoint. The external module will initialize the display device, clear the display device, show the temperature, the setpoint, the thermostat mode, and whether or not the fan is running. What we'll find is that the main module will be completely unaware of the mechanics of displaying data — it will simply pass the command and/or data and rely on the external code to handle it. This aspect of the program design will let us change the display device and code later without affecting our main module.

Based on what we have so far, here's how we'll use the Scratchpad:

0 Bank 0 task
1 Bank 1 task (command)
2 thermostat mode (plus fan status)
3 temperature (low byte)
4 temperature (high byte)
5 setpoint (low byte)
6 setpoint (high byte)

As you can see, the start of our data "package" for the external module starts at address 2. We'll actually define this value as a constant so we can shift the package around, if necessary, to accommodate the use of more than one external module.

Cool It, Buddy

Okay, it's time to write some code. As you can see by the schematics, we're working with simple parts that we've all dealt with a thousand times (if you're new, don't worry, there's plenty of documentation available to explain how these parts work). As I pointed out earlier, we'll use a task manager approach to our design so we can save what we're doing when we access an external

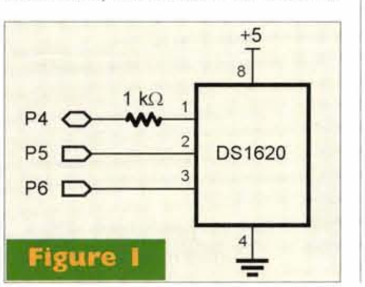


Figure 1

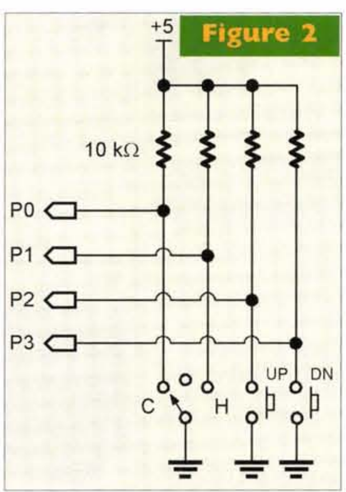


Figure 2

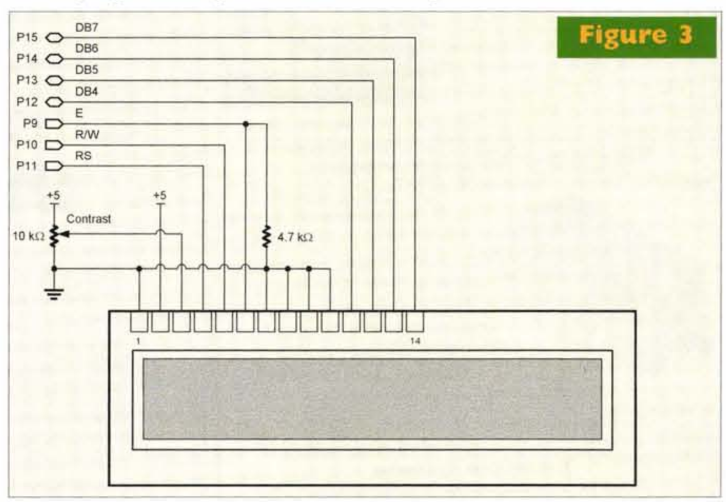


Figure 3

module. For the main program, we'll need to do the following tasks:

0 Initialize the display (external code)
1 Initialize the DS1620
2 Read the temperature
3 Get the setpoint
4 Update the display (external code)

Tasks 0 and 1 will only have to run once — the others will repeat through the run of the program. Now, you may be wondering why we don't define scanning the mode switch and buttons as a task. The reason is that we want this to happen all the time, so our design will allow us to do that between every iteration of tasks 2, 3, and 4.

Take a look at the Initialization section in Listing 1. You'll notice that the first thing we do is read the Scratchpad for our current task and the stored setpoint. On power-up or reset, these values will be zero so the **BRANCH** command that follows will take us to **Init_Screen**. This section of code prepares us to launch the [external] code that initializes our display device (LCD). What we have to do before running the external module is save what we want to do when we get back. In this case, we'll want to initialize the DS1620 (task value of 1). In Scratchpad address 1, we'll tell the external module what to do. Then we run the external module. So let's go there.

Jump over to Listing 2. What you'll see is that this module simply holds a group of subroutines that deal with the display: initialize, clear, and update. The routine to run is passed via the Scratchpad in location 1.

Our first task is to initialize the display. This is pretty common code as we're using a standard 2x16 LCD for this program. What you'll notice is that the end of the initialization section is allowed to drop through to the code that clears the display. This is necessary in case of a reset when the program has been running. Re-initializing the display does not automatically clear it. Once the display is cleared, the program exits back to the main code module (Listing 1).

Now when we return to the main module, the program starts all over again. This is why we save the current task and the setpoint in the Scratchpad — they will probably get destroyed because of the different variable definitions in the other program bank. This time through, our task value is one, so the program will **BRANCH** to the [internal] code that initializes the DS1620. Again, this is code we've used before. It sets up the DS1620 to "free-run" and be accessed by an external CPU. When this is complete, we update our task variable and initialize the setpoint to a default value.

Now we're in the heart of the main control program. At the top is where we scan our mode switch and Up/Down buttons for the setpoint. This little loop of code is useful for debouncing multiple inputs. The tilde (~) operator inverts our active-low inputs to "1" when pressed or on to make the inputs easier to deal with in code. Once done, the mode value is isolated so we can pass it to the external module. The modulus operator (//) keeps the mode value in the range of 0 (off), 1 (cool), and 2 (heat).

The first [repeating] task is to get the current temperature and compare it to the setpoint. This

Listing 1

```
'
' ==========================================================================
'
'   File...... Thermo_Demo.BSE
'   Purpose... Multi-bank Program Demo
'   Author.... Jon Williams
'   E-mail.... jwilliams@parallaxinc.com
'   Started...
'   Updated... 02 JUN 2002
'
'   {$STAMP BS2e, Thermo_LCD.BSE}
'
'
' ==========================================================================


' --------------------------------------------------------------------------
' Program Description
' --------------------------------------------------------------------------
'
' The pupose of these programs is to demonstrate the multi-bank capability of
' the BS2e, BS2sx and BS2p.  The core program monitors a DS1620 and functions
' as a simple thermostat control.  Information from the program is displayed
' on an LCD that is controlled from a different program bank.
'
' Tasks:
'
'   0     Initialize LCD (code in bank 1)
'   1     Initialize DS1620
'   2     Read temperature
'   3     Get setpoint
'   4     Update LCD (code in bank 1)
'
' Tasks 0 and 1 run only once.


' --------------------------------------------------------------------------
' Revision History
' --------------------------------------------------------------------------


' --------------------------------------------------------------------------
' I/O Definitions
' --------------------------------------------------------------------------

Inputs          VAR     InA                     ' mode and temp change inputs
DQ              CON     4                       ' DS1620.1 (data I/O)
Clock           CON     5                       ' DS1620.2
Reset           CON     6                       ' DS1620.3


' --------------------------------------------------------------------------
' Constants
' --------------------------------------------------------------------------

RdTmp           CON     $AA                     ' read temperature
WrHi            CON     $01                     ' write TH (high temp)
WrLo            CON     $02                     ' write TL (low temp)
RdHi            CON     $A1                     ' read TH
RdLo            CON     $A2                     ' read TL
StartC          CON     $EE                     ' start conversion
StopC           CON     $22                     ' stop conversion
WrCfg           CON     $0C                     ' write config register
RdCfg           CON     $AC                     ' read config register

TskInitScr      CON     0                       ' program tasks
TskInitTmp      CON     1
TskTemp CON     2
TskSetPoint     CON     3
TskScreen       CON     4

ScreenBank      CON     1                       ' bank that holds output code

ScrInit         CON     0                       ' initialize screen
ScrClear        CON     1                       ' clear screen
ScrUpdate       CON     2                       ' update screen

AcOff           CON     0                       ' A/C modes
AcCool          CON     1
AcHeat          CON     2

MinTemp         CON     0                       ' valid temp range
MaxTemp         CON     125
DefaultSP       CON     75                      ' default setpoint

Yes             CON     1
No              CON     0

DataStart       CON     2                       ' data block starts at loc 2


' --------------------------------------------------------------------------
' Variables
' --------------------------------------------------------------------------

task            VAR     Nib                     ' current task
loop            VAR     Nib                     ' loop counter
btnIns          VAR     Nib                     ' switch and button inputs
btnUp           VAR     btnIns.Bit2
btnDn           VAR     btnIns.Bit3
mode            VAR     Nib
fanCtrl         VAR     mode.Bit3               ' 1 = run fan
fan             VAR     bit
setpoint        VAR     Word                    ' temperature setpoint
tempIn          VAR     Word                    ' raw temp from DS1620
sign            VAR     tempIn.Bit8             ' 1 = negative temperature
tSign           VAR     Bit
tempC           VAR     Word
tempF           VAR     Word


' --------------------------------------------------------------------------
' EEPROM Data
' --------------------------------------------------------------------------


' --------------------------------------------------------------------------
' Initialization
' --------------------------------------------------------------------------

Initialize:
  GET 0, task                                   ' get current task
```

code calls an internal subroutine to read the DS1620 and to convert its output (half degrees Celsius) to whole degrees Fahrenheit. The returned value is compared to the setpoint and, based on the current control mode, the fan control bit is set or cleared.

The end of this code updates the task variable and goes back to the top where we scan the inputs again, then **BRANCH** to checking for a setpoint change. This is actually very simple code and demonstrates the usefulness of aliasing variables. If you look at the variables section, you'll see that the Up and Down bits have been aliased from the btnIns variable. As bits, these variables will have values or 0 (not pressed) or 1 (pressed).

The entry portion of this code actually looks to see if both buttons are being pressed at the same time. If not, it jumps to code that handles a possible setpoint change. If both buttons are pressed, the setpoint is reset to the default value. Most of the time, though, only one button will be pressed.

Let's say, for example, that our current setpoint is lower than the specified maximum. In this case, the value of the Up button will be added to the current setpoint. If pressed, this value will be one. If not, the value will be zero. The nice thing is that we don't have to use an **IF-THEN** construct to check if the button was pressed or not, we simply add the current button value. Pretty neat. But what if you wanted to increment or decrement by a different value, say five? No problem. Just change the code so it looks like this:

```
setpoint = setpoint + (btnUp * 5)
```

The same approach is used to check the down button and decrease the setpoint if it's pressed.

Now that we have the current temperature and setpoint, it's time to update the LCD. The task that handles this actually sets up everything so that it can run externally. In this task, we'll store what we want to do when we get back, what external routine to run (display update), and the values used by the external code.

Notice that the fan control bit is added into the mode value and passed that way. Since the temperature and setpoint are stored as words, we have to use **PUT** twice to pass the value. This is required because **PUT** and **GET** only work with bytes. The technique of storing low-byte first is often referred to as "Little Endian" and is common practice.

Resources:

Jon Williams
jonwms@aol.com

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

Now we want to update the display, so let's jump back over to Listing 2. At this point, the command passed will cause the program to **BRANCH** to **Update_LCD**. Since this routine uses data passed from the main module, the first thing it has to do is use **GET** to retrieve the data from the Scratchpad.

With the data in hand, the

```
  GET (DataStart + 3), setpoint.LowByte     ' get last setpoint
  GET (DataStart + 4), setpoint.HighByte

  BRANCH task, [Init_Screen, Init_DS1620, Main, Main, Main]

Init_Screen:
  PUT 0, TskInitTmp                         ' store task for retrun
  PUT 1, ScrInit                            ' store task for external code
  RUN ScreenBank                            ' run external code

Init_DS1620:
  HIGH Reset                                        ' alert the DS1620
  SHIFTOUT DQ, Clock, LSBFirst, [WrCfg, %10]        ' use with CPU; free-run
  LOW Reset
  PAUSE 10
  HIGH Reset
  SHIFTOUT DQ, Clock, LSBFirst, [StartC]            ' start conversions
  LOW Reset

  task = TskTemp
  setpoint = DefaultSP


' ---------------------------------------------------------------------------
' Program Code
' ---------------------------------------------------------------------------

Main:
  btnIns = %1111                            ' enable all four inputs
  FOR loop = 1 TO 10
    btnIns = btnIns & ~Inputs               ' test inputs
    PAUSE 5                                 ' delay between tests
  NEXT

  mode = (btnIns & %0011) // 3              ' isolate mode switch bits

Task_Manager:
  BRANCH (task - 2), [Get_Temperature, Get_SetPoint, Update_Screen]
  GOTO Main


Get_Temperature:
  GOSUB Read_DS1620                         ' read current temperature
  fan = No                                  ' assume fan is off
  BRANCH mode, [Get_TempX, Check_Cool, Check_Heat]

Check_Cool:                                 ' check for cooling on
  IF (tempF <= setpoint) THEN Get_TempX
  fan = Yes
  GOTO Get_TempX

Check_Heat:                                 ' check for heating on
  IF (tempF >= setpoint) THEN Get_TempX
  fan = Yes

Get_TempX:
  task = TskSetPoint
  GOTO Main


Get_SetPoint:                               ' check for both pressed
  IF ((btnIns >> 2) <> %11) THEN Check_Increase
  setpoint = DefaultSP
  GOTO SP_Done

Check_Increase:
  IF (setpoint = MaxTemp) THEN Check_Decrease
  setpoint = setpoint + btnUp

Check_Decrease:
  IF (setpoint = MinTemp) THEN SP_Done
  setpoint = setpoint - btnDn

SP_Done:
  PAUSE 100                                 ' delay between keys
  task = TskScreen
  GOTO Main


Update_Screen:
  PUT 0, TskTemp                            ' save next task
  PUT 1, ScrUpdate                          ' store task for external
code

  fanCtrl = fan                             ' pass fan control in mode
  PUT (DataStart + 0), mode                ' store data packet
  PUT (DataStart + 1), tempF.LowByte
  PUT (DataStart + 2), tempF.HighByte
  PUT (DataStart + 3), setpoint.LowByte
  PUT (DataStart + 4), setpoint.HighByte
  RUN ScreenBank                            ' run external code


' ---------------------------------------------------------------------------
-
' Subroutines
' ---------------------------------------------------------------------------
-

Read_DS1620:
  HIGH Reset                                 ' alert the DS1620
  SHIFTOUT DQ, Clock, LSBFIRST, [RdTmp]     ' give command to read temp
  SHIFTIN DQ, Clock, LSBPRE, [tempIn\9]     ' read it in
  LOW Reset                                  ' release the DS1620

  tSign = sign                               ' save sign bit
  tempIn = tempIn / 2                       ' round to whole degrees
  IF (tSign = 0) THEN No_Neg1
  tempIn = tempIn | $FF00                   ' extend sign bits for nega-
tive

No_Neg1:
  tempC = tempIn                             ' save Celsius value
  tempIn = tempIn */ $01CC                  ' multiply by 1.8
  IF (tSign = 0) THEN No_Neg2               ' if negative, extend sign
bits
  tempIn = tempIn | $FF00

No_Neg2:
  tempIn = tempIn + 32                      ' finish C -> F conversion
  tempF = tempIn                             ' save Fahrenheit value
  RETURN
```

temperature and setpoint values are printed using a subroutine called **Print_Temperature**. This code prints a three-digit, right justified (space padded) value. It assumes the value to be positive, so if you want to deal with negative values, this code will have to be updated. It's not tough to do. Simply look at bit 15 of the tPrint value. If it's a one, the value is negative. In this case, you would print a "-" then use the **ABS** function to get the positive temperature value and print using the code as shown.

The next thing to do is print the current thermostat mode. The various mode strings are stored in **DATA** statements. **LOOKUP** is used to locate the first character of a string and a simple loop writes the characters to the LCD. The strings are terminated with zero so that the print loop knows when to stop. Also note that the strings are also padded with a leading space that will erase the fan running indicator when we change the mode.

The final step, then, is to display the fan status. In this demo, I took the lead from my own home thermostat that prints an asterisk when the fan is running. Once the fan status is displayed (or not), the program exits back to the control program and the process starts over again at reading the temperature.

That wasn't too tough, was it? Of course, we could have easily fit both programs into one bank, but then updating the display portion would lead to us potentially damaging the control code. By using the external module to deal with the display, we free up variable and code space for control code and can change display types without worry.

Saving Everything ... Almost Everything

I am not a fan of — and I actually discourage — the use of internal variable names (like B0, W1, etc.), but there is a case here where it can be useful. Let's say, for example, that you need to save and retrieve a lot of variables when dealing with an external program module. Here's a bit of code that will save everything to the Scratchpad except one byte:

```
Push_Vars:
  FOR B25 = 0 TO 24
    PUT (BankVarsStart + B25),
B0(B25)
  NEXT
  RETURN
```

This routine uses B25 (last allocated byte in the variable RAM space) as a loop counter and takes advantage of the fact that the BASIC Stamp treats the variable RAM space as an array. So B0(0) is the first byte of variable RAM and B0(24) is the penultimate byte. The constant called BankVarsStart determines where the data is saved in the Scratchpad (be careful not to make it so high as to overrun the end of the Scratchpad). The only thing that doesn't get saved is B25 since it's used as the loop control. Of course, if things get really desperate, you could use 26 **PUT** statements to save the data. But that's not likely to be the case since the use of an external module for subroutines generally frees up some variable space.

Retrieving data is just as easy:

```
Pop_Vars:
  FOR B25 = 0 TO 24
    GET (BankVarsStart + B25),
B0(B25)
  NEXT
  RETURN
```

Go For It!

Okay, now that you've seen how easy using multiple program banks can be, it's time for you to use this technique in your own programs. It only takes a little bit of planning to organize the use of the Scratchpad and a task-manager approach to your code so that you can direct the flow across modules. Remember to plan your work and work your plan and you won't have any trouble.

For those of you that have either of the Scott Edwards graphics displays, a good first project would be to create a module that is compatible with the code we've built here. Could be a lot of fun ...

Happy Stamping! **NV**

Listing 2

```
'
' =========================================================================
'
'   File...... Thermo_LCD.BSE
'   Purpose... LCD output for THERMO DEMO.BSE
'   Author.... Jon Williams
'   E-mail.... jwilliams@parallaxinc.com
'   Started...
'   Updated... 02 JUN 2002
'
'   {$STAMP BS2e}
'
'
' =========================================================================


' -------------------------------------------------------------------------
' Program Description
' -------------------------------------------------------------------------

' This module provides LCD output for the THEMO DEMO program.  The main program
' will pass a task value using Scratchpad RAM location 1.
'
' Task Values:
'
' 0     Initialize LCD
' 1     Clear LCD
' 2     Update LCD
'
' For task 2, the following values are passed via the Scratchpad
'
' mode (off, cool, heat, cool-running, heat-running)
' temp.LowByte
' temp.HighByte
' setpoint.LowByte
' setpoint.HighByte


' -------------------------------------------------------------------------
' Revision History
' -------------------------------------------------------------------------


' -------------------------------------------------------------------------
' I/O Definitions
' -------------------------------------------------------------------------

E               CON     9               ' LCD Enable pin  (1 = enabled)
RW              CON     10              ' LCD read/write  (0 = write)
RS              CON     11              ' Register Select (1 = char)
LcdBus          VAR     OutD            ' 4-bit LCD data bus
LcdBusDirs      VAR     DirD


' -------------------------------------------------------------------------
' Constants
' -------------------------------------------------------------------------

ClrLCD          CON     $01             ' clear the LCD
CrsrHm          CON     $02             ' move cursor to home position
CrsrLf          CON     $10             ' move cursor left
CrsrRt          CON     $14             ' move cursor right
DispLf          CON     $18             ' shift displayed chars left
DispRt          CON     $1C             ' shift displayed chars right
DDRam           CON     $80             ' Display Data RAM control
Line1           CON     $80             ' DDRAM address of line 1
Line2           CON     $C0             ' DDRAM address of line 2

LcdInit         CON     0               ' initialize screen
LcdClear        CON     1               ' clear screen
LcdUpdate       CON     2               ' update screen

Yes             CON     1
No              CON     0

PgmBank         CON     0               ' main program in bank 0
DataStart       CON     2               ' data block starts at loc 2


' -------------------------------------------------------------------------
' Variables
' -------------------------------------------------------------------------

task            VAR     Nib
mode            VAR     Nib             ' A/C control mode
running         VAR     mode.Bit3
temp            VAR     Word            ' current temperature
setpoint        VAR     Word            ' A/C setpoint
tPrint          VAR     Word            ' temp to print
char            VAR     Byte            ' character sent to LCD
index           VAR     Byte            ' loop counter
eeAddr          VAR     Byte            ' address of string char


' -------------------------------------------------------------------------
' EEPROM Data
' -------------------------------------------------------------------------

Msg_Off         DATA    "  OFF", 0
Msg_Cool        DATA    " COOL", 0
Msg_Heat        DATA    " HEAT", 0
```

```
' -------------------------------------------------------------------------
' Initialization
' -------------------------------------------------------------------------

Initialize:
  GET 1, task
  BRANCH task, [Init_LCD, Clear_LCD, Update_LCD]


' -------------------------------------------------------------------------
' Program Code
' -------------------------------------------------------------------------

Init_LCD:
  LOW E                                 ' initialize LCD pins
  LOW RW
  LOW RS
  LcdBusDirs = %1111                    ' make bus lines outputs

  PAUSE 500                             ' let the LCD settle
  LCDbus = %0011                        ' 8-bit mode
  PULSOUT E, 1
  PAUSE 5
  PULSOUT E, 1
  PULSOUT E, 1
  LCDbus = %0010                        ' 4-bit mode
  PULSOUT E, 1
  char = %00101000                      ' multi-line mode
  GOSUB LCD_Command
  char = %00001100                      ' disp on, crsr off, blink off
  GOSUB LCD_Command
  char = %00000110                      ' inc crsr, no disp shift
  GOSUB LCD_Command


Clear_LCD:
  char = ClrLCD
  GOSUB LCD_Command
  GOTO Exit


Update_LCD:
  GET (DataStart + 0), mode             ' retrieve data packet
  GET (DataStart + 1), temp.LowByte
  GET (DataStart + 2), temp.HighByte
  GET (DataStart + 3), setpoint.LowByte
  GET (DataStart + 4), setpoint.HighByte

  char = Line1 + 0                      ' print temperature
  GOSUB LCD_Command
  tPrint = temp
  GOSUB Print_Temperarature

  char = Line1 + 4                      ' print (setpoint)
  GOSUB LCD_Command
  char = "("
  GOSUB LCD_Write
  tPrint = setpoint
  GOSUB Print_Temperarature
  char = ")"
  GOSUB LCD_Write

Show_Mode:
  char = Line2 + 11                     ' show system mode
  GOSUB LCD_Command
  LOOKUP (mode & %0011), [Msg_Off, Msg_Cool, Msg_Heat], eeAddr

Print_Char:
  READ eeAddr, char
  IF (char = 0) THEN Show_Fan
  GOSUB LCD_Write
  eeAddr = eeAddr + 1
  GOTO Print_Char

Show_Fan:
  IF (running = No) THEN Exit
  char = Line2 + 11                     ' show fan status
  GOSUB LCD_Command
  char = "*"                            ' show on
  GOSUB LCD_Write


Exit:
  RUN PgmBank


' -------------------------------------------------------------------------
' Subroutines
' -------------------------------------------------------------------------

Print_Temperarature:                    ' prints 3-digit, space padded
  char = " "                            ' clear old digit
  GOSUB LCD_Write
  IF (tPrint < 100) THEN Print_T10
  char = CrsrLf
  GOSUB LCD_Command
  char = "0" + (tPrint DIG 2)           ' convert 100's digit to ASCII
  GOSUB LCD_Write

Print_T10:
  char = " "
  GOSUB LCD_Write
  IF (tPrint < 10) THEN Print_T01
  char = CrsrLf
  GOSUB LCD_Command
  char = "0" + (tPrint DIG 1)           ' convert 10's digit to ASCII
  GOSUB LCD_Write

Print_T01:
  char = "0" + (tPrint DIG 0)           ' convert 1's digit to ASCII
  GOSUB LCD_Write
  RETURN


LCD_Command:
  LOW RS                                ' enter command mode

LCD_Write:
  LCDbus = char.HighNib                 ' output high nibble
  PULSOUT E, 1                          ' strobe the Enable line
  LCDbus = char.LowNib                  ' output low nibble
  PULSOUT E, 1
  HIGH RS                               ' return to character mode
  RETURN
```

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HP 8717B-001 Transistor Bias Supply $350.00
HP 8751A-001,002 Network Analyzer, 5 Hz-500 MHz $12500.00
HP 8756A Scalar Network Analyzer, HPIB $1375.00
HP R85026A WR28 Detector, 26.5-40 GHz, for HP 8757 series $1200.00

SIGNAL GENERATORS

FLUKE 6060B/AK Signal Generator, 0.1-1050 MHz, 10 Hz res. $1250.00
FLUKE 6060B-130,830 Signal Generator, 0.1-1050 MHz, 10 Hz res., GPIB $1600.00
GIGATRONICS 1018 Signal/Sweep Gen., 0.05-18 GHz, 1 kHz res., +8 dBm $5000.00
GIGATRONICS 600/ 6-12 Synthesized Source, 6-12 GHz, 1 MHz res., GPIB $1500.00
GIGATRONICS 6000/ 8-16 Synthesized Source, 8-16 GHz, 1MHz res., GPIB $2250.00
GIGATRONICS 6061A-830 Signal Generator, 0.1-1050 MHz, 10 Hz res., AM, FM, GPIB $1900.00
HP 11707A Test Plug-in, for HP 8660 series $400.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio $450.00
HP 8341B Synth. Signal Generator, 10 MHz-20 GHz, 1 kHz res., AM, FM $16000.00
HP 8642M Signal Generator, 0.1-2100 MHz, 1 Hz res., HPIB $3750.00
HP 8656B-001 Signal Generator, 0.1-990 MHz, 10 Hz res., HPIB, OCXO $2000.00
HP 8657A Signal Generator, 0.1-1040 MHz, 10 Hz res., AM, FM, HPIB $3000.00
HP 8660C/603A/633B Signal Generator, 1-2600 MHz, 1 or 2 Hz res., AM, FM $3250.00
HP 8660D/603A-002 Signal Generator, 1-2600 MHz, FM/PM, includes 86635A $6000.00
HP 8671A Signal Gen., 2.0-6.2 GHz, 1 kHz res., CW, FM, +8 dBm, HPIB $2750.00
HP 8671B Synthesized Signal Generator, 2-18 GHz $4000.00
HP 8672A Signal Generator, 2-18 GHz, 1-3 kHz res., AM, FM, +3 dBm $4500.00
HP 8672A-008 Signal Generator, 2-18 GHz, 1-3 kHz res., AM, FM, +8 dBm $5000.00
HP 8673C Signal Gen., 0.05-18.6 GHz, 1 kHz res., AM, FM, Pulse, HPIB $14000.00
HP 8673D-H15 Signal Gen., 0.05-26 GHz, 1 kHz res., AM, FM, HPIB $15000.00
HP 8673H-212 Signal Generator, 2.0-12.4 GHz, 1 kHz res., AM, FM, +8 dBm $8500.00
HP 8673M Signal Generator, 2-18 GHz, 1 kHz res., AM, FM, +8 dBm $9500.00
HP 8683B Signal Generator, 2.3-6.5 GHz, cavity tuned, AM/ WBFM/ Pulse $2250.00
HP 8683D Signal Generator, 2.3-13.0 GHz, cavity tuned, AM/ WBFM/ Pulse $3750.00
HP 8684B Signal Generator, 5.4-12.5 GHz, cavity tuned, AM/ WBFM/ Pulse $2250.00
MARCONI 2019 Signal Generator, 80 kHz-1040 MHz, 10 or 20 Hz res $850.00
WAVETEK 955 Signal Generator, 7.5-12.4 GHz, +7 dBm, AM, FM $750.00
WAVETEK 957 Signal Generator, 12-18 GHz, +7 dBm, AM, FM $750.00

SWEEP GENERATORS

HP 8350B/ 83522A Sweep Oscillator, 10-2400 MHz, +13 dBm levelled $3750.00
HP 8350B/ 83525A Sweep Oscillator, 10 MHz-8.4 GHz, +13 dBm levelled $5000.00
HP 8350B/ 83540A-002 Sweep Oscillator, 2.0-8.4 GHz, 70 dB step atten. $3250.00
HP 8350B/ 83550A Sweep Oscillator, 8-20 GHz, +20 dBm levelled output $5000.00
HP 8620C Sweep Oscillator Frame $500.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, +13 dBm, 70 dB step atten. $1250.00
HP 86222B-E69/8620C Sweep Osc. & frame, 0.01-2 GHz & 2-4 GHz bands $1200.00
HP 86241A RF Plug-in, 3.2-6.5 GHz, +8 dBm unlevelled $250.00
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm unlevelled $400.00
HP 86251A RF Plug-in, 7.5-18.6 GHz, +10 dBm levelled $500.00
HP 86260A RF Plug-in, 12-18 GHz, +10 dBm unlevelled $400.00
HP 86260A-H04 RF Plug-in, 10-15 GHz, +10 dBm unlevelled $400.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled $1500.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled $1750.00
WAVETEK 2001 Sweep Generator, 1-1400 MHz, +10 dBm, 70 dB atten. $750.00
WAVETEK 2002B Sweep Generator, 1-2500 MHz, +13 dBm, GPIB $1750.00
WILTRON 6647M Sweep Generator, 10 MHz-20 GHz, +10 dBm, GPIB $4500.00
WILTRON 6669B-02,03 Sweep Gen., 0.01-26.5 GHz/ K conn.& 26-40 GHz/ WR28 $7500.00
WILTRON 6717B-20 Synthesizer/ Sweeper, 10 MHz-8.4 GHz, +13 dBm,GPIB $6000.00

POWER METERS

BOONTON 42B/ 41-4E Analog Power Meter, with 1 MHz-18 GHz sensor $400.00
HP 11683A Range Calibrator, for HP 435/6/7/8 $750.00
HP 435B/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz $900.00
HP 436A-022/ 8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HPIB $1200.00
HP 436A-022/ 8482A Power Meter, -30 to +20 dBm, 100 kHz-4.2 GHz, HPIB $1200.00
HP 436A-022/ 8484A Power Meter, -70 to -20 dBm, 10 MHz-18 GHz, HPIB $1200.00
HP 436A-022/ 8485A Power Meter, -30 to +20 dBm, 50 MHz-26.5 GHz, HPIB $1500.00
HP 436A-022/ 8485D Power Meter, -70 to -20 dBm, 50 MHz-26.5 GHz, HPIB $1700.00
HP 438A Dual Channel Power Meter $3000.00
HP 8477A Power Meter Calibtator, for HP 432 series $400.00
HP 8487D High Sensitivity Sensor, -70 to -20 dBm, 50 MHz-50 GHz, 2.4mm $1850.00
HP 8900D/84811A Peak Power Meter, 0.1-18 GHz, 0-20 dBm peak $2500.00
HP Q8486A Power Sensor, 33-50 GHz, -30 to +20 dBm, for 435/6/7/8 $1500.00
HP R8486A Power Sensor, 26.5-40 GHz, -30 to +20 dBm, for 435/6/7/8 $1500.00
HP R8486D Power Sensor, 26.5-40 GHz, -70 to -20 dBm, for 435/6/7/8 $1750.00

RF MILLIVOLTMETERS

BOONTON 92C RF Millivoltmeter, 3 mV-3 V f.s., 10 kHz-1.2 GHz $500.00
RACAL-DANA 9303 RF Millivoltmeter, -70 to +20 dBm, 10 kHz-2 GHz, GPIB $750.00

AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RESEARCH 4W1000 Amplifier, 40 dB gain, 4 Watts, 1-1000 MHz $950.00
BOONTON 82AD Modulation Meter, AM/ FM, 10-1200 MHz $500.00
HP 11713A Switch / Attenuator Driver, HPIB $800.00
HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz $1900.00
HP 3730B/3738B Downconverter, 5.9-8.9 GHz & 8.7-11.7 GHz $1200.00
HP 415E SWR Meter $200.00
HP 8347A RF Amplifier, 25 dB gain, 100 kHz-3 GHz, +20 dBm, HPIB $2750.00
HP 8349A Amplifier, 15 dB gain, 2-20 GHz, +20 dBm output $1650.00
HP 8403A-002 Pulse Modulator, 0.8-2.4 GHz, 80 dB dynamic range $450.00
HP 8406A Comb Generator, 1/ 10/ 100 MHz increments, to 5GHz $500.00
HP 8447A-001 Dual Amplifier, 20 dB, 0.1-400 MHz, +6 dBm Po, NF <7 dB $650.00
HP 8447D-010 Preamplifier, 25 dB gain, 0.1-1300 MHz, <8.5 dB NF $750.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output $650.00
HP 8447F-H64 Dual Amp., 0.01-50 MHz 28 dB & 0.1-1300 MHz 25 dB $900.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz, HPIB $1350.00
HP 8901B-001 Modulation Analyzer, 150 kHz-1300 MHz, HPIB $1900.00
MPD LAB-1-510-10 Amplifier, 48 dB gain, 500-1000 MHz, 10 Watts $750.00
RACAL 9009 Modulation Meter, 30-1500 MHz, AM, 1.5-100 kHz pk FM $350.00
RF POWER LABS ML50 Amplifier, 2-30 MHz, 47 dB gain, 50 Watts, metered, 28 V $200.00
ROHDE&SCHWARZ ESH2 Test Receiver, 9 kHz-30 MHz $3250.00

COAXIAL & WAVEGUIDE

AEROWAVE 28-3000/10 WR28 Directional Coupler, 10 dB, 26.5-40 GHz $300.00
AMERICAN NUC. AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz, TNC(f) *NEW* $95.00
AVANTEK AMT-400X2 WR28 Active Doubler, +10 dBm in & out $450.00
BIRD 8201 500 Watt Oil Dielectric Load, DC-2.5 GHz $350.00
FXR/MICROLAB SL-03N Stub Stretcher, 0.3-6.0 GHz, 100 Watts max., N(m/f) $75.00
GENERAL RADIO 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz $400.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 $450.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz, N connectors $450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz $800.00
HP 33327L-006 Prog. Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm $1000.00
HP 778D-011 Dual Dir. Coupler, 20 dB, 0.1-2.0 GHz, APC7 $450.00
HP 8498A-030 30 dB Attenuator, 25 Watts, DC-18 GHz $500.00
HP 87300C-020 Directional Coupler, 20 dB, 1.0-26.5 GHz, 3.5mm $475.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz $350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz $450.00
HP K752C WR42 Directional Coupler, 10 dB, 18.0-26.5 GHz $450.00
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz $250.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz $650.00
HP R281A WR28 x 2.4mm(f) Adapter $600.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz $400.00
HP R752A WR28 Directional Coupler, 3 dB, 26.5-40 GHz $450.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz $450.00
HP R914B WR28 Moving Load, 26.5-40 GHz $250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz $750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz $650.00
HP X870A WR90 Slide Screw Tuner $150.00
HUGHES 45322H-1110/1120 WR22 Directional Couplers, 10 or 20 dB, 33-50 GHz $350.00
HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz $750.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz $900.00
HUGHES 45722H-1000 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $1000.00
HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz $1000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz $250.00
HUGHES 45752H-1000 WR22 Direct Reading Phase Shifter, 0-360, 33-50 GHz $1400.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz $400.00
HUGHES 47316H-1111 WR10 Tunable Detector, 75-110 GHz, pos. polarity $600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32 GHz, +18 dBm $2000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42 GHz, +18 dBm $2750.00
KRYTAR 201020010 Directional Detector, 1-20 GHz, SMA(f/f)/SMC $200.00
KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC $200.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz $450.00
NARDA 3000-series Octave Band Directional Couplers, N connectors $150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $375.00
NARDA 3090 Precision High Directivity Couplers $225.00
NARDA 368BNM Coaxial Hih Power Load, 500 Watts, 2-18 GHz, N(m) $500.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz $900.00
NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz $950.00
NARDA 4000-series Octave Band Directional Couplers, SMA connectors $75.00
NARDA 4247-20 Directional Coupler, 20 dB, 6.0-26.5 GHz, 3.5mm(f) $200.00
NARDA 5070-series Precision Reflectometer Couplers $300.00
NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f) $65.00
NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) $165.00
NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz $500.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
NARDA 793FM Direct Reading Variable Attenuator, 0-20 dB,4-8GHz $225.00
NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB,4-8GHz $375.00
OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, neg. polarity, SMA m/f $50.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz $250.00
SONOMA SCI. 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz $75.00
TEKTRONIX 2701 Step Attenuator, 0-79 dB, DC-1 GHz $150.00
TEKTRONIX WM782U WR19 Harmonic Mixer, 40-60 GHz $1500.00
TRG B510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $900.00
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG W510 WR10 Direct Reading Attenuator, 0-50 dB, 75-110 GHz $1000.00
TRG W551 WR10 Frequency Meter, 75-110 GHz $750.00
WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB $200.00
WEINSCHEL 150-110 Programmable Step Atten., DC-18 GHz, SMA $450.00
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) $150.00
WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) $150.00

COMMUNICATIONS

HP 37204A-003 HPIB Extender, fiber-optic connection *unused* $250.00
HP 4934A-J02 TIMS; CCITT option; battery power $1650.00
HP 59401A HPIB Bus Analyzer $375.00
TAMPA MW. LAB BUC1W-02W-CST Ku band Upconverter, 1 Watt 14.0-14.5 GHz WR75 *NEW* $150.00
TEKTRONIX 1411R-opt.04 PAL Test Gen., w/SPG12,TSG11,TSP11,TSG13,15,16 $1400.00
TEKTRONIX 147A NTSC Test Signal Generator, with noise test signal $800.00

MISCELLANEOUS

EG&G/ P.A.R. 5302 / 5316 Lock-in Amplifier, 100 mHz-1 MHz, GPIB / RS232C $2250.00
FLUKE 2180A RTD Digital Thermometer $500.00
HP 59307A HPIB VHF Switch $200.00
P.A.R. 5206-95.98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB $1250.00
TEKTRONIX TM5003 TM5000-series 3-slot Programmable Power Module $450.00
TEKTRONIX TM5006 TM5000-series 6-slot Programmable Power Module $500.00
TEKTRONIX TM503 TM500-series 3-slot Power Module $150.00
TEKTRONIX TM504 TM500-series 4-slot Power Module $175.00
TEKTRONIX TM506 TM500-series 6-slot Power Module $250.00
TEKTRONIX TM515 TM500-series 5-slot Portable Power Module $250.00

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Reader Feedback

Dear Nuts & Volts:

Concerning my article on the GlobeSpan Receiver in the June 2002 issue of *Nuts & Volts*, it has come to my attention that an IC specified for the project, the MC3340P has been discontinued and is unavailable. Likewise, the replacement parts NCG829 and NTE829 have been discontinued and are in short supply. Readers may be able to find a few of these parts, but I have not been able to obtain adequate supplies to include with my kits. Fortunately, the part is not essential and I have redesigned the circuit to exclude it. A copy of the new circuit is shown below in Figure 6. (Corrected schematic diagram of the GlobeSpan Receiver.)

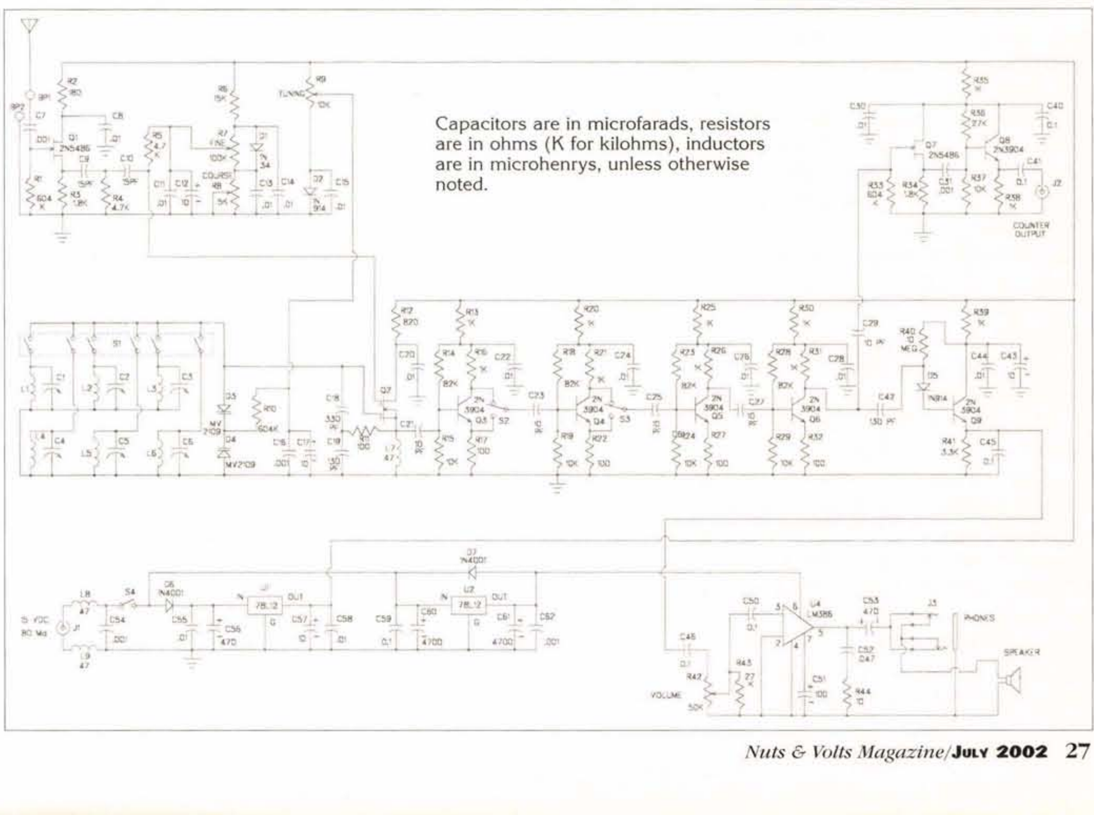
Without the MC3340P, the parts C47, C48, and C49 are unnecessary and are not included in my kits. C46 is changed to a 0.1µF ceramic capacitor and R43 is changed to 27 Kohm. The wiring of R43 is changed and the part can be mounted on the terminals of volume control (R42). Wires to connect to the volume control to the printed circuit board may be brought from the holes in the board intended for the MC3340P pins 1, 3, and 7.

R3 and R34 are changed from 1,800 ohms to 1,820 ohms, the standard EIA value for 1% resistors. R4 and R5 are changed from 4,700 ohms to 4,870 ohms for the same reason.

My apologies to the readers for any inconvenience this may have caused.

Lyle R. Williams

Editor's Note: A full size diagram is available for download from the Nuts & Volts web site at www.nutsvolts.com. The figure shown here is for reference purposes only.



Computer Interfacing: Part 3

Body Building 101 for TTL — Interfacing With Non-TTL Compatible Devices

By David A. Ward

Computer interfacing with TTL level signals (+5VDC = "1" and 0VDC = "0") is relatively easy and straightforward. In the real world, however, voltages are typically higher, poorly regulated, and may even be AC. This article – the third in a series of five – will show several devices and methods of inputting from non-TTL compatible sources, as well as outputting to control devices that are not TTL compatible. There is also the danger of damage to the delicate and expensive PC circuitry whenever any outside device is electrically connected to the PC expansion slot that must be prevented.

One of the safest ways to input digital data or either "ON" or "OFF" conditions is through an optoisolator, or optical isolator, or optical coupler. The most basic optoisolators are simply an LED and a photo-transistor encased together in a DIP package, see Figure 1. There are no electrical connections between the input side — the LED — and the output side — the photo-transistor. Therefore, only light connects the input to the output and there is little chance of any high voltage getting through to the computer circuitry. In fact, the isolation surge voltage rating for the 4N25 optoisolator is 7.5KV (AC Peak).

There are several varieties of optoisolators available: photo darlingtons, triacs, FETs, and multiple channel, to name a few. This article will introduce circuitry for the simplest optoisolator, the single channel, NPN transistor, 4N25.

Let's take a minute and look at a few of the 4N25's most important electrical ratings. The LED ratings are for a forward current of from 10mA up to a maximum of 60mA (continuous) and a maximum reverse voltage of 3V. The transistor is rated for a maximum continuous collector current of 150mA. There are many other ratings given on the manufacturer's data sheets, but these should be enough to do a circuit design, see Figure 2.

This circuit could be used as a digital input for one section of a burglar alarm system, for example, or anywhere you needed to input a single data bit from a higher DC voltage source. Although only two N.C. (normally closed) switches are shown in the schematic, you can place as many as you desire for different doors, windows, etc., in the alarm system.

The computer should expect to input a "0" if all of the switches are closed, the battery is good, and the wiring is complete. If any of the above changes, the LED will be off, the transistor will be off, and the computer will input a "1." Diode D1 is added to the circuit to protect the 4N25's LED from reverse electrical connections, since the PRV (peak reverse voltage) of the LED is only 3V. Any general-purpose diode with a higher PRV than the LED will help.

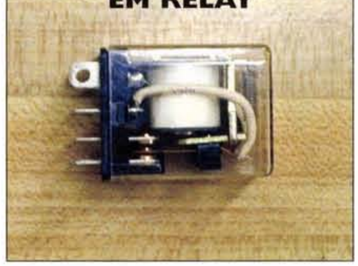
Resistor R1 is needed to limit the current flow through the LED to somewhere between 10mA and 60mA. To calculate the needed value for R1, figure a 0.7V drop across D1 and a 1.5V drop across the LED, that leaves 9.8V (12V - 0.7V - 1.5V) for the resistor to drop. A good LED current to shoot for might be 20mA, therefore, 9.8V / 20mA = a 490W resistor that will dissipate 196mW.

This circuit allows you to convert about any DC voltage over +5VDC into a TTL-compatible computer signal with no electrical connections between the higher voltage source and the computer. In fact, you don't want any connections, not even a common ground. The circuit can even accommodate AC input voltages by simply adding a capacitor, see Figure 3.

Notice also that there are no connections made to the base of the photo-transistor; this connection is only needed if you desire to adjust the sensitivity of the circuit. On some optoisolators, this connection is not even available to the user.

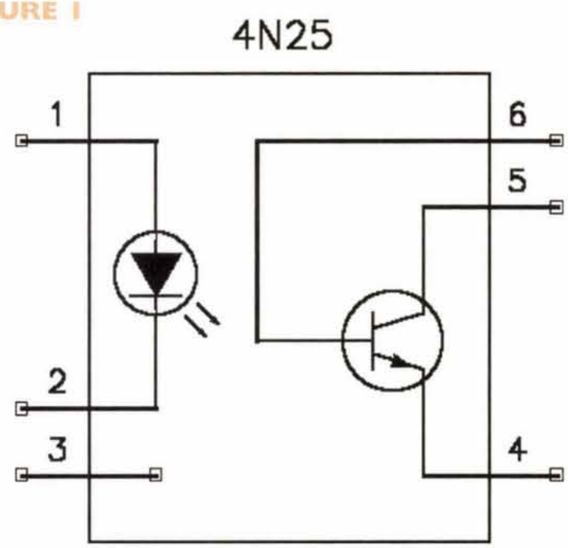
Since only one bit of the eight possible bits is being connected to the input port in this circuit, let's take a minute and look at ways to make the software look at only this particular bit (BD0) and ignore all of the others. This is referred to as "masking" which allows you to pick out one or more particular bits and ignore what the others are doing. This is a good idea in this case, since the other seven bits on the input side of the

EM RELAY



SOLID STATE RELAY

FIGURE 1



74LS244 are floating and could possibly pick up stray voltages and give unpredictable results. The QBASIC software example shown below could be used as a very simple burglar alarm program which masks out all bits but bit BD0.

```
X = INP(768) AND 1
WHILE X = 0
  X = INP(768) AND 1
WEND
SOUND 1000, 10
PRINT "Intruder Alert in Section "; X
```

The process of logically "ANDing" the number 1 with what is input into the computer provides the masking out of the other unwanted seven bits. All that is necessary to determine the number needed for masking is to add the binary weighting of the data bits together that you are interested in. For example, suppose you were interested in what bits BD1, BD4, and BD7 were doing and wanted to ignore the status of the other five bits, you would then determine the binary weighting of those bits, see Figure 4. BD1 has a weighting of 2, BD4 has a weighting of 16, and finally BD7 has a weighting of 128. The masking number then is 2 + 16 + 128 or 146. Changing the two lines in the program shown earlier to X = INP(768) AND 146 will now give you the status of the three bits you are interested in and ignore the others.

Now let's examine outputting to control a non-TTL device. We will look at two different ways to do this, first electro mechanical (EM) relays and secondly solid-state relays (SSRs), see Photos 1 and 2.

The circuit shown in Figure 5 can be used to control a low-voltage small current draw EM relay. For illustration purposes the contacts are shown controlling the voltage to a 6VAC incandescent lamp, however, you can connect whatever load you desire to those contacts depending on the contact voltage and current ratings. The +5VDC coil supply can also be changed to match the requirements of the relay's coil. The main thing to be concerned about is making sure that the transistor, Q1, can handle the current flow through the coil. Diode D1 was added to the circuit to protect Q1 when the transistor is turned off and the coil's electro magnetic fields collapse and produce a voltage. The software to operate the circuit is simple: OUT 769, 1 to turn the relay on, and OUT 769, 0 to turn it off.

When selecting EM relays, there are a few important specifications to consider. First, the coil's voltage rating and whether it is AC or DC. Typically, lower voltage relays are DC. Secondly, the coil's current draw — often times the manufacturer's specifications list a coil's DC resistance, but not its current draw. You can calculate the current draw by dividing the coil voltage by its DC resistance.

FIGURE 2

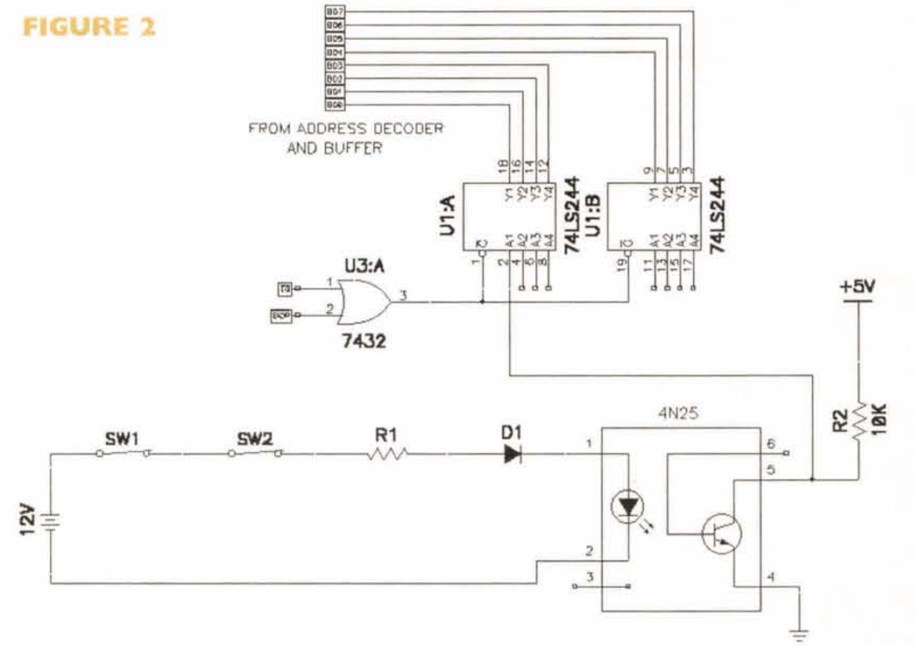
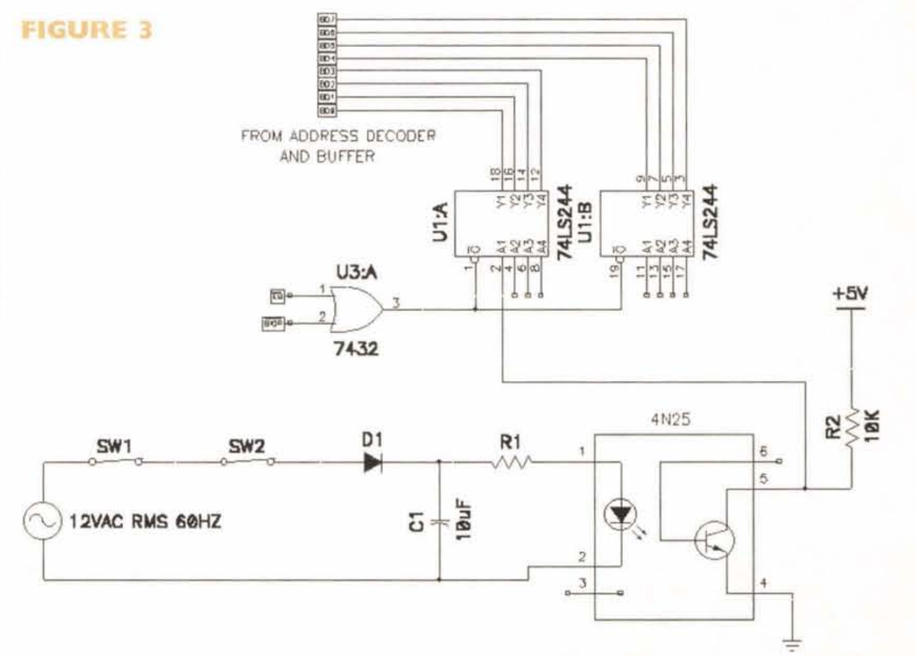


FIGURE 3



BD7	BD6	BD5	BD4	BD3	BD2	BD1	BD0	Data Bits
128	64	32	16	8	4	2	1	Binary Weighting
1	0	0	1	0	0	1	0	Wanted Bits = 1

FIGURE 4

The EM relay's contact specifications are the next item to consider. Of course, the voltage and current ratings are the most important. The contact configuration is usually listed the same as switches are: N.O. stands for normally open, N.C. stands for normally closed, S stands for single, D stands for double, P stands for pole, and T stands for throw. One of the most common EM relay contact configurations is DPDT (double pole double throw) for a total of six contact connections. The contacts in Figure 5 are SPDT (single pole double throw), contact C1 is the common contact, C3 is the N.C. (normally closed) contact, and C2 is the N.O. (normally open) contact.

One last thing to consider is the type of package that the relay comes in. Is it a PCB mount package, or does it have solder terminals, and how big is it?

Now let's take a look at solid-state relays or SSRs. There are two types of SSR outputs, DC and AC. Since SSRs use a semiconductor at their output, they typically cannot handle both AC and DC voltages like EM relays can. Also, this may require that the SSR have some heatsinking connected to the package to keep the semiconductor cool, which is not required on EM relays. SSRs typically have only one type of output configuration, SPST N.O. But SSRs do have a couple of advantages over EM relays, first they usually come equipped with TTL compatible, opti-

FIGURE 5

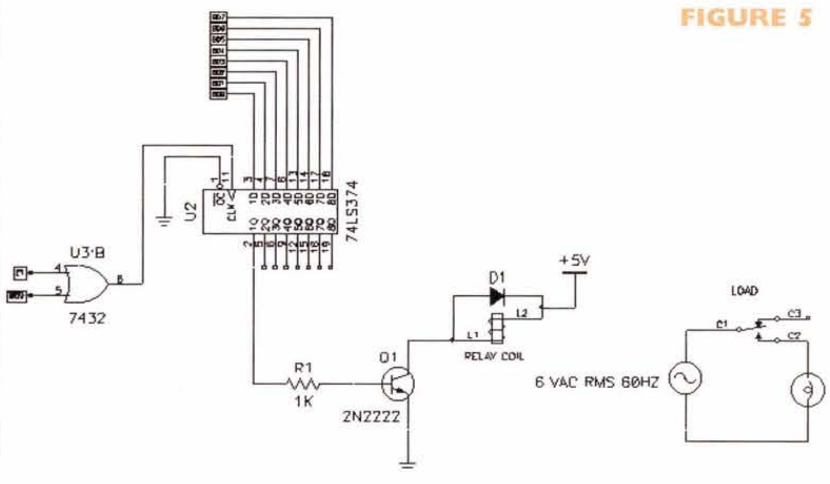
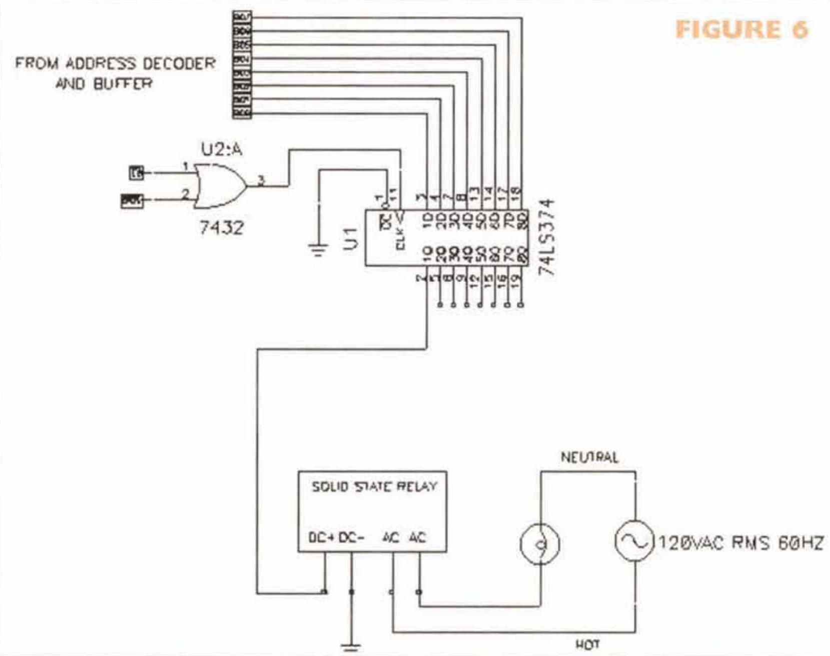


FIGURE 6



cally-isolated inputs and secondly they can be switched off and on at a much higher rate than any EM relay can operate at. All that is necessary to control a SSR is to connect the DC positive input to a TTL level output and the DC negative input to the ground coming from that TTL level output, see Figure 6.

You might even think of an SSR as an optoisolator on steroids. It has the circuitry inside to handle high voltages up to 240VAC, high currents up to 40 amps, is TTL compatible, is quiet, provides a high degree of protection for your computer circuitry, and can be cycled off and on at high speeds.

Well that introduces inputting and outputting with non-TTL level devices. The next article in this five-part series of computer interfacing articles will deal with inputting from analog devices, such as a temperature transducer, and outputting an analog signal. **NV**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A major revision of the bestselling "bible" of amateur robotics building — packed with the latest in servo motor technology, microcontrolled robots, remote control, Lego Mindstorms Kits, and other commercial kits. ***$24.95***

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This reference is the first guide to cover all the most common types of microcontrollers. With its from-the-bottom-up approach, this book/CD-ROM package gives you all the information you need to simplify the job of selecting the right microcontroller and writing an application for it. ***$54.95***

Programming & Customizing the 8051 Microcontroller
by Myke Predko

Programming and Customizing the 8051 Microcontroller puts you in control of the 8051's architecture and instruction set — and even supplies a baker's dozen of ready-to-build example applications, programs, and circuits. Best of all, the included CD-ROM supplies source code for the book's experiments and applications. ***$39.95***

Programming & Customizing the HC11 Microcontroller
by Tom Fox

Applications bazaar for the 68HC11 microcontroller. Squeeze every last drop of power out of Motorola's wildly popular family of 68HC11 true 8-bit single chip computers! From basics to complete applications. ***$39.95***

Programming & Customizing PICmicro Microcontrollers *2nd Edition*
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This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicro's hardware architecture and software schemes complement the host of experiments and projects making this a true, "learn as you go" tutorial. ***$49.95***

PICmicro Microcontroller Pocket Reference
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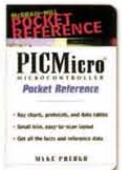
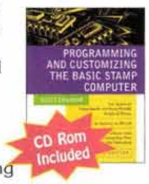


Designed to complement Programming & Customizing the PICMICRO, this book contains a minimum of verbiage and serves as an immediate device, code and circuit look-up for experienced PICMICRO applications designers. **$49.95**

Programming & Customizing the BASIC Stamp Computer
by Scott Edwards



This edition moves you briskly from electronic foundations through BASIC Stamp "Boot Camps" and an intelligent traffic signal simulation to build a robotic bug with whisker sensors, a time/temperature display, and a data-logging thermometer. ***$39.95***

PIC Microcontroller Project Book
by John Iovine

This project-oriented guide gives you 12 complete projects, including: using transistors to control DC and AC motors, DTMF phone number logger and distinct ring detector and router ... home automation using X-10 communications ... digital oscilloscope ... simulations of fuzzy logic and neural networks ... and many other applications. ***$29.95***

The Nuts & Volts of BASIC Stamps Vol. 1 & 2

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In 1995, Scott Edwards began authoring a column on BASIC Stamp projects in *Nuts & Volts Magazine*. The column quickly became a favorite of *Nuts & Volts* readers and continues today with Jon Williams at the helm. *The Nuts and Volts of BASIC Stamps* is a collection of about 75 of these columns.

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Secrets of RF Circuit Design *3rd Edition*
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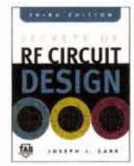

This revised and updated guide gives you the best ways to design, build, and test today's radio frequency circuits. It's filled with projects and experiments that make it easy to apply RF principles to real-life applications. ***$39.95***

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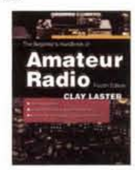

The revised edition of the most trusted guide in ham radio is here. This edition delivers all the guidance you need — from radio and electronics fundamentals needed to set up a transmitter to the newest equipment to revisions to the FCC rules and tests. ***$34.95***

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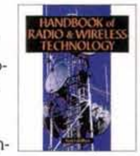

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This experiment-oriented guide is loaded with over 750 hand-drawn images that support author Paul Scherz's crystal-clear, fully detailed instructions, showing you how to turn theoretical ideas into real-life gadgets. ***$39.95***

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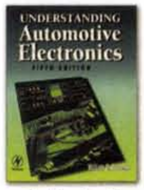
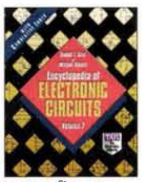


This edition of *Understanding Automotive Electronics* covers the most recent technological advances in operation and troubleshooting of electronic systems and components. This is a practical text, suitable for the automotive technician, student or enthusiast. It includes low-emission standards, on-board diagnostics and communications, digital instrumentation, and digital engine control. ***$34.99***

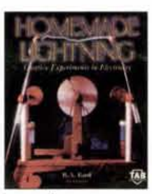
Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graff



Designed for quick reference and on-the-job use, the *Encyclopedia of Electronic Circuits*, Volume 7, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants such as Advanced Micro Devices, Motorola, Teledyne, GE, and others, as well as your favorite publications, including *Nuts & Volts*! ***$39.95***

High Voltage

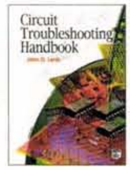
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



Enter the wide-open frontier of high-voltage electrostatics with this fascinating, experiment-filled guide. You'll discover how to make your own equipment, how electricity is used in healing, and the workings of many experiments in high potential physics! ***$24.95***

Troubleshooting

Circuit Troubleshooting Handbook
by John D. Lenk



Heavily illustrated with diagrams and schematics, it uses a standard, easy-to-follow format to help readers understand and troubleshoot a wide range of circuit types, and provides proven circuit testing techniques for all levels of instrumentation. ***$39.95***

Electronic Troubleshooting *2nd Edition*
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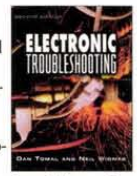
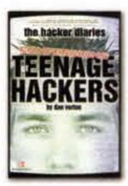


This updated tool gives all the fundamentals needed to do successful servicing and repair work, blending traditional theory with the very latest insight into modern electronics technology. Time-saving tables, charts, and illustrations pinpoint equipment problems in a snap. Numerous reference guides, rules of thumb, and tricks of the trade all combine to assist in troubleshooting the full spectrum of devices and products more easily than ever before. ***$39.95***

Miscellaneous

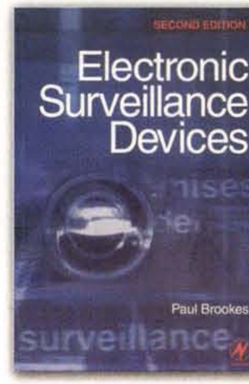
The Hacker Diaries: Confessions of Teenage Hackers
by Dan Verton



Through fascinating interviews with FBI agents, criminal psychologists, law-enforcement officials—as well as current and former hackers—you'll get a glimpse inside the mind of today's teenage hacker. Learn how they think and understand the internal and external pressures that pushed them deeper and deeper into the hacker underground. ***$24.99***

This Month's Featured Titles

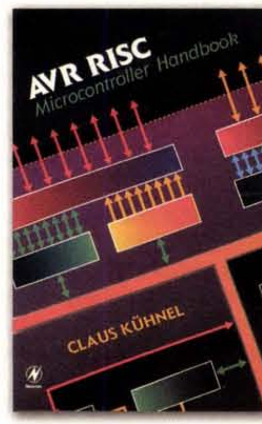
Electronic Surveillance Devices
by Paul Brookes
$39.99



This is the book that security professionals, security system installers and hobbyists have been waiting for. Paul Brookes launches straight into the practicalities of electronic surveillance with plenty of clear, detailed information on building the devices that are at the heart of surveillance and counter-surveillance. Self-build electronics projects are supported by principles and a brief survey of each type of device.

Check out these new additions

AVR RISC Microcontroller Handbook
by Claus Kuhnel
$39.99



The *AVR RISC Microcontroller Handbook* is a comprehensive guide to designing with Atmel's new controller family, which is designed to offer high speed and low power consumption at a lower cost. The main text is divided into three sections: hardware, which covers all internal peripherals; software, which covers programming and the instruction set; and tools, which explains using Atmel's Assembler and Simulator (available on the Web) as well as IAR's C compiler.

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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's projects include a radiation detector, mosquito microphone, and two camping solutions. USB ports and ATX power supplies complete, and a reader invents a better mouse trap. Plus more.

Get A Half-Life

Q. I have seen a lot of information about the suitability of low-cost cadmium zinc telluride (CZT) devices for making an inexpensive nuclear radiation detector, but I've never seen a diagram or any applications information to begin experimenting. Any idea of how these things are actually implemented in an inexpensive detector, or where to get one?

Bob Grove
via Internet

A. Since September 11, a lot of news reports and publications would lead you to believe that this technology is more advanced and readily available than it is. In fact, a recent article in *Technology Review* **(www.techreview.com/offthewire/3001_842002_3.asp)** describes a Palm Pilot Cadmium Zinc Telluride, nicknamed the PPCZT, that converts data from the crystal sensor into a "radiological fingerprint," which it checks against the computer's own library to identify the type of radioactive material. Obviously, this is far beyond what the typical hobbyist can do within a limited budget. However, if you're still interested in finding more information and a source for this technology, start with Bicron at **http://pub.bicronne.com/inorganics/czt.pdf** (Figure 1).

Now, if you're looking for a cheap, practical way to detect nuclear radiation, I suggest using a Geiger-Mueller tube, which you can purchase from **www.surplustuff.com/radiolog.html** for $29.95. The Geiger tube is evacuated and filled with neon, argon, and halogen (chlorine or bromine) gases. In the center is a positively-charged, high-voltage rod. When an atomic particle passes through the gases, it ionizes them, which sharply reduces its internal resistance and causes current to flow. This situation is short-lived, and the gases quickly (typically 100 uS) return to their non-conducting state, armed and ready for another passing particle. This pulse is easily amplified for audio or visual output. The Internet is chock-full of schematics for Geiger counter devices **(www.mathematik.uni-marburg.de/~kronjaeg/hv/radio/geiger/)**. Here's one (Figure 2) I find particularly interesting and easy to build.

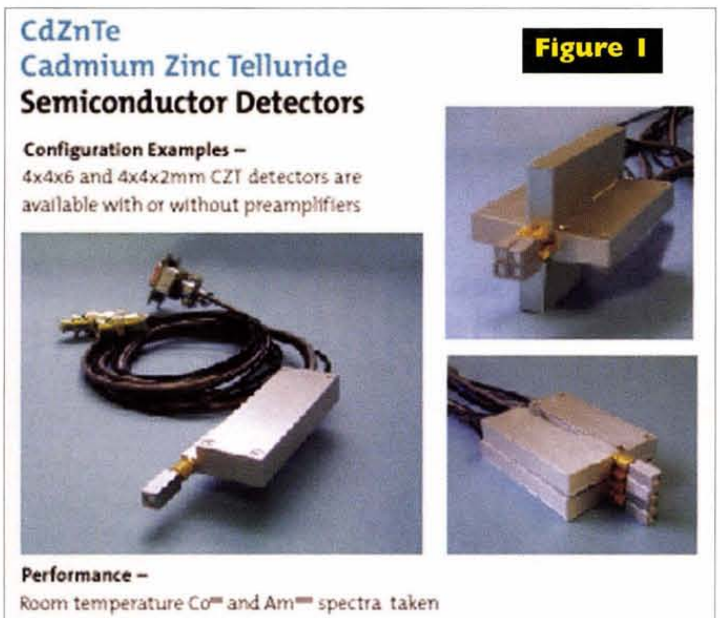


Figure 1

The USB Connection

Q. I have an ATX motherboard which has two USB connectors on the back, accessible from the rear of the computer. I am installing the board in a cabinet which has two external USB jacks mounted on the front of the computer with only three wire leads that are labeled: +5V, -D, and +D (I presume that the -D and +D are the data connectors). The USB jacks on the motherboard have four contacts plus a metal shell which contacts the motherboard ground and feeds through as a shield to the other end of the USB cable.

I propose to feed the leads from the front panel jacks and connect them to the motherboard's USB connectors on the back. Which contacts in the motherboard USB connector are -

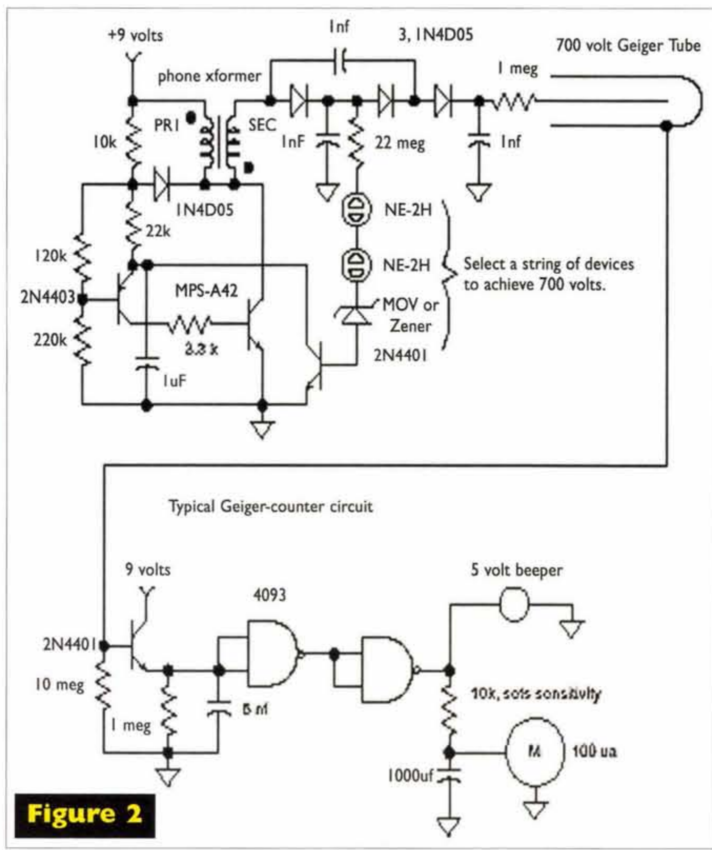


Figure 2

D, +D, and +5V? Is the fourth USB jack contact not used? Do I need a ground lead for the shield? If so, why is a [drain] wire lead not provided for this in the cabinet connector?

Curt Powell
via Internet

A. If your motherboard is like mine, it has two USB mini-B ports, which have five connections. And I bet the front panel of the cabinet has the older USB Series B connector with four connections. Here's how the two compare (Figure 3).

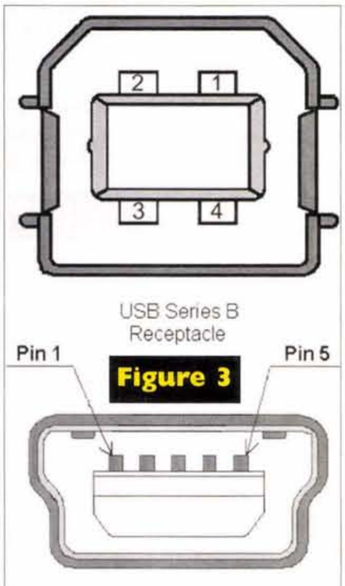
Now to connect the two together, follow this wiring chart. Why isn't a lead provided for the shield? Probably because everything is grounded inside the cabinet which provides the drain wire connection, but check it out with an ohmmeter just to be sure.

USB Series B Pinout

Pin Number	Signal Name	Wire Color
1	VBUS (+5V)	Red
2	D- (data)	White
3	D+ (data)	Green
4	GND	Black
Shell	Shield	Drain Wire

USB mini-B Pinout

Pin Number	Signal Name	Wire Color
1	VBUS (+5V)	Red
2	D- (data)	White
3	D+ (data)	Green
4	ID	not connected
5	GND	Black
Shell	Shield	Drain Wire



USB Series B Receptacle

Figure 3

USB Mini-B Receptacle

USB Converters

Q. I have a 3Com Homeconnect webcam that has a parallel port connector. Can this be adapted to a USB connector?

Marvin Rosen
Baltimore, MD

A. According to what I know about this camera, it already has a USB interface. Do you have a model I don't know about? And no, the only parallel port to USB converters I know of are printer adapters for PCs with USB ports. Now, if you want to convert a USB port to an RS-232 serial port, there is an abundance of them on the market from sources like **B&B Electronics (815-433-5100; www.bb-elec.com)**, with prices starting as low as $39.95.

Stop And Smell The Coffee

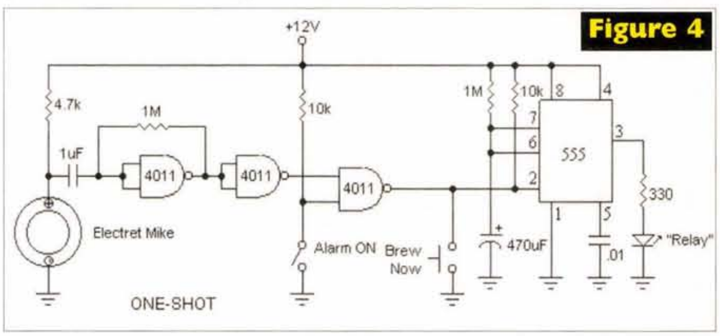
Q. I own a small camper with a 12-volt system (what else) and have a 12-volt coffee pot that brews coffee at a very slow rate (it takes 45 to 55 minutes to brew five cups). I would like to have an alarm clock (AA-battery operated) set to go off an hour or so before I wake up and have coffee ready. I have a solid-state DC relay that can handle 15 amps at 12 volts so that end is covered. Two problems: I don't think most battery-operated alarm clocks operate their alarms long enough for the coffee to perk, and where do I get the three volts from the alarm to activate the "coil?" Oh yes, another one on my requests is to keep this circuit as small and as simple as possible.

Tom Farkas
Seattle, WA

A. I really like it when I can keep it simple stupid (KISS), and this is an opportunity. What I'd do is get a traveling alarm clock with a LOUD buzzer. Then, I'd use a rubber band or masking tape to secure a electret microphone (RadioShack 270-092 or equivalent) against the buzzer. The circuit I've shown in Figure 4 responds to that alarm and starts your coffee brewing.

The first stage is a NAND gate that I've configured as an amplifier (via the 1M feedback resistor). This signal goes to another gate that generates a pulse that triggers a monostable 555 multivibrator. Using the values shown in the schematic, the timer will turn your relay on for just over an hour. (I'm assuming your solid-state relay uses an internal LED to turn on. If not, adjust the output of the 555 accordingly). If you wish to keep your coffee pot going for longer, increase the capacitance of the 470uF timing capacitor; a rule of thumb is about 330uF per hour.

Figure 4



Nature Abhors A Vacuum

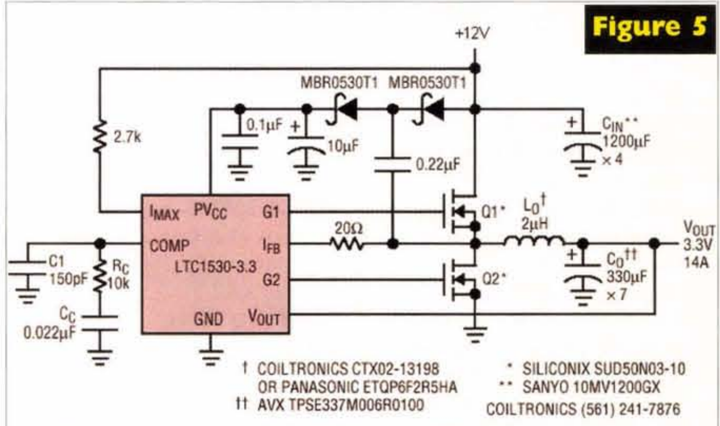
Q. We have a very small, Class B motorhome with very limited space. I use an old Black & Decker hand vacuum, which runs on rechargeable batteries — and not very well, at that — to keep the place clean. I would like to try it on the motorhome battery. Can you show me a practical circuit that will convert 12.6 volts DC to 3.6 volts DC and deliver 15 amps? Or is this a lost cause?

Don Smith K6CHS
via Internet

A. This is an easy call, but I hope you have your construction skills up to speed because the LTC1530 IC has a tiny SOIC footprint, as do the power transistors, and a lot of attention has to be paid to the layout. I suggest studying the datasheet **(www.linear-tech.com/pdf/1530fs.pdf)** before you attempt this project (Figure 5.

Although the IC is rated at 3.3 volts, I'm sure it'll provide as much, if not more, power than your current batteries. Don't attempt to substitute the specified capacitors and coils because they are critical to the circuit's performance. Finally, the circuit is small enough to fit in the handle of your vacuum, which is the best place to install it.

Figure 5



Supersonic Sensor

Q. I'm working on a hobby project to set a quartz wrist watch to better than one second per month and perhaps one second per year. I want to use a microphone to pick up the sound from the crystal inside a metal encased wrist watch, which I'll monitor with my counter that's calibrated to a rubidium standard (next I'll get a cesium). It's just a good way to waste time that I find intriguing. I've searched the Internet for an ultrasonic microphone that's sensitive at 32.768 kHz, but can find nothing under $2,000.00. Do you know of any suppliers?

Hank WD5JFR
via Internet

A. There are some transducers that are tuned for 32 kHz, but they are generally designed for sonar applications and are, therefore, quite expensive. The reason that so many transducers peak at 40 kHz is because that's the frequency of virtually all IR remote devices, which are plentiful and cheap. However, it is possible to use a 40 kHz microphone at 32 kHz by detuning the pick-up, as I've done in the circuit below (Figure 6).

Each sonic transducer has different electrical parameters, hence, each requires a different detuning method. The "microphone" I chose is from **Mouser Electronics (800-346-6873; www.mouser.com)**, and requires a 6.8-uH inductor (also available from Mouser) to equalize its frequency response. The signal is then amplified by 200 using an LM386 amplifier and squared up via a pair of inverter gates. If you need more gain, a second LM386 can be inserted between the first amp and the 4001 inverters.

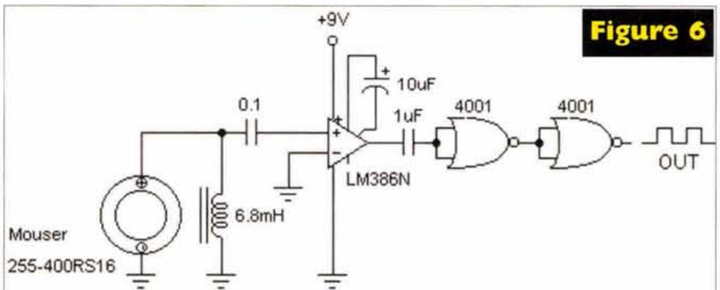


Figure 6

Sharing One Phone Line

Q. My need is for an indicator that will tell me when my phone rings when I am on a telephone call. I have voice mail that picks up the call if I am using the line, but then I do not know that a call has come in unless, after I complete my phone call and hang up the phone, I raise the handset to determine if there is a special beep that indicates there has been a phone call. It is worse when I am using my email because my computer modem and telephone are connected to the same telephone number. Thus, I do not know when using my AOL service when a call has arrived.

Harold M. Tepper
via Internet

A. There's a nifty software program, called CallWave, that lets you surf the Internet on a single phone line without worrying about missing important phone calls. CallWave works with the "Call Forward On Busy" feature of your phone line to answer calls while you are online. Once activated, callers no longer get annoying busy signals when you're online. Instead, callers will hear a brief CallWave greeting after which they can leave a short message at the tone — that you will be able to hear instantly through your PC speakers. Although the service is free, you may have to endure some ads. CallWave is located at **http://psstt.com/1/c/23071/48121/166150/166150**.

If you prefer a hardware solution, there's the **Emerson Switchboard (800-878-4764; www.emerson-switchboard.com)**. The Emerson Switchboard ($39.99) temporarily splits your phone signal into three separate lines — computer, phone, and fax. There's no software needed and no installation; it simply plugs into your existing phone jack. You do need a "Call Waiting" service, though, from which the Switchboard gets its cue and flashes an indicator of an incoming call. Catch-A-Call **(www.catch-a-call-online.com)** sells a similar device for $49.95.

Care And Feeding Of Batteries

Q. I have a couple of questions about batteries. When Nickel-Cadmium batteries are not in use, is it better to leave them charged or uncharged? Same

Building A PC Power Supply From Scratch

Q. Do you know how to power a desktop PC from a 12-volt battery, like those used in cars and trucks? I don't want to use a notebook computer — or a 12-volt DC to 120 VAC inverter because it wastes too much power.

David Keefe
via Internet

A. The answer is yes, but the question is why? This is quite an undertaking because the internal PC power supply is designed to run off 160 volts DC, which is derived from the rectified AC line. So you could make a 12-volt to 160-volt DC converter at 250 watts and feed that to the PC's power supply. Or you could replace the PC power supply with a DC design of your own. Here are the voltages required by the PC and what they power.

+3.3 VDC	Motherboard logic, AGP, PCI bus
+5 VDC	Motherboard logic, drive logic, PCI bus, ISA bus
+12 VDC	Fans, disk drive motors, PCI bus, ISA bus
-5 VDC	Legacy ISA bus
-12 VDC	Legacy ISA bus, serial ports (including PS/2)
+5 VSB	Motherboard standby, LAN standby, modem standby

Typical ATX Power Supply Distribution

Output Voltage	200 Watts	250 Watts	300 Watts
+3.3 VDC	14.0 amps	16.0 amps	20.0 amps
+5 VDC	21.0 amps	25.0 amps	30.0 amps
+12 VDC	8.0 amps	10.0 amps	12.0 amps
-5 VDC	0.3 amps	0.3 amps	0.3 amps
-12 VDC	0.8 amps	0.8 amps	0.8 amps
+5 VSB	1.5 amps	1.5 amps	1.5 amps

Typical ATX12V Power Supply Distribution

Output Voltage	200 Watts	250 Watts	300 Watts
+3.3 VDC	14.0 amps	20.0 amps	28.0 amps
+5 VDC	21.0 amps	25.0 amps	30.0 amps
+12 VDC	10.0 amps	13.0 amps	15.0 amps
-5 VDC	0.3 amps	0.3 amps	0.3 amps
-12 VDC	0.8 amps	0.8 amps	0.8 amps
+5 VSB	1.5 amps	1.5 amps	2.0 amps

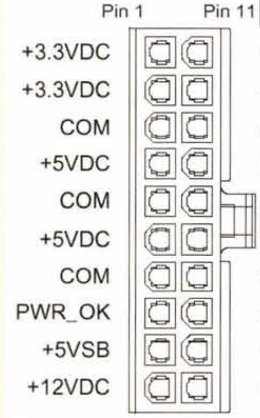
ATX Connector Pinout

Pin	Signal	Color	Pin	Signal	Color
1	+3.3 VDC	Orange	11	+3.3 VDC	Orange
2	+3.3 VDC	Orange	12	-12 VDC	Blue
3	Common	Black	13	Common	Black
4	+5 VDC	Red	14	PS_ON#	Green
5	Common	Black	15	Common	Black
6	+5 VDC	Red	16	Common	Black
7	Common	Black	17	Common	Black
8	PWR_OK	Gray	18	-5 VDC	White
9	+5 VSB	Purple	19	+5 VDC	Red
10	+12 VDC	Yellow	20	+5 VDC	Red

The ATX connector and pinouts are shown in the table to the left and drawing below (Figure 7). Be aware that all voltages must be held to ±5% of the nominal value, which means the voltage limits of the +3.3 VDC line must be held within the range of 3.14 to 3.47 volts. Once you have the voltage regulators conquered, you still have to match them to the motherboard power-up sequence **(www.enhanceusa.com/documents/ATX12V.pdf)**.

I know you didn't want to use a notebook PC or a 12-volt inverter for this application, but given the amount of work you have to do to build an ATX power supply from the ground up, I'd seriously consider using one or the other.

Figure 7



Cool Web Sites!

This vivid scene reproduced from Rudolph Zallinger's famous dinosaur mural **The Age of Reptiles**, overlooking the Great Hall in Yale's Peabody Museum, is far more than a magnificent work of art. It is also a scientific document transforming the knowledge, ideas, and thoughts of many scholars of earth history spanning more than 300 million years.

www.peabody.yale.edu/mural/.

The history of computer development is often referred to in reference to the different generations of computing devices. Read about each generation and the developments that led to the current devices that we use today.

www.webopedia.com/DidYouKnow/2002/April/FiveGenerations.html

The history of the Apollo project from the first earth orbiters to the Swan Song of Apollo 17 is choreographed in this NASA site. Includes mission assignment, fractoids, spacecraft details, and a full library of photos for each mission.

http://spaceflight.nasa.gov/history/apollo/

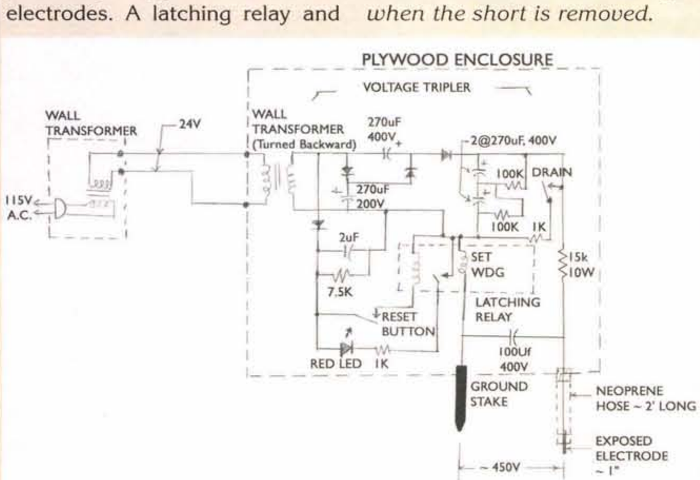
Reader's Tip: A Better "Mouse" Trap

After reading your column in the Jul. 01 issue on pest control, I wondered if you might be interested in my solution to a local pest known as a pocket gopher. These critters live in tunnels some 8 to 10 inches beneath the surface, and periodically throw up unsightly piles of dirt as they expand their underground subway system (which can extend for acres). Professional exterminators prefer to trap them using miniature "bear" traps. However, my personal experience has found this method to be less than ideal.

My solution is the assembly shown in the drawing below. It needs only a small hole through the sod to place the hot electrode. The circuit is essentially a voltage tripler that will deliver a 400-volt jolt to anything placed across the electrodes. A latching relay and LED indicate when the circuit has been "tripped" either by a furry body or a misplaced electrode. A drain switch is included for safety purposes to discharge the capacitors after power is disconnected so that you don't get a jolt, too. Somewhat limited experience to date indicates this method to be effective in ridding my lawn of the rodents.

John S. Young
Scottsdale, AZ

Editor's note: *I took the liberty of adding a 15k resistor and a 100uF capacitor to John's original design to limit the amount of current the electrodes would draw if shorted, thus preventing possible damage to the circuit. The 100uF cap slowly charges (1.5 sec) through the resistor and provides a 400-volt zap to the varmint when the electrode is contacted, and recharges when the short is removed.*



question about Nickel Metal Hydride. I have never seen this subject addressed in any article.

Al Izatt
via Internet

A. Yes, it's hard to find short, useful papers on battery maintenance. Most concentrate just on battery charging chemistry. So let me try to fill in the gaps.

When you buy a rechargeable battery off the shelf, it's fully discharged. Which means you have to give it life. As a rule, you should run the battery through three full charge/discharge cycles before putting it into service. The exception is sealed lead-acid batteries, which require one charge cycle.

Rechargeable batteries perform better when trickle charged. Fast charging is permitted if the battery's charge time or internal temperature is carefully monitored to prevent overheating. To calculate charge time (in hours) for any battery, here's a rule of thumb.

Slow charge: (cell capacity in mAH / charge rate in mA) x 1.4
where the charge rate is about 1/10 battery capacity

Fast charge: (cell capacity in mAH / charge rate in mA) x 1.5
where the charge rate is between 1/5 and 4x battery capacity

For example, if the battery is rated at 1000 mAH and the charge rate is 500 mA, you will need to charge the battery for approximately three hours. NiCd batteries should never be left on charge for more than 30 hours.

When not in use, store the battery in a cool, dry place. Do not expose it to direct sunlight, below 30 degrees F, or above 100 degrees F. (NASA recommends 32 degrees F for long-term storage.) Always discharge NiCd, NiMH, and Li-Ion batteries before storing. Fully charge lead-acid batteries before storing and periodically check the charge in the battery during storage, replenishing the charge if it drops below 50 percent of full charge.

Finally, exercising your battery can improve battery life. To exercise a rechargeable battery, first discharge the battery to one volt per cell, or until the "low battery" indicator turns on. Then recharge the battery with a trickle current until fully charged. A fully charged NiCd battery will show approximately 1.35 volts per cell, and a NiMH battery will show about 1.39 volts per cell. Immediately place the battery back in service, don't let it sit on the shelf.

New Product News

FUTURE OF SURVEILLANCE TECHNOLOGY

American Innovations, Inc., introduces their newest fully-automated, battery-powered, motion-activated Wireless Covert Surveillance system.

Simply charge your plant, place it in the area you need to monitor, and walk away. As soon as someone enters the area, your monitoring system will turn itself on and begin transmitting video through walls, floors, and ceilings up to 300 feet to its designated receiver that is built into an event recorder.

An intelligent chip also built into the recorder will trigger the record function and transmit a confirmation signal back to a remote control that confirms the system is engaged and actually recording.

This plug and play system is ready to use out of the box and includes: one battery-powered intelligent plant camera, battery charger with full charge LED indicator, and a Sony 24-hour event recorder that incorporates a receiver, high-gain antenna, intelligent chip, and flip-up color LCD monitor for live monitoring or event playback. When a fast installation is a must, power isn't available, running video cables isn't an option, and reliability is imperative, here's your solution that requires no technical background to operate!

For more information, contact:

AMERICAN INNOVATIONS, INC.
383 W. Rt. 59, Dept. NV
Spring Valley, NY 10977
845-371-3333 ext. 907
Fax **845-371-3885**
SFisher@AmericanInnovations.com

INDUSTRIAL GRADE 7.8" TOUCH MONITOR

Earth Computer Technologies launches a new 7.8"analog resistive touch monitor designed for the avid computer user seeking a smaller, secondary reference monitor for applications where an additional display would provide a more efficient work environment.

The XLM-78ST 7.8" color LCD monitor is rugged enough to withstand the punishment of kiosk applications and small enough to use as a secondary monitor to display dash controls for video game enthusiasts. The monitor's sturdy welded aluminum enclosure is powder coated for a long life finish.

The XLM-78ST complies with the VESA standards and is equipped with a 75mm interface, allowing for virtually any type of mounting options.

The LCD touch feature is enabled through a simple connection to a standard serial mouse port.

Additional features include: 640x480 resolution, 45:1 contrast ratio, 80 cd/m2 brightness and 0.246 x 0.246 pixel pitch, and is standard with an analog VGA input, and includes a five-volt power supply.

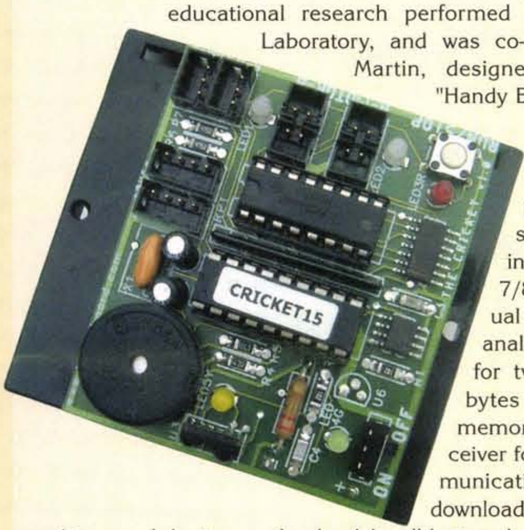
The XLM-78ST can be purchased directly from Earth at www.earthlcd.com. Priced at $349.00 for the cost-conscious buyer.

For additional information, contact Jennifer Arnold at 949-248-2333 ext. 223.

EARTH COMPUTER TECHNOLOGIES, INC.
32701 Calle Perfecto, Dept. NV
San Juan Capistrano, CA 92675
949-248-2333 ext. 223
Fax: **949-248-2392**
Web: **www.earthlcd.com**

THE "HANDY CRICKET"

The Handy Cricket, a new PIC-based microcontroller board, is now available from Gleason Research. The Handy Cricket is based on educational research performed at the MIT Media Laboratory, and was co-developed by Fred Martin, designer of the popular "Handy Board" controller.



The Handy Cricket puts a group of essential features into one small board measuring just 2-1/4" x 1-7/8". There are individual connectors for two analog sensors, drivers for two DC motors, 4K bytes of user-program memory, an infrared transceiver for inter-Cricket communications and program download, a piezo beeper, a run/stop push button, and a 4 x AA cell battery holder.

In addition, the Handy Cricket includes a powered expansion bus that allows you to connect a variety of "smart" peripherals, daisy-chain style. A series of add-on devices are in the works, including a four-digit LED display, a servo motor control board, and a motor/sensor expansion board.

Crickets are programmed using "Cricket Logo," an easy-to-learn yet powerful language that includes features such as 16-bit numbers, global variables and arrays, looping and conditional control structures, and user functions with arguments and return values.

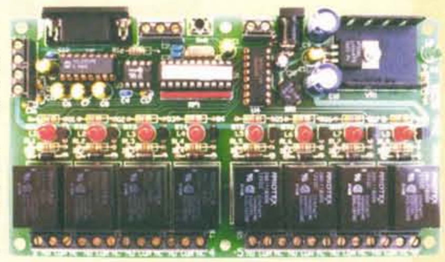
Cricket Logo also includes a command window that lets you interactively test and develop your code. Cricket Logo runs on Windows, Macintosh, and the Linux operating system.

Individual Handy Crickets sell for $59.00; a starter kit including one Handy Cricket, a serial-to-IR interface, and a sensor/motor package is $99.00.

For more information, contact:

GLEASON RESEARCH
P.O. Box 1494, Dept. NV
Concord, MA 01742
1-800-265-7727 Fax: **978-287-4170**
Email: **info@gleasonresearch.com**
Web: **http://gleasonresearch.com**

RC51 PROGRAMMABLE RELAY CONTROLLER



Industrologic, Inc., announces the release of their RC51 Programmable Relay Controller.

The Industro-logic RC51 is a microcontroller-based single board computer designed to be a complete industrial relay controller assembly that is easy to program and connect to external signals. It includes not only a large bank of high current relays, but a number of logic level input/output signals, as well.

The board can be programmed as a stand-alone controller using its on-board Tiny Machine Basic programming language, or it can be used as an RS-232 serial data acquisition board.

The RC51 is based on the Atmel AT89C4051 microcontroller chip with EEPROM program memory, and can be reprogrammed using any number of software development tools and device programmers available for Atmel microcontrollers.

The RC51 package is shipped complete with all items necessary to immediately begin application development, including a serial port cable for connection to a PC-compatible computer, a wall block power supply, host computer software and programming examples, and hardware and software reference manuals.

For more information, contact:

INDUSTROLOGIC, INC.
3201 Highgate Ln., Dept. NV
St. Charles, MO 63301
636-723-4000 Fax: **636-723-6000**
1-800-435-1975
Email: **info@industrologic.com**
Web: **www.industrologic.com**

IsoPod™

The new IsoPod™ , a tiny 1.2" x 3.0" controller board, ships this month from New Micros, Inc. The IsoPod is a complete system with a built-in high-level language and parallel processing operating system, IsoMax™.

Hardware features on this new processor include 16 general-purpose digital I/O lines, two serial channels, RS-232 and RS-422/485, CAN BUS, an SPI Interface, eight channels of 12-bit A/D, eight general-purpose timers, 12 (PWM) outputs which can be used individually to control R/C Servos, or grouped to control up to two three-phase brushless DC motors, and a two-channel quadrature decoder to read motor position encoders.

The IsoPod brings an amazing amount of computing and control function to a very small space at a very reasonable cost. A single unit is $99.00.

NEW MICROS, INC.
1601 Chalk Hill Rd., Dept. NV
Dallas, TX 75212
214-339-2204
Email: **nmisales@newmicros.com**
Web: **www.newmicros.com**

Which Way Does Current *Really* Flow?

By Louis E. Frenzel

Do we even know which way current flows? And, in fact, does it actually matter which direction current flows? Let's clear all of this up.

If you ask several electronic engineers, technicians, scientists, or professors which way current in an electrical circuit flows, some will tell you that it flows from the negative terminal of a supply through a load to the positive terminal of the supply. Others will tell you just the opposite, that current actually flows from the plus side of the voltage source to the minus.

Who is right? How can so many technical professionals be confused about something so basic as current flow? Do we even know which way current flows? And, in fact, does it actually matter which direction current flows? Let's clear all of this up.

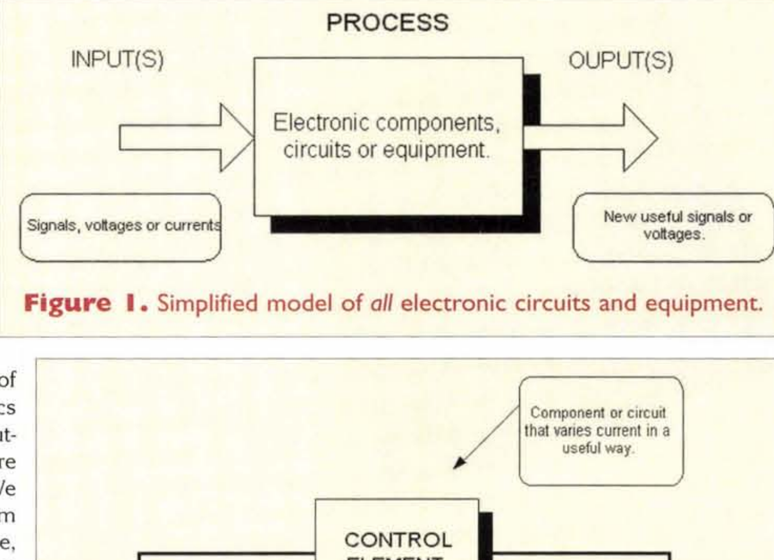


Figure 1. Simplified model of *all* electronic circuits and equipment.

Why Is This So Important?

The core principle of every electronic application is the control of current flow. Think about it. Isn't everything we do in electronics designed to control current flow in some way to produce a useful outcome like TV, computers, or cellular telephones? Take a look at Figure 1. This very simple model represents all electronic applications. We produce inputs that are some type of electronic signal, process them in some way, then generate appropriate output signals. For example, the input signal may come from a microphone. It is processed by an amplifier to increase its power level. The output drives a speaker.

Now, consider again what is in that box labeled "process" in Figure 1. In its simplest form, it may just be one electronic component such as a resistor. But it could also be a circuit like an instrument amplifier or millions of MOSFETs as in a Pentium microprocessor.

Now look at Figure 2. Here is another way to help you visualize what happens in all electrical or electronic circuits. A voltage source initiates current flow in a load. The voltage source may be a battery, signal generator, power supply, radio signal, or a signal from a transducer like a microphone or photocell. The load is the device that produces some useful end result. It could be a light bulb, heating element, motor, solenoid, or just another electronic circuit. Now, note the control element. This is the electronic component or circuit that controls the current in the load.

The control circuits may be more complex like an op-amp or a batch of logic gates or even a complete collection of different electronic circuits. The components and circuits control the current produced by the initial input in various ways, sometimes in many different sequential and parallel steps, until an appropriate output is generated. The bottom line here is that generating and controlling current is what electronics is all about.

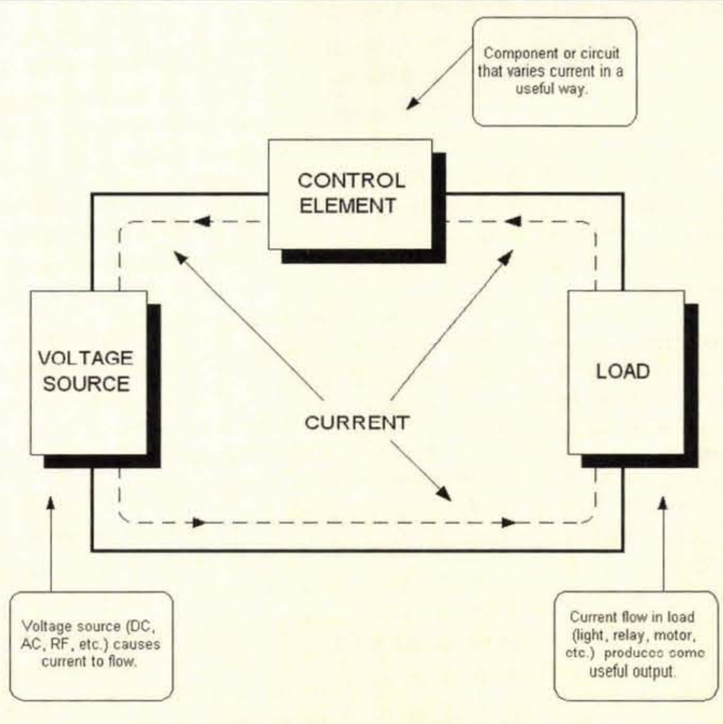


Figure 2. Simplified explanation of how all electronic circuits work.

Which Way Does Current Really Flow?

Conventional Current vs. Electron Flow

Scientists, engineers, college professors, and others have known for over 100 years that current is really moving electrons. Yet they have continued to use the original positive-to-negative current flow model. This has come to be known as conventional current flow (CCF). Today, this concept is still widely used and almost universally still taught in science and engineering programs.

It wasn't until the mid-20th century that electron flow (EF) was widely taught. This came about as a result of the massive training of electronic technicians during World War II. The Army and Navy decided that electron flow was more appropriate than conventional current flow, so they developed all of their classes and training materials using electron flow. After the war, electron flow caught on and became the primary way of teaching technicians in community colleges, technical institutes, and vocational schools. Why the scientific, engineering, and academic communities refused to change to electron flow is not known. It is likely that the feeling was that electrical theory was always taught using the conventional current flow model and there was no particular need, desire, or reason to change. Change is difficult and tradition dies hard.

Just What Is An Electron?

An electron is a subatomic particle, one of several different parts of an atom. Atoms are the tiny particles out of which all matter is made. Everything we know, feel, see, touch, and smell is composed of atoms. Atoms are the smallest particle of materials we call elements. Elements are the basic building blocks of nature. Typical elements are oxygen, hydrogen, carbon, copper, silver, gold, and silicon. If you take a piece of copper, for example, and divide it again and again until you get the smallest possible piece that is still recognizable as copper, then you have one copper atom. Anything that is not a basic element is made up of two or more elements combined to form what we call compounds. Water is a compound of two hydrogen atoms and one oxygen atom – you know, H_2O. Salt is a compound of sodium and chlorine (HCl). The smallest recognizable particle of a compound is called a molecule.

The atoms can be further divided into smaller parts. Since no one has ever really seen an atom, physicists have for centuries theorized about what an atom looks like and is made of. One popular theory says that an atom consists of a center nucleus made up of tiny particles called protons and neutrons. The protons have a positive electrical charge. Neutrons are, of course, neutral. Orbiting around the nucleus are rings or shells of electrons. The electrons have a negative electrical charge. There are as many electrons as there are protons so the atom is balanced electrically or neutral. The number of protons in an atom is its atomic number and that number establishes the characteristics of the element.

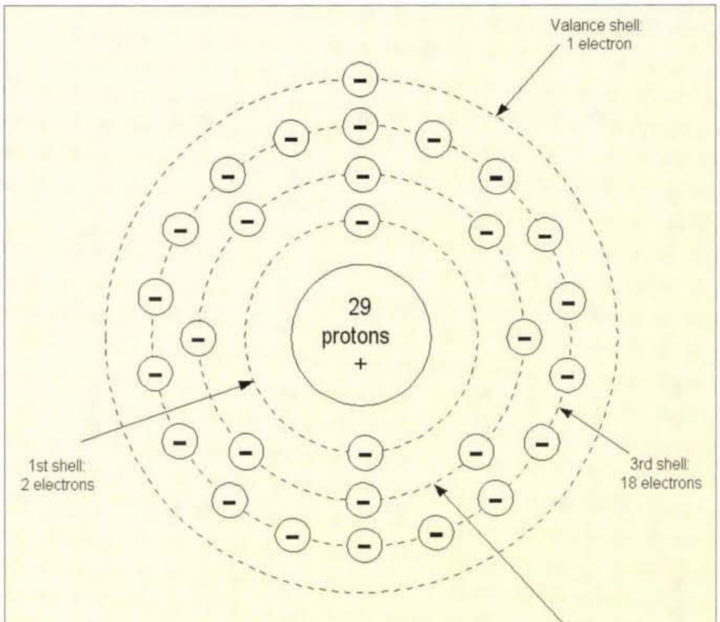


Figure 3. The copper atom.

Figure 3 shows an atom of copper. There are 29 protons and 29 electrons. Notice the outer shell of the atom. This is called the valence shell as it contains the electrons that combine and react with other elements to form chemical bonds in compounds. And it is the electron or electrons in the outer valence shell that are freed up to produce current flow in electrical and electronic components and circuits.

How Current Flows

Current flow in most electrical and electronic circuits is electron flow. However, there are some special cases where other particles are involved. Assume that a copper wire is connected between the positive and negative terminals of a flashlight cell as in Figure 4. An excess of electrons accumulates on the negative terminal of the cell while the positive terminal has a shortage of electrons. This condition is caused by the chemical action in the cell.

When the copper wire is connected to the cell, two things happen. First, the positive terminal pulls the valence electrons away from copper atoms in the wire. When an atom loses one or more electrons, it becomes a positive ion because it now has more protons than electrons. Being positive, the ions attract other negative electrons from neighboring atoms thus creating a chain reaction of current flow.

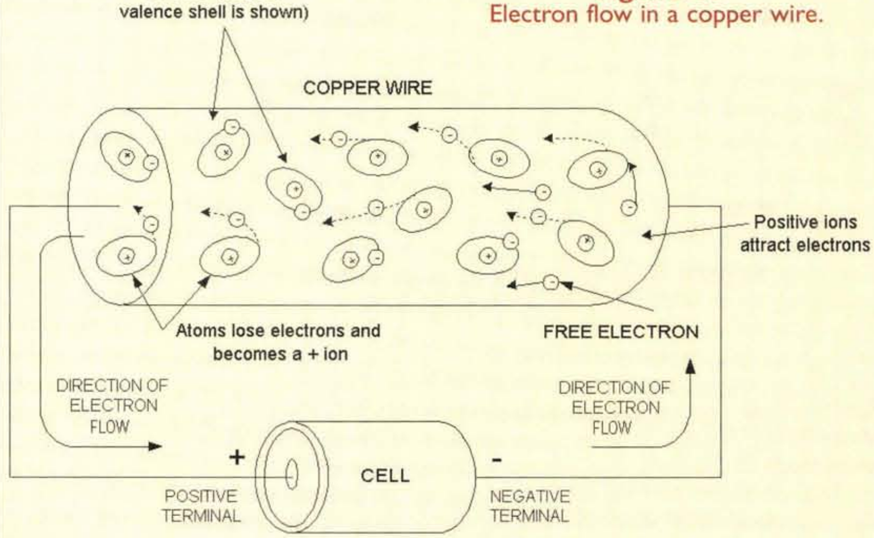
At the same instant, the negative terminal of the cell repels the valence electrons from the nearby atoms in the copper wire. These freed electrons are attracted to the positive ions created by the positive terminal of the cell. The net result is a massive movement of electrons from the negative terminal of the battery to the positive terminal. This is how current flows in wires and cables and most electronic components.

Not all current flow is by electron movement. In some cases, the current is actually the movement of other current carriers. For example, holes are unique to current flow in certain types of semiconductor materials. Ion flow is the method of current flow in plasmas and electrochemical reactions in batteries.

Current Flow In Semiconductors

A semiconductor is a special type of material whose resistivity or

Figure 4. Electron flow in a copper wire.



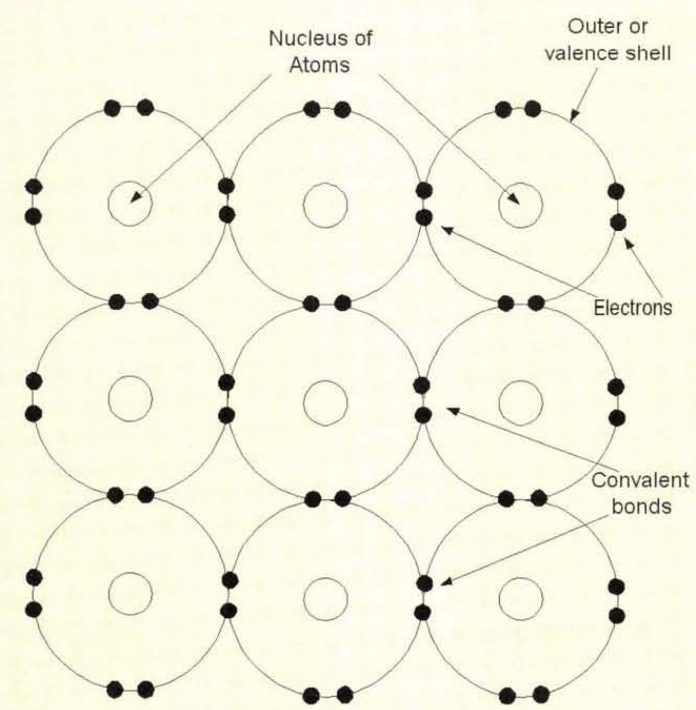


Figure 5. Pure silicon consists of atoms that form covalent bonds with adjacent atoms to form a crystal lattice structure.

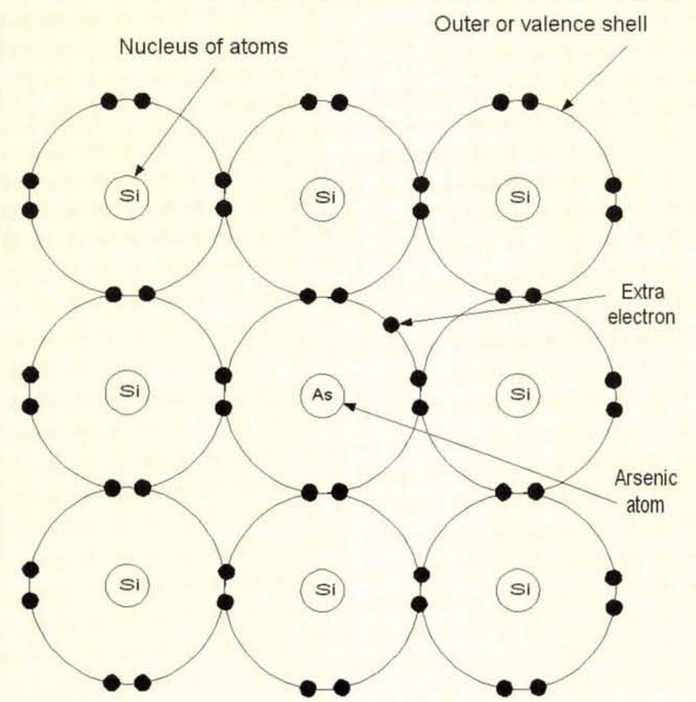


Figure 6. N-type semiconductor material uses electrons for current flow.

HISTORICAL NOTE

Early researchers of electricity first discovered the concept of voltage and polarity, then later went on to define current as the motion of charges. The term voltage means the energy that makes current flow. Initially, voltages were created by static means such as friction or by lightening. Later, chemical cells and batteries were used to create a constant charge or voltage. Mechanical generators were developed next.

Charges refer to some kind of physical object that moves when it is subjected to the force of the voltage. Of course, back in the 18th century, those working on electrical projects didn't really know what the charges were. For all they knew, the charges could have been micro miniature purple cubes inside a wire or other conductor. What they did know was that the voltage caused the charges to move. For purpose of analysis and discussion, they arbitrarily assumed that the charges were positive and flowed from positive-to-negative. This is a key point. They didn't really know the direction of current flow, so they theorized what was happening. And, as it turned out, they guessed wrong. There is nothing wrong with being wrong as scientists are often hypothesizing one thing, then later finding that the truth is something else. The big mistake is that the incorrect hypothesis has been retained and taught as truth.

In the late 19th century, it was finally determined that the charges being discussed were really electrons and the current was really electrons flowing from the negative terminal of a voltage source through the circuit to the positive side of the voltage source. British physicist, Joseph J. Thomson made this discovery in1897. The truth was at last proven and revealed.

conductivity falls somewhere between that of good conductors, like copper and aluminum, and insulators such as glass, ceramic, or plastic. Semiconductors are unique in that they can be made to have any degree of conduction desired. Of course, semiconductors are the materials from which diodes, transistors, and integrated circuits are made.

The most common semiconductor material is the element silicon (Si). Germanium (Ge) is another semiconductor element. There are also semiconductor compounds like gallium arsenide (GaAs), indium phosphide (InP), and silicon-germanium (SiGe). Silicon, like other semiconductor materials, is unique in that it has four valence electrons. This characteristic causes the silicon atoms to bond together in such a way that they share their valence electrons. The result is a unique crystal lattice structure like that shown in Figure 5. Only the valence electrons are shown. Note how the atoms share their valence electrons with adjacent atoms. The result of this is that each atom thinks that it has eight electrons in its outer orbit. This causes the material to be extremely stable.

The silicon atoms form what is called a crystal lattice structure. All of the valence electrons are fully occupied as they are shared amongst the atoms. What this means is that in a pure silicon crystal lattice structure, no electrons are available for electron flow as they are all occupied in their co-valent bonds. As a result, semiconductors like silicon in a pure state are essentially insulators. Of course, if sufficient heat is applied to the silicon or a high external voltage is applied, some of the electrons can be pulled free to cause a small amount of current flow.

To make silicon conduct, we add other chemicals to it. This process is called doping. By doping the silicon with chemicals that have either three or five valence electrons, we can create silicon in which current easily flows. Figure 6 shows what happens when we dope silicon with arsenic (As). Arsenic has five valence electrons. Four of the electrons combine with the electrons in the adjacent silicon atoms to form covalent bonds as before. However, there is one extra electron left over. This extra electron is available for current flow.

Silicon doped with chemicals that have an extra electron is referred to as an N-type semiconductor. The "N" means negative, which refers to the extra negative electron. When an external voltage is applied to a piece of N-type semiconductor material, current easily flows as the unbound electrons are attracted and pulled through the silicon by the external voltage. If the silicon is heavily doped with arsenic, many free electrons are available and a high amount of current will flow. This is the same as saying that the material has a very low resistance. If only a few arsenic atoms are added, fewer electrons are available for current flow so the current level will be less with an external voltage. Such material has a much higher resistance.

As you can see, current flow in N-type semiconductor material is still by electrons. However, we can also dope the silicon with a material that has only three valence electrons. This is illustrated in Figure 7 where the silicon is doped with boron (B) atoms. The three valence electrons in the boron atom form co-valent bonds with adjacent silicon atoms. However, one of the silicon atoms is missing an electron. This missing valence electron is referred to as a hole. A hole, therefore, is not an actual particle, but simply a vacancy in the valence shell of the crystal lattice struc-

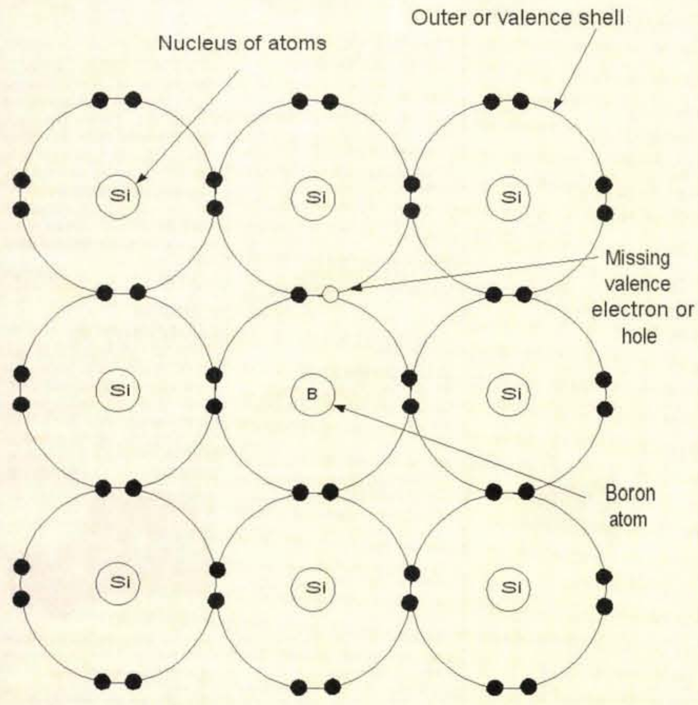


Figure 7. P-type semiconductor material where holes are the current carriers.

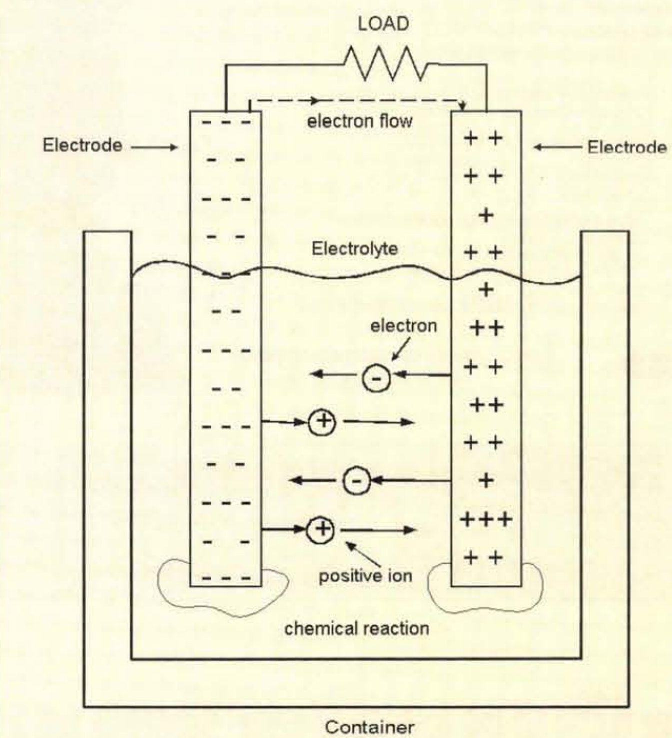


Figure 8. Current flow in a chemical cell.

ture that acts like a current carrier. This vacancy or hole has a positive charge. If an electron passes near the hole, it will be attracted and it will fill the hole, completing the co-valent bond.

Current flow in this type of semiconductor material is by way of holes. This type of semiconductor material is referred to as P-type material. P means positive, which refers to the charge of the hole.

When an electrical voltage is applied to a piece of P-type semiconductor material, electrons flow into the material from the negative terminal of the voltage source and fill the holes. The positive charge of the external voltage source pulls electrons from the external orbits, creating new holes. Thus, electrons move from hole-to-hole. Electrons still flow from negative-to-positive, but holes move from positive-to-negative as they are created by the external charge.

Ion Flow

In certain types of materials, particularly liquids and plasmas, current flow is a combination of both electrons and ions.

Figure 8 shows the simplified drawing of a voltage cell. All cells consist of two electrodes of different materials immersed in a chemical called an electrolyte. The chemical reaction that takes place separates the charges that are created. Electrons pile up on one electrode as it gives up positive ions creating the negative terminal while electrons are pulled from the other electrode creating the positive terminal.

Whenever you connect an external load to this battery, electrons flow from the negative plate, through the load, to the positive electrode. Inside the cell, electrons actually flow from positive-to-negative while positive ions move from negative-to-positive.

The case for conventional current flow.

1. It is traditional.
2. Most engineers and some techs have learned it this way.
3. It is a lot of trouble to change things like engineering textbooks and schematic symbols (the arrows in diodes and transistors point in the direction of CCF).
4. Human nature abhors change.
5. CCF has become a de facto standard.

The case for electron flow.

1. It is the truth.
2. The operation of electronic devices is easier to explain and learn using electron flow.
3. Why not standardize on the way it really is?

Living In Denial

So why do we continue to perpetuate the myth of conventional current flow (CCF) when we have known for a century that current in most electrical and electronic circuits is electron flow (EF)? I have been asking that question of my colleagues and others in industry and academic for years. Despite the fact that electron flow is the reality, all engineering schools insist on teaching CCF. If you were in the armed services or came up through the ranks as a technician, chances are you learned and favor electron flow. The way you learned it in school is what you tend to use when you design, analyze, troubleshoot, or teach out in the real world.

Does It Really Matter?

As you may know, it doesn't really matter which current direction you use as circuit analysis and design works either way. In fact, this issue only affects DC that flows in only one direction. In alternating current, electrons flow in both directions, moving back and forth at the frequency of operation. But if it truly does not matter which direction we assume, then why don't we default to the truth and end this nonsense once and for all?

In Conclusion

If you ever want to start a lively conversation, maybe even an argument, try bringing up this subject in a group of technical people. You just may be surprised at the intensity of the feelings and the sanctimonious attitudes on both sides. I've done this numerous times and I am still amazed at the emotional response this issue generates.

My conclusion is that the concept of CCF will never be abandoned. It is somewhat akin to forcing us all to switch to the metric system of measurement using meters and Celsius rather than feet and Fahrenheit with which we are more familiar and comfortable. CCF will continue to be taught from now on. I have come to accept this whole thing as one of the stranger quirks of electronics. **NV**

Laser Insight

by Stanley York

Over the past several issues, we have looked at various types of lasers, and some of the applications where lasers are used most effectively. When the series first started, we looked at the ubiquitous HeNe laser that we seem to see in just about every supermarket, dollar store, and hardware store these days. The HeNe laser is slowly losing to the laser diode though, and many grocery store scanners now use handheld bar-code readers using diode lasers to scan the UPC code.

Some time ago, I wrote an article using a laser diode to check the speed of a rotating shaft or wheel, and this month I want to describe a security system using a laser diode as a perimeter monitoring device. This system follows a suggestion by one of our readers, will not be easy to fool, and will offer peace of mind to anyone who surrounds his home with its telltale red beam.

Simple light-interrupt circuit

Look first at Figure 14-1. This is a quick and dirty light beam interrupt circuit that was popular several years ago, before the advent of laser diodes. A light source (usually an incandescent lamp) was positioned at the focal point of a spherical lens. The output beam was fairly well collimated (almost parallel) and was directed back toward the sensor via front surface mirrors. The intensity of the light fell off quite sharply, and so this device was limited in how far the beam could be thrown before the sensitivity suffered. Upon returning, the light beam fell onto another lens (the collector) that focused the light onto a photodiode or photoresistor. As long as the light beam was illuminating the sensor, a trigger circuit inside the device would hold a relay in the on condition (or off, depending on how the circuit was set up). Anything interrupting the light beam would then trigger the circuit, and set off an alarm.

This was all fine and dandy, until the smarter crooks figured out how to get around the light beam without breaking it. Simply shine a flashlight at it, and walk through. As long as the photosensor was illuminated, it didn't know (or care) if it was the real beam, or a crook's flashlight! It would still not trigger the alarm circuit.

Later on, manufacturers made these systems with infrared light sources and detectors, but it was only a matter of time before these were also beaten. A breakthrough came when a modulated beam was used. In this method, the light source was modulated by an AC signal of a given frequency, and the receiver circuit was sensitive only to AC signals. Anyone trying to overcome the beam using any kind of static light source (flashlight) was in for a surprise, because it wouldn't work. Usually, the source and sensor were set for approximately the same frequency, and there was some room for tuning error and temperature drift built into the circuit.

Circuit description

Figure 14-2 shows an updated version of the modulated beam device. Here, a laser diode (D1) is modulated by the timer circuit IC1a,b, and drive transistors Q1 and Q2. The output frequency is controlled by potentiometer VR1; IC1a and b are part of a 4011 CMOS gate array, and is normally allowed to free run. A push-to-test button has been added to allow the unit to be tested as required. The laser diode draws very little current, so there is no need to mount Q2 on a heatsink. Zener diode D2 and resistor R5 limit the maximum voltage and current that the laser diode is allowed to see.

You may have to play with the values here, depending on your particular laser. Some laser diodes run on three volts some on 4.5 volts, etc. You have to make sure that the safe limits of voltage and current for your laser diode are not exceeded when Q2 turns on. The pulse generator is set to a convenient frequency (here approximately 1kHz with the values shown). Here again, you may need to change the frequency of oscillation depending on your laser diode.

The dashed line represents the beam path around your yard, house, swimming pool, etc. The beam is deflected using cheap first-surface mirrors obtainable from Edmund Scientific. They must be firmly mounted on a metal or concrete post, or the corner of your house. A tree will not be stable enough, and is constantly changing due to growth, wind, and moisture content, etc.

The detector/trigger circuit consists of light sensitive transistor Q3, and the remaining circuit. U2 is set up as a missing pulse detector, and works like this: Essentially, U2 is a monostable timer that is continuously retriggered by the pulses appearing on pin 2. At the same time, Q5 discharges C2, allowing a full timing cycle to be repeated. If a pulse is delayed or missing, U2 will not receive a retriggering pulse, the timing cycle will complete, and U2 pin 3 will be forced low. Q6 is normally in a conducting state, the base being held high by pin 3. It will remain so as long as U2 receives pulses from U1c.

If the pulses stop or are delayed, U2 pin 3 will go low, turning off Q6. This causes the collector of Q6 to go high, rapidly charging C4 and turning on Q7. Q7 controls the alarm relay. A spare set of N/O contacts on the relay are used to latch the relay once triggered. A N/C push button is included in the circuit to reset the alarm. A visual indication of the alarm relay status is given by D4 wired across the alarm relay coil. The alarm relay may be used to sound an alarm bell, a siren, or just a light, depending on the application.

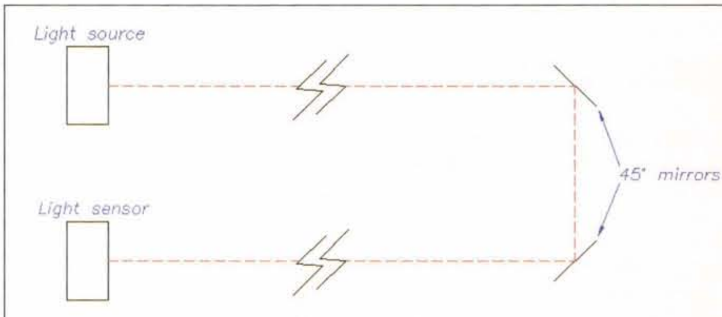


Figure 14-1. Simple light-interrupt.

Construction

You may use any convenient construction method you may be used to. Many people like to make PC boards, but not everyone has access to the proper tools and equipment for doing this. Perfboard is a good substitute, and one that I frequently use, particularly if I am only making a prototype or one or two of any particular item. I recommend a sealed, waterproof box if you will be installing this device outside. Also, cover the entire perfboard with one or two coats of clear polyurethane varnish to prevent moisture damage. The component layout is not at all critical, except perhaps for two points: the wiring to the alarm relay, and the phototransistor.

Make sure you leave enough space to bring in and connect the wiring to your alarm, and since these can be run at high voltages, be sure you have enough clearance to prevent shorting anything.

Mount the phototransistor at the end of a short cardboard tube, painted matt black on the inside. This will minimize any influence from car headlights, sunlight, etc. I ran seriously short of time while writing this article, and I didn't get time to prepare any construction drawings. However, I'll do my best to make sure it doesn't happen again.

Setting up

The system is probably best

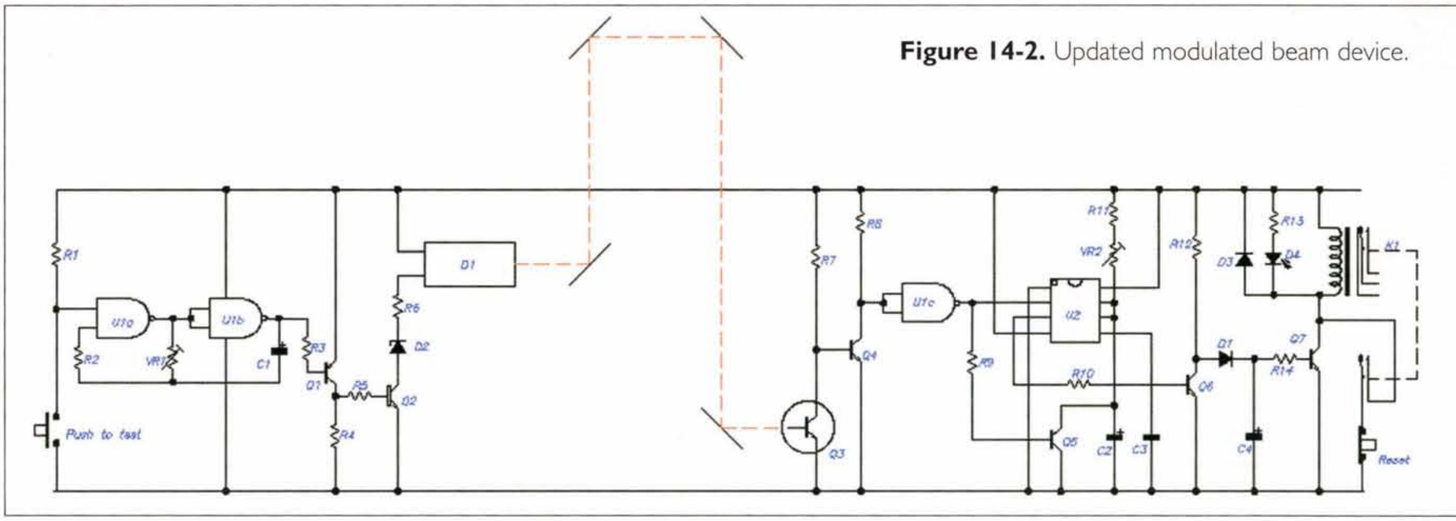


Figure 14-2. Updated modulated beam device.

set up on a test bench initially, before being taken to the installation site. Once set up, the only thing left to do is carefully align the laser beam to the mirrors and phototransistor.

Initially set the laser pulse generator to 1kHz using VR1, and monitoring the output on an oscilloscope. Depending on the type of laser diode you have, you may have to modify the frequency of the modulation to something lower than 1kHz, to ensure complete on-off switching.

Reflect the laser beam back onto the phototransistor using a front-surface mirror and monitor the output from the 555 timer. Start by adjusting the timer delay for minimum time. You should see the output rising and falling in sync with the laser pulse. Gradually increase the time delay until the output from the 555 stays high. When it goes high and stays, block the beam with your hand and the output should almost immediately go low.

If you can, carefully adjust the timing period so that a few pulses can be missed without turning on the alarm. This will prevent the alarm going off if, for instance, a bird were to fly through the laser beam. At this point, check the collector of Q7, it should be low also, K1 should be energized, and D4 should be illuminated. Remove your hand and note that the output of the 555 returns high. K1 will remain energized until you press the reset button to break the latched contacts.

Laser/mirror alignment

When you install this device, you need to be careful that all mounting surfaces are stable. As the throw on the beam (the distance from the origin) becomes greater, the greater any misalignment error becomes, and any vibrations on the laser mounting surface or mirror mounts will be greatly magnified by the time the beam is returned to the phototransistor. You also need to mount the laser where it cannot hit anyone in the eyes. Even though the power output from these devices is only a few milliwatts, it is *very important* to avoid hitting anyone in the eyes. So, try to keep the laser at about waist level or perhaps lower, to avoid any eye contact.

Set up paper targets at all the mirror mounting sites so that you may see more clearly where the laser beam is directed. The mirrors should be firmly bonded to a stiff metal bracket that can be bent to shape for alignment, but stay put when you let go of it. The most critical mounts are the laser housing itself, and the first couple of mirrors, since these will have the greatest influence on the beam path around the protected area. Vibrations on the laser and the first couple of mirrors in particular will upset the installation.

Most laser diodes have an adjustable lens assembly at the business end that is used to focus and collimate the beam. When you install the laser, you need to adjust the lens to get the most nearly parallel beam you can. This will ensure that the phototransistor receives adequate illumination, and the installed device will work as well as it does on the test bench.

When the laser is mounted, the beam should be centered on the first target. Look carefully at the target, making sure there are no vibrations present in the laser spot. If there are, find out the cause and correct it, otherwise the system will be useless.

If everything is okay, remove the paper target and replace it with the first mirror. Make doubly sure the mirror is bonded firmly to the bracket, and secure in place with the laser beam falling on the center of the mirror. The reflected beam should then be centered on the second paper target. If it is not, correct this before you go any further. Repeat the procedure for the remaining mirrors. The final mirror should be mounted so that the reflected beam falls squarely on the phototransistor.

Again, see if there is any vibration present in the beam falling on the phototransistor. If there is, try to locate the source of the vibration, because it will get worse, and it will give false trigger situations. To some extent, you can get around this by increasing the number of missing pulses before a trigger is allowed, as explained above, or by reducing the pulse frequency and allowing more time between pulses. However, by doing this, you are reducing the sensitivity of the system.

Applications

The completed device may be used as an intruder alarm around your house or yard, or if you have a swimming pool (down here in Florida, about every third or fourth house), it would give an alarm if a small child entered the pool area unaccompanied. About one death per week or two is reported here in Florida, due to unaccompanied toddlers finding access to unpopulated pool areas.

You could also use the device to turn on outside lights when walking up to your front door, similar to a passive infrared (PIR) device. This makes finding your keys and unlocking the door more comfortable than fumbling around in the dark.

To the reader who suggested this article, thank you very much, and if anyone out there has any more ideas, please feel free to contact me through this magazine or directly via email at: stanley.york@att.net. **NV**

Parts list ...

R1................4.7k
R2................1M
R3................1k
R4................1k
R5................1k
R6................See text
R7................47k
R8................4.7k
R9................1k
R10..............2.2k
R11..............2.2k
R12..............4.7k
R13..............470
R14..............1k

VR1..............100k
VR2..............100k

C1................0.01uF
C2................1uF
C3................0.01uF
C4................47uF

U1................4011 Quad 2 input NAND gate
U2................555 Timer

Q1................2N3906 PNP
Q2................2N3904 NPN
Q3................Phototransistor
Q4................2N3904 NPN
Q5................2N3906 PNP
Q6................2N3904 NPN
Q7................2N3904 NPN

D1................Laser diode (visible red)
D2................See text
D3................1N4001
D4................Red LED
D5................1N4001

K1................12V two-pole c/o alarm relay
PB1..............one-pole N/O Push to test
PB2..............one-pole N/C Push to reset
Mirrors..........Edmund Scientific PN L45-519 35mm x 35mm x 3mm

Miscellaneous:
Perfboard, hook-up wire, mounting hardware, waterproof enclosure (if mounting outside).

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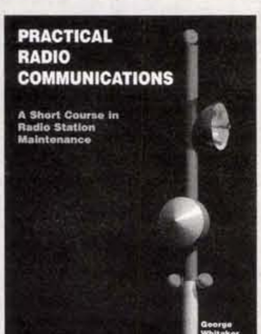

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Understanding and Using 'Norton' Op-Amp ICs — Part I

By Ray Marston

Ray Marston looks at Norton Current-Differencing Amplifier (CDA) op-amp principles and circuits in this two-part mini-series.

Most popular op-amp (operational amplifier) ICs, such as the 741, CA3140, and LF351, etc., give an output voltage that is proportional to the difference between the IC's two input pin voltages, as shown in *Figure 1(a)*, and are thus known as voltage-differencing amplifiers or 'VDAs.' There are, however, two other basic types of op-amps that are in common use. One of these is the type that gives an output voltage that is proportional to the difference between the *currents* applied to its two input terminals, and is thus known as a current-differencing amplifier or 'CDA.'

Figure 1(b) shows the standard symbol and basic operating formula of a CDA, which is also known as a Norton op-amp and is the subject of this two-part mini-series. (Norton is the name of a man who produced a general theorem concerning the *current* flow in a circuit.) The third type of op-amp is known as an operational transconductance amplifier or 'OTA' and will be the subject of a future two-part mini-series.

The two best-known versions of the Norton op-amp are the LM3900 and the LM359. The LM3900 is a low-cost medium performance IC that houses four identical Norton op-amps in a 14-pin DIL package (see *Figure 2*) and can operate from a single-ended 4V to 36V power supply. Each of its four OTAs has a non-inverting (+) input, an inverting (-) input, and an output connection, and has a basic 2.5MHz unity-gain bandwidth and a 70dB open-loop gain, and gives a large output voltage swing. The four OTAs share a common positive supply connection and a common ground (or negative line) connection. This IC is very useful in DC and low-frequency applications where several op-amp stages are needed in single-ended supply circuits.

The LM359, on the other hand, is a very fast dual Norton amplifier in which each OTA has a 30MHz unity-gain bandwidth and a 72dB open-loop gain, and in which most of the op-amp parameters are externally programmable. This IC is particularly useful in video and high-frequency amplifier/filter applications.

The LM3900 and LM359 operate in a different way to conventional op-amps, and require the use of special biasing techniques. This mini-series explains how the devices work, and shows how to use them in a variety of practical applications.

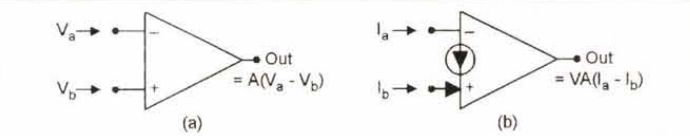

Figure 1. A conventional op-amp (a) is a voltage-differencing amplifier, but a Norton op-amp (b) is a current-differencing amplifier.

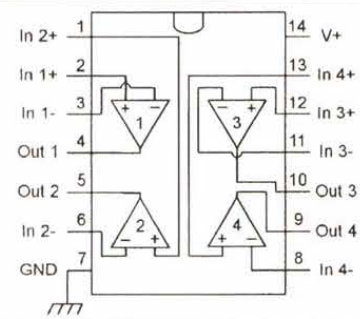

Figure 2. Basic connections of the 14-pin LM3900 quad Norton op-amp.

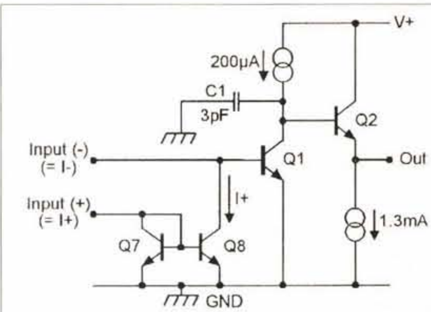

Figure 3. Basic Norton op-amp circuit.

LM3900 BASIC PRINCIPLES

The LM3900 incorporates four identical current-differencing op-amps, each having the greatly simplified basic circuit shown in *Figure 3*. Here, Q1 is configured as a common emitter amplifier with a high-impedance (constant current) collector load, and has its output buffered via emitter follower Q2, which provides a large output voltage swing that can typically source up to 10mA (via Q2), but can sink only 1.3mA (via Q2's constant-current emitter load). Note that the basic Q1-Q2 circuit gives an inverting input-to-output amplifier action, and has its upper frequency response rolled off by C1, to enhance circuit stability.

The most important point to note about the *Figure 3* circuit is that its differential amplifier action is obtained with the aid of matched and integrated transistors Q7-Q8, which act together as a non-inverting current mirror in which the output current (flowing into Q8 collector) is almost identical (within a few percent) to the input current flowing into Q7-Q8, irrespective of the input current magnitude. Note that, since the collector of Q8 is connected directly to the base of common emitter amplifier Q1, the actual Q1 base current is equal to (I-)-(I+), and is thus equal to the difference between the two input currents; the complete Norton op-amp thus gives a current-differencing amplifier action.

Figure 4 shows the basic *Figure 3* circuit expanded into a more practical and comprehensive form. Here, PNP transistor Q3 is compounded with Q2 to increase its overall current gain, and Q4 help increase the circuit's sink current capacity under overdrive conditions. Q5 and Q6 are used as the circuit's 200µA and 1.3mA constant-current generators (which are biased via a common network that is built into the LM3900 and is used by all four of the IC's op-amps).

Note that, since both input terminals of each LM3900 op-amp are wired to transistor base-emitter junctions, both inputs act (in voltage terms) as virtual-ground points. Consequently, these CDA circuits can be made to act like conventional voltage-differencing op-amps by wiring high-value resistors in series with their input terminals, so that the input currents are directly proportional to the input voltage/resistor values; when this technique is used, there is no upper limit to the available input common-mode voltage range of the LM3900 op-amp.

LM3900 BASIC USAGE NOTES

The first practical point to note about the Norton op-amp is its recommended circuit symbol (see *Figure 1b*), which distinguishes it from conventional op-amps. This symbol contains a circled arrow between its two inputs, and indicates that the inverting input is current-operated and that much of this input current flows from the inverting to the non-inverting input. The arrow on the input of the non-inverting input indicates that this input is current-operated.The LM3900 can use any single-ended DC supply in the range

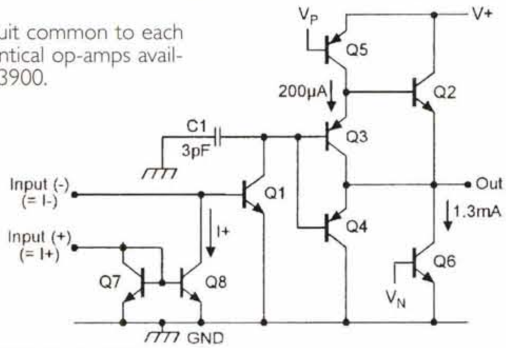

Figure 4. Circuit common to each of the four identical op-amps available in the LM3900.

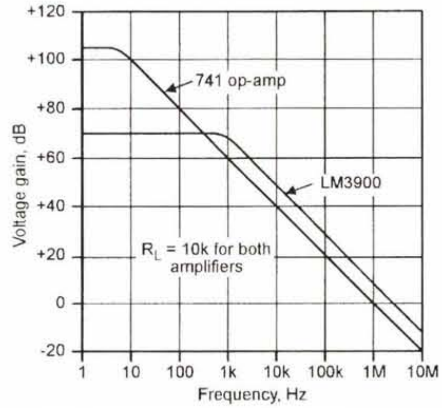

Figure 5. Comparative open-loop performances of the 741 and LM3900 op-amps.

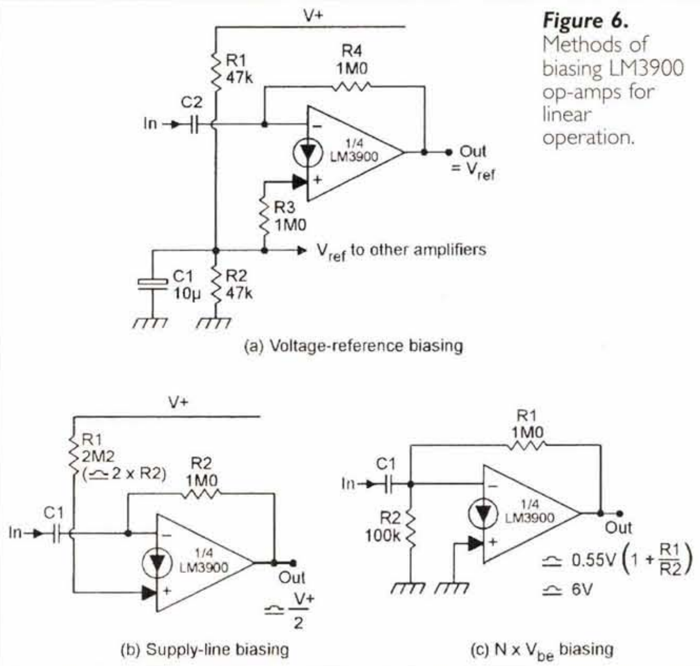

Figure 6. Methods of biasing LM3900 op-amps for linear operation.

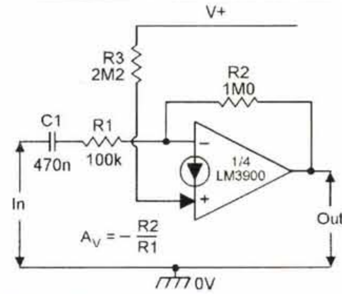

Figure 7. Inverting AC amplifier with supply-line biasing.

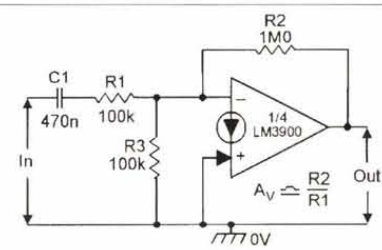

Figure 8. Inverting AC amplifier with N x Vbe biasing.

4V to 32V (or a split supply in the range ±2V to ±16V), and typically consumes a total unloaded quiescent current of 6.2mA. The IC houses four op-amps, which each have a typical low-frequency open-loop voltage gain of 70dB and has a basic 2.5MHz unity-gain bandwidth. The output of each amplifier can swing to within 1V of the supply-line voltage. *Figure 5* shows the comparative open-loop gain/frequency performances of the standard 741 op-amp and the LM3900 Norton op-amp. In applications where individual LM3900 op-amps are not used in the IC, they can be disabled by simply wiring their two input terminals directly to ground (pin 7).

The basic 'don't do' rules of the LM3900 are pretty simple, as follows. Never connect the power supply in reverse polarity. Do not allow short circuits to occur between the output and either supply rail for any significant time. When driving the input from a low impedance source, use an external resistor to limit the drive current to ±100μA (note that the inputs are protected by an internal clamp that prevents the input voltage from swinging more than roughly 0.3V below ground).

LM3900 BIASING TECHNIQUES

The basic amplifier stages of the LM3900 have high current gains, and the output of the amplifier starts to swing down through the half-supply point when the input bias current of Q1 starts to rise above 30nA or so. This input current is normally equal to the difference between the two input terminal currents, which should normally be restricted to the range 0.5μA to 500μA (ideally about 10μA).

In linear applications, an op-amp is normally biased so that its output takes up a quiescent value of half-supply volts, to accommodate maximum undistorted signal swings. *Figure 6(a)* shows how the LM3900 can be biased to meet this condition. R1-R2-C1 generate a decoupled half-supply reference voltage, which applies a reference current to the non-inverting terminal via R3, and a negative feedback current is applied from the op-amp output to the inverting terminal via R4. The basic action is such that the op-amp output automatically adjusts to such a value that the two input currents equalize and hence reduce the internal Q1 base current to near-zero (about 30nA) and, in the case of *Figure 6(a)*, this situation occurs when V_{out} equals V_{ref}. In practice, the single reference voltage source can be used to apply biasing to several op-amp stages. A variation of this biasing system is shown in *Figure 6(b)*. In this case, the non-inverting terminal is biased from the positive supply rail via R1, which has a value approximately double that of R2, causing the output to bias at a quiescent value of half-supply volts. A minor defect of this biasing technique is that it allows supply line ripple to break through to the output, with a gain of x0.5.

Finally, *Figure 6(c)* shows an alternative biasing technique that can be used when the op-amp is to be operated only as an inverting amplifier. In this case, the non-inverting terminal is disabled, and feedback potential divider R1-R2 is applied between the output and the inverting terminal. Consequently, since the inverting terminal acts as a transistor base-emitter junction (with a V_{be} value of about 0.55V at 10μA bias), the output automatically takes up a quiescent value of V_{be} x (1 + R1/R2), or about 6V with the component values shown.

LINEAR AMPLIFIER CIRCUITS

Figures 7 to *12* show six ways of using LM3900 op-amps as linear amplifiers. In the *Figure 7* circuit, R2 and R3 bias the output to a quiescent half-supply value, using the technique shown in *Figure 6(b)*. The input signal is applied to the inverting terminal via R1, and the voltage gain is determined by the R1-R2 ratio, so this design acts as a x10 inverting amplifier. *Figure 8* shows an alternative version of the x10 inverting amplifier, in which N x V_{be} biasing is used and the gain is determined by the R1-R2 ratio.

Figure 9 shows the connections for making a non-inverting amplifier with a gain of approximately x10. Supply-rail biasing is again used, but the input signal is applied to the non-inverting pin via R1.

The LM3900 op-amps are fairly slow devices; they have slew rates of only 0.5V/μS, and thus have very limited useful bandwidths. *Figure 10* shows how

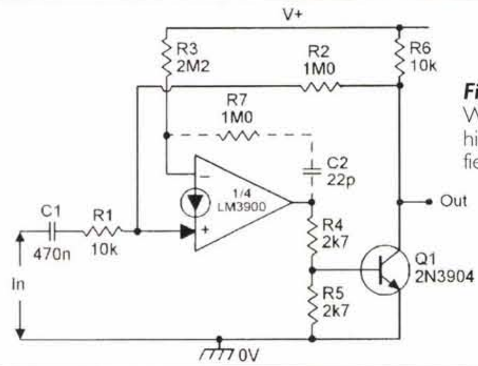

Figure 10. Wideband (200kHz) high-gain (x100) amplifier.

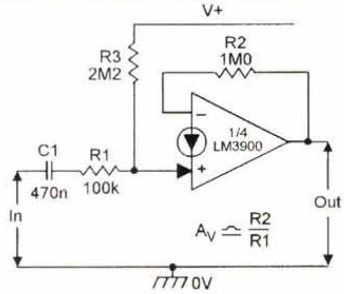

Figure 9. Non-inverting amplifier.

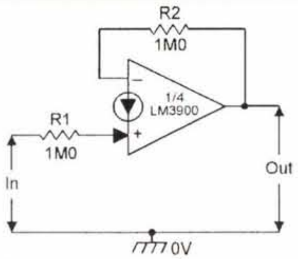

Figure 12. DC voltage-following buffer.

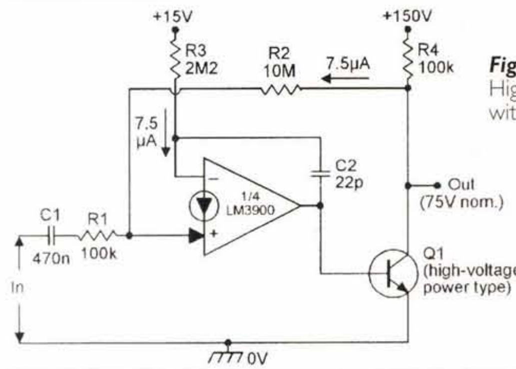

Figure 11. High-voltage amplifier with x100 gain.

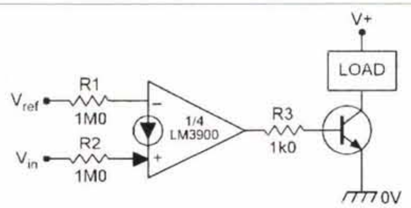

Figure 14. Non-inverting power comparator.

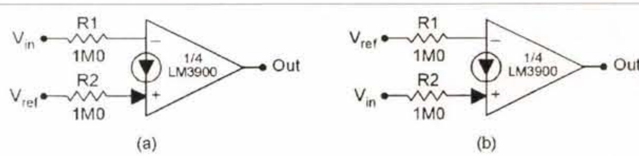

Figure 13. Inverting (a) and non-inverting (b) voltage comparators.

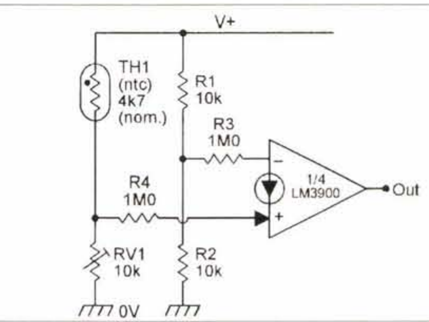

Figure 16. Over-temperature switch.

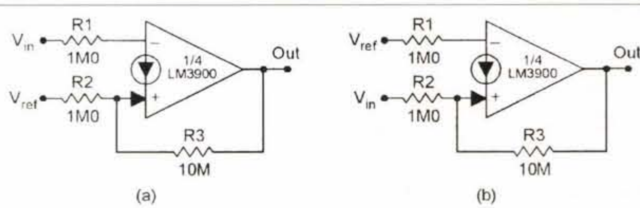

Figure 15. Inverting (a) and non-inverting (b) Schmitt triggers.

the useful bandwidth can be increased by connecting an external common emitter transistor to the output and transposing the input connections of the standard amplifier to make a x100 compound amplifier with a 200kHz bandwidth. Because of its very high overall gain, this circuit may be unstable if care is not taken in layout. R7 and C2 can be used to slightly reduce the bandwidth and enhance circuit stability, if required.

Figure 11 shows how the above circuit can be modified to give a peak-to-peak output voltage swing of 150V (or whatever voltage is used to power Q1). Note that the output voltage of this circuit has a quiescent value of 75V, causing 7.5μA to be fed to the non-inverting terminal of the op-amp via R2, so, to give correct biasing, R3 (powered from the 15V supply rail of the op-amp) must apply 7.5μA to the inverting pin of the op-amp, as shown.

Finally, *Figure 12* shows how to connect an LM3900 op-amp as a unity-gain non-inverting amplifier or voltage following buffer. The input is connected to the non-inverting terminal via R1, thus giving the non-inverting action, and R1 and R2 have equal values, thus giving unity gain (this circuit would give a gain of x2 if R1 were half the value of R2).

COMPARATORS AND SCHMITT CIRCUITS

The LM3900 op-amp can be made to act as a voltage comparator by simply wiring equal value current limiting resistors in series with each input, and then using one resistor as the input point of the voltage reference and the other as the sample input point, as shown in the circuits in *Figures 13* and *14*. The *Figure 13(a)* circuit gives inverting voltage comparator action, in which the output switches high when V_{in} falls below V_{ref}, and the *Figure 13(b)* circuit gives non-inverting voltage comparator action, in which the output switches high when V_{in} rises above V_{ref}.

The *Figure 13* comparator circuits can supply output currents of only a few milliamps. The available output current can be boosted to tens or hundreds of milliamps by wiring a common emitter transistor stage to the output, as in the non-inverting power comparator circuit in *Figure 14*.

Hysteresis can be added to the LM3900 voltage comparator circuits, so that they act as Schmitt triggers, by simply connecting a high-value resistor between the output and the non-inverting terminal, as shown in *Figure 15*. The *Figure 15(a)* circuit gives an inverting Schmitt action, and *Figure 15(b)* gives a non-inverting Schmitt action. The R2-R3 ratio determines the hysteresis magnitude.

COMPARATOR APPLICATIONS

Figures 16 to *20* show some useful applications of voltage comparators. The *Figure 16* design is that of an over-temperature switch, the output of which goes high when the temperature of NTC (negative temperature coefficient) thermistor TH1 exceeds a value pre-set via RV1. Potential divider R1-R2 feeds a fixed half-supply reference voltage to R3, which then feeds a reference current to the inverting terminal, and TH1-RV1 form a potential divider that feeds a variable current to the non-inverting input via R4. The potential on the TH1-RV1 junction rises with temperature, and the op-amp output switches high when this voltage exceeds half-supply value; the trip temperature can be pre-set via RV1.

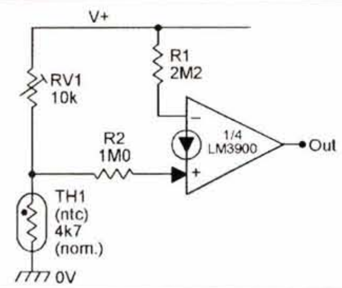

Figure 17. Under-temperature switch.

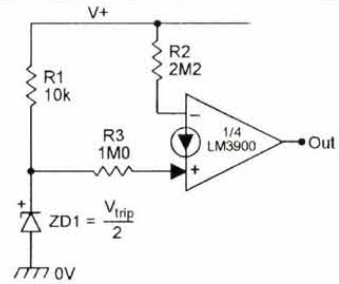

Figure 18. Supply under-voltage detector.

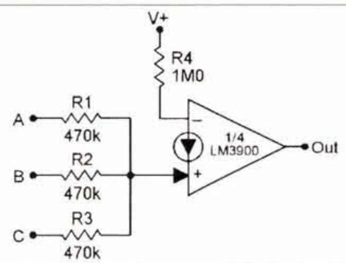

Figure 19. Three-input OR gate (can be converted to a NOR gate by transposing the op-amp inputs).

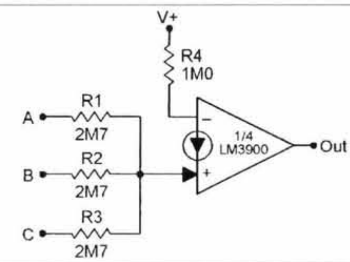

Figure 20. Three-input AND gate (can be converted to a NAND gate by transposing the op-amp inputs).

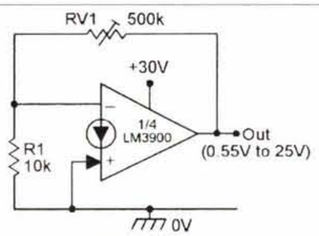

Figure 21. Simple variable-voltage reference.

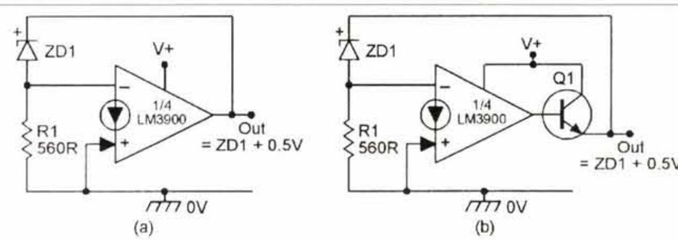

Figure 22. Fixed-voltage reference with (a) basic and (b) boosted output current capacity.

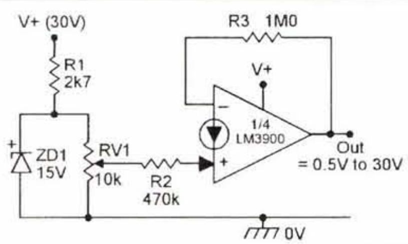

Figure 23. Variable voltage regulator.

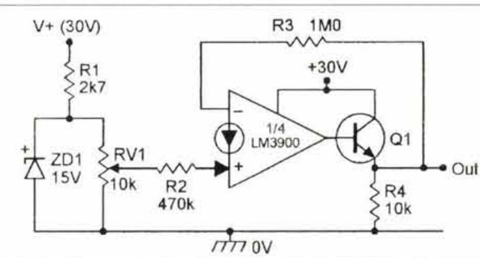

Figure 24. Variable voltage regulator with boosted output.

Note that the operation of the above circuit can be reversed, so that it operates as an under-temperature switch, by transposing the TH1-RV1 positions. Also note that, since RV1-TH1-R1-R2 are wired in a Wheatstone bridge configuration, the trip point is independent of supply rail variations.

Figure 17 shows a useful variation of the above circuit, wired as an under-temperature switch. In this case, the reference (inverting) current is derived from the supply rail via R1, and the variable (non-inverting) current is again derived from the RV1-TH1 junction. Since the R1 value is roughly double that of R2 and generates a current proportional to the supply rail voltage, the trip point of this circuit is also independent of variations in supply rail voltage. A variant of the above circuit is shown in *Figure 18*, and gives a high output when the supply voltage falls below a value determined by ZD1. If ZD1 has a value of 5V6, the op-amp output switches high when the supply rail voltage falls below roughly 11V; the precise trip point can be varied by replacing R3 with a series-connected 820k resistor and a 470k pot.

Finally, *Figures 19* and *20* show how the comparator can be made to act as a three-input logic gate. In *Figure 19*, a reference current is fed to the inverting pin via R4, and a greater current can be fed to the non-inverting pin via any of the R1 to R3 resistors, thus causing the output to switch high if any of the input terminals go high; this circuit thus acts as a three-input OR gate. This circuit can be converted into a three-input NOR gate by simply transposing the input connections of the op-amp.

The *Figure 20* circuit is that of a three-input AND gate, which gives a high output only when all three inputs are taken high, making the non-inverting input terminal current exceed that of R4. This circuit can be converted into a three-input NAND gate by transposing the op-amp's input connections.

VOLTAGE REGULATOR CIRCUITS

To conclude this month's article, *Figures 21* to *24* show various ways of using LM3900 op-amps to make simple voltage regulators and references. The *Figure 21* circuit is a simple but useful variable voltage reference. The non-inverting terminal of the op-amp is disabled, and the circuit uses the Vbe potential of the inverting terminal as a reference, and has a voltage gain determined by the RV1-R1 ratio.

When RV1 is set to zero, the circuit gives unity gain and gives a nominal output of 0.55V; when RV1 is set to maximum value, the circuit has a gain of x50 and gives an output of 25V. The circuit has good regulation and can supply output currents of several milliamps. Note, however, that the output voltage is not temperature-compensated.

Figure 22(a) shows a fixed voltage reference circuit that generates a well-regulated output that is slightly greater that the ZD1 voltage. R1 sets the zener current at about 1mA. The circuit can safely supply output currents of only a few milliamps, but this can easily be boosted to tens or hundreds of milliamps by wiring a current booster transistor into the output feedback loop of the circuit, as shown in *Figure 22(b)*.

Figure 23 shows an alternative type of voltage regulator, which gives a well-regulated variable voltage output. In this case, the op-amp is wired as a x2 non-inverting DC amplifier (with gain determined by the R3-R2 ratio), and the input voltage is variable from zero to 15V via RV1; the output voltage is thus variable over the approximate range 0.5V to 30V via RV1. Finally, *Figure 24* shows how the available output current of this circuit can be boosted to tens or hundreds of milliamps with the aid of an external transistor.

Next month, we will show how to use the LM3900 in various current-regulator and waveform generator circuits, and will then describe the operating theory and practical applications of the high-performance LM359 dual Norton op-amp IC. **NV**

Learning RVK-Basic Part 7

By Bob Vun Kannon

RVK-Basic is a free Basic compiler for the Atmel AVR line of microcontrollers. You can download a copy of this compiler from the Nuts & Volts web site (www.nutsvolts.com). With this compiler, you can write and compile very fast, efficient programs for most of the AVR microcontrollers.

In this month's article, we will investigate the question of how to perform fractional math using only the unsigned integers available in RVK-Basic. Along the way, we will develop code to turn a simple AVR into a Digital Multimeter with digital output (using your PC as the display device).

Fractional Math Using Unsigned Integers

A fairly common requirement for a microcontroller is that it convert an integer number into a series of ASCII digits for some sort of display. This situation can occur when you are sending data to an LCD, or a seven-segment LED, or when the data is being sent over RS-232 to a PC.

For a typical example, we will take the output from the A/D converter of the microcontroller and produce four ASCII digits, which we will send over RS-232 to your PC. When you have this project up and running, you can just connect the serial port of your development board (an STK200 or an STK500) to a COM port on your PC and use Hyper Terminal to see the data coming out.

The A/D produces a 10-bit output for its result. Thus, the output number of the A/D ranges from 0 to 1023. If the A/D converter is running from the +5V supply, then a 0 VDC input will generate an output of 0, and a 5 VDC input will produce an output of 1023. What we would like to have is a number that ranges from 0 to 5000 for the full conversion range because we could convert an integer value of 5000 to a BCD (Binary Coded Decimal) number of &H5000. Given the BCD number, we can easily strip off each nibble of the number, convert to ASCII by adding &H30, and transmit out the result one digit at a time. As an example, if we put in 4.255 volts to the A/D converter, we should get a reading of 871 counts. Now we need some magic routine to convert that number of 871 to an integer value of 4255. Then we convert the 4255 to a BCD number and get &H4255.

In order to perform the conversion, we will first expand the counts from the A/D to a value at least a factor of two higher than the result we want to get. We will do this by shifting the 871 number left a few times, let's say four times. Each time we shift it left, we get double the original number, so after four shifts 871 had become 13936. (We could have shifted left as many as six times because the original number is a 10-bit number and an integer holds 16 bits.)

Following our line of thought, we would like to be able to divide our 13936 number by a constant to produce a result of 4255. Clearly that constant would be 13936 / 4255 or 3.2751. We could have arrived at the same constant using full-scale numbers: 1023 is five volts, shifted left four times becomes 16368, and needs to be divided by 3.2736 to result in 5000. The latter constant – 3.2736 – is more accurate than the first constant because of the higher precision in our larger integers.

Since we don't know how to divide an integer by a real number like 3.2736 using only unsigned numbers, let's think just a moment. We could arrive at a correct result if we could multiply the 16368 by the reciprocal of 3.2736, or 0.305474. We don't know how to do this either, but we will in a few more lines if you'll bear with me. Let's suppose that we could write a procedure, which would multiply an integer by a second integer, where we treat the second integer as a fraction.

What do we really mean by a fraction? Does not multiplying the number 0.305474 times something else mean that we will add up 3/10 plus 5/100 plus 4/1000 plus 7/10000 plus 4/100000 times that something else? So then a binary fraction like &B10010011 would mean the sum of 1/2 plus 1/16 plus 1/128 plus 1/256. Each one in the binary fraction represents the addition of the multiplicand after shifting it right one place for each place in the binary fraction. The following procedure – IMULF – does exactly that and it's only 11 lines of active code.

```
'=====BEGIN IMULF================================
'=      inputs: a%,f%                        =
'=      output: r%                           =
'= r% is a% multiplied by the fraction f%       =
'================================================
SUB IMULF(a%,f%)(r%)
     r% = 0
     WHILE f% | 0
       SHIFT a%,1,RIGHT       '...a% = a% \ 2
       IF f% < &H8000 THEN
       ELSE
         r% = r% + a%
       END IF
       SHIFT f%,1,LEFT
     WEND
END SUB
'=====END IMULF==================================
```

It should be clear that the above routine successively shifts a% right (dividing it by two) and adds the piece to the result only if the corresponding bit of f% is a 1.

Now, our only remaining problem is to figure out what f% needs to be in binary or hex to correspond to 0.305474.

I have written and tested a program which solves this problem for us. It is written in Quickbasic and will run under the Qbasic interpreter supplied with most (ugh!) Windows sl-operating systems. (Real men use DOS: quiche-eaters use Windows.)

```
'..Program computes fractional integer for use in
   '..unsigned fractional multiplications...........

   PRINT
   INPUT "Raw value (larger of the two numbers)"; raw#
   INPUT "Desired result (Smaller of the two numbers)"; tgt#
```

```
orgraw# = raw#

fraction$ = ""
FOR i = 1 TO 16
  raw# = raw# \ 2
  IF raw# <= tgt# THEN
    a$ = "1"
    tgt# = tgt# - raw#
  ELSE
    a$ = "0"
  END IF
  fraction$ = fraction$ + a$
NEXT

PRINT "Resulting fraction is "; fraction$;

'...convert fraction$ to mul&...
'...compute actual result from a multiplication...
mul& = 0
result& = 0
raw# = orgraw#
WHILE fraction$ <> ""
  mul& = mul& * 2
  raw# = raw# \ 2
  IF LEFT$(fraction$, 1) = "1" THEN
    mul& = mul& + 1
    result& = result& + raw#
  END IF
  fraction$ = MID$(fraction$, 2)
WEND

PRINT " or &H"; HEX$(mul&)
PRINT "Result is "; result&

END
```

The program just listed, which I call FCOMP.BAS, will ask you for your raw value (16368, in our case), and then the desired result (5000, in our case). Then it will compute the fraction which when multiplied by 16368 will result in 5000 and print it in binary for you.

As a second step, the program computes this integer fraction in hex for you and also computes the actual result obtained when the integer fraction is multiplied by the raw value. In our case — entering 16368 and 5000 as data — we get a fraction of &H4E47. So now we are ready to write the entire program to read a channel of the A/D converter and transmit the result in BCD volts out on RS-232. Here is the program.

```
DEVICE  4433
    MHZ    4
    REVISION RB7CODE REV. 011113.0-rvk

'=========================================================
'=    DEMONSTRATION PROGRAM FOR SCALING              =
'=    (Part of RB7.DOC article)             =
'=                                    =
'=    This program reads an analog input on analog   =
'=    channel 0 and display the value as percent of  =
'=    full scale on the LED's on a development       =
'=    board as well as transmitting the result in    =
'=    volts out over RS-232.                 =
'=========================================================

'=======PORT B I/O DEFINITION===================
'=    BIT   DIR   FUNCTION            =
'=    0     IN    SPARE               =
'=    1     IN    SPARE               =
'=    2     IN    SPARE               =
'=    3     IN    SPARE               =
'=    4     IN    SPARE               =
'=    5     IN    SPARE               =
'==============================================
    'DIRPORT B,IN
    OUTPORT B,&HFF

'=======PORT C I/O DEFINITION===================
'=    BIT   DIR   FUNCTION            =
'=    0     IN    ANALOG INPUT        =
'=    1     IN    SPARE               =
'=    2     IN    SPARE               =
'=    3     IN    SPARE               =
'=    4     IN    SPARE               =
'=    5     IN    SPARE               =
'==============================================
    'DIRPORT C,IN
    OUTPORT C,0
    EQU "0","A2D_0"

'=======PORT D I/O DEFINITION===================
'=    BIT   DIR   FUNCTION            =
'=    0     IN    RXD                 =
'=    1     OUT   TXD                 =
'=    2     IN    SPARE               =
'=    3     IN    SPARE               =
'=    4     IN    SPARE               =
'=    5     IN    SPARE               =
'=    6     IN    SPARE               =
'=    7     IN    SPARE               =
'==============================================
    DIRPORT D,&B00000010
    OUTPORT D,&B11111101
    EQU "D,1","TXD"

    XMIT INIT 9600  '..initialize the UART for 9600 Baud..

MAIN:
    DO
      A2D raw%,"A2D_0",IDLE
      FILTER cur%,raw%,1
      comp% = cur%
      SHIFT comp%,4,LEFT    '..5 volts is 16368 counts..
      frac% = &H4E47        '..fractional multiplier....
      CALL IMULF(comp%,frac%)(result%)
          '...result% is now scaled for conversion to
          '...a bcd number with a max value of 5000.
      CALL INT2BCD(result%)(bcd%)
      GOSUB WRSER           '...write bcd% out serial port..
      PAUSE 43              '...Loop delay is .05 sec
    LOOP

'=====BEGIN WRSER============================
'=    input:  bcd%                  =
'=    output: uart                  =
'=============================================
    STACK 2
WRSER:  BYTES bcd%
    wrser0~ = bcd%          '...MSB first...
    SHIFT wrser0~,4,RIGHT   '..upper nybble
    wrser0~ = wrser0~ + &H30
    XMIT OUT  wrser0~       '..xmit 1st byte..
    wrser0~ = 46            '..a period......
    XMIT OUT  wrser0~       '..xmit 2nd byte..
    wrser0~ = bcd%
    wrser0~ = wrser0~ AND &HF + &H30
```

```
        XMIT OUT  wrser0~       '..xmit 3rd byte..

        BYTES bcd%
        wrser0~ = bcd%          '...LSB last...
        SHIFT wrser0~,4,RIGHT  '..upper nybble
        wrser0~ = wrser0~ + &H30
        XMIT OUT  wrser0~       '..xmit 4th byte..
        wrser0~ = bcd%
        wrser0~ = wrser0~ AND &HF + &H30
        XMIT OUT  wrser0~       '..xmit 5th byte..
        XMIT OUT 13
        XMIT OUT 10
        PAUSE 50
RETURN
'=====END WRSER=================================


'=====BEGIN IMULF===============================
'=    inputs: a%,f%                             =
'=    output: r%                                =
'= r% is a% multiplied by the fraction f%       =
'===============================================
SUB IMULF(a%,f%)(r%)
        r% = 0
        WHILE f% | 0
          SHIFT a%,1,RIGHT     '...a% = a% \ 2
          IF f% < &H8000 THEN
          ELSE
            r% = r% + a%
          END IF
          SHIFT f%,1,LEFT
        WEND
END SUB
'=====END IMULF=================================


'====INTEGER TO BCD PROCEDURE===================
'= CONVERTS a% to n% in packed BCD format       =
'===============================================
SUB INT2BCD(a%)(n%)
        n% = 0
        WHILE a% > 999
          a% = a% - 1000
          n% = n% + &H1000
        WEND
        WHILE a% > 99
          a% = a% - 100
          n% = n% + &H100
        WEND
        WHILE a% > 9
          a% = a% - 10
          n% = n% + &H10
        WEND
        n% = n% + a%
END SUB
'====END SUB INT2BCD============================
```

You are invited to notice that the main program is fairly short. The WRSER writes the BCD number out as four ASCII numbers with a decimal point after the first digit and follows the digits with a carriage-return and line-feed. The IMULF routine is exactly as discussed earlier and the INT2BCD routine should be intuitively obvious to even the most casual reader.

What the diligent student should notice here is that I have used Quickbasic to test my algorithm before I committed it to a microcontroller. By implementing the algorithm in FCOMP as I did, I was able to prove that the concept works before ever writing a line of RVK-Basic. This is a very powerful technique that I recommend to all. It is far easier to debug an algorithm in Quickbasic than it is when it is embedded in a microcontroller.

Happy computing! **NV**

Events Calendar

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, name of the person to contact, and phone number. While we strive for accuracy in our calendar, we cannot be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

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July-Aug

JULY 2002

JULY 4

PA - HARRISBURG (BRESSLER) - Hamfest. Harrisburg RAC, 717-938-8249. Email: k3pd@arrl.net Web: http://hrac.tripod.com/July4.htm

JULY 6

WI - OAK CREEK - Hamfest. American Legion Post 434, 9327 S. Shepard Ave. South Milwaukee ARC, Inc., 414-762-3235, email: ryatex@aol.com

JULY 7

IL - PEOTONE - Hamfest. Kankakee Area Radio Society, 815-933-1323. Email: karsfest@yahoo.com Web: www.w9az.com

PA - WILKES-BARRE - Hamfest. Luzerne County Fairgrounds. Murgas ARC, 570-824-7579. Email: n3wpg@juno.com Web: http://www.qsl.net/k3ytl

JULY 12-13-14

UT - BRYCE - Convention. Utah Hamfest Committee, 801-547-9218. Email: jimkatpa@aol.com Web: www.utahhamfest.org

JULY 13

GA - GAINESVILLE - Hamfest. Lanierland ARC, 770-967-6364. Email: w4tl@arrl.net Web: www.lanierlandarc.org/hamfest.htm

TN - CLEVELAND - Hamfest. Cleveland ARC, 423-472-1660. Email: bgault@wingnet.net

JULY 14

NJ - AUGUSTA - Hamfest. Sussex County Fairgrounds. Sussex County ARC, 973-948-6999. Email: n2erh@email.com Web: www.scarcnj.org

PA - KIMBERTON - Hamfest. Mid-Atlantic ARC, 610-667-1650. Email: sflink@juno.com. www.marc-radio.org/hamfest.html

PA - PITTSBURGH (NORTH HILLS) - Hamfest. Northland Public Library. North Hills ARC, 412-486-1681. Email: aa3ta@bellatlantic.net Web: www.nharc.pgh.pa.us

JULY 19-20

OK - OKLAHOMA CITY - Oklahoma State Fair Park, Oklahoma Bldg., intersection I-40 & I-44. Central Oklahoma Radio Amateurs, Inc., www.geocities.com/heartland/7332

JULY 20

CO - LOVELAND - Hamfest. Larimer County Fairgrounds, 710 S. Railroad Ave. Northern Colorado ARC, 970-288-6748. www.radioactivehams.com/superfest

NC - CARY - Hamfest. Cary Community Center. Cary ARC, email: n4nc@arrl.net

NY - ALEXANDER - Hamfest. Genesee Radio Amateurs, 716-343-2844. Email: wa2abq@localnet.com

JULY 21

IL - SUGAR GROVE - Hamfest. Fox River Radio League, 815-786-2860. Email: w9ceo@arrl.net Web: www.frrl.org/

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., email: w1gsl@mit.edu (617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html

MO - WASHINGTON - Hamfest. Zero Beaters ARC, 636-629-7368 (days) Email: n0mfd@arrl.net

JULY 26-27

FL - MILTON - Hamfest. Santa Rosa County Auditorium. Milton ARC, 850-994-7335. Email: wa4tfr@worldnet.att.net Web: http://home.att.net/~k4ozl/marc.htm

WI - MILWAUKEE - Conference. Four Points, 4747 S. Howell Ave. Central States VHF Society, email: kboston@lsr.com Web: www.csvhfs.org

JULY 26-27-28

AZ - FLAGSTAFF - Convention. Amateur Radio Council of AZ, 602-881-2722. Web: www.arca-az.org/arca

JULY 27

NC - WAYNESVILLE - Hamfest. Western Carolina ARS, 828-236-0181. Email: wa4ola@arrl.net http://wcars.org/hamfest/index.htm

NJ - MARCELLA - Special Event. NJ Camp of the Blind. Nutley ARS, American Red Cross Bldg., 169 Chestnut St., Nutley, NJ 07110

NY - FRANKFORT - Hamfest. Utica ARC, 315-797-6614. Email: ktrnd@borg.com

OH - CINCINNATI - Hamfest. Diamond Oaks Career Development Campus, 6375

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603-272-5008
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Harrison Ave. OH-KY-IN ARS, 859-657-6161. Email: wd8jaw@arrl.net Web: http://www.ohkyin.org

JULY 28

CA - SANTA ANA - ACP Computer Show & Swapmeet. Giant ACP Parking Lot. 714-558-8813. Email: jferguson@acpsuperstore.com Web: www.acpsuperstore.com

MD - TIMONIUM - Hamfest. BRATS, 410-828-1605. Email: bbennett@ketron.com Web: www.bratsatv.org

OH - RANDOLPH - Hamfest. Portage County Fairgrounds. Portage ARC, 330-274-8240. Email: ljs@config.com Web: http://parc.portage.oh.us

AUGUST 2002

AUGUST 2-3-4

OH - MIDDLEBURG HEIGHTS - Convention. Buckeye Belles, 440-327-3832. Email: kc4iyd@arrl.net Web: www.geocities.com/kc4iyd

OR - PORTLAND - Convention. Willamette Valley DX Club, 360-256-7437. Email: k7ar@arrl.net Web: www.wvdxc.org

AUGUST 3

MI - ALPHA (UPPER PENINSULA) - Hamfest. Iron Range ARC, 906-875-3803

NY - ITHACA - Hamfest. Tompkins County ARC, 607-257-6066. Email: jdreid@lightlink.com Web: www2.compcenter.com/~tcarc/

OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, 614-846-7790. Email: kb8kpj@cs.com

AUGUST 3-4

KY - LEXINGTON - Convention. National Guard Armory. Bluegrass ARS, Inc., 859-253-1178. Email: jrbarnes@iglou.com

OH - CAIRO - Hamfest. Cairo Community Center. Northwest OH ARC, 419-641-5623. Email: w6mdn@hotmail.com

AUGUST 4

NY - WILLIAMSVILLE - Convention. Lancaster ARC, 716-683-8880. Email: luke@towncountryflorist.com Web: http://hamgate1.sunyerie.edu/~larc

AUGUST 10

IL - QUINCY - Hamfest. Western IL ARC, 217-222-4467. Email: w9awe@arrl.net Web: www.qsl.net/w9awe

MI - JACKSON - Hamfest. Jackson Community College. CARS, Inc., web: www.w8jxn.org

WI - BARABOO - Circus City Swapfest. Sauk County Fairgrounds, Hwy. 33. Yellow Thunder ARC, Inc., 608-356-2313, email n9udo@arrl.net or 608-643-6908 days, 608-643-6453 eves. Web: www.qsl.net/ytarc/hamfest.htm

AUGUST 11

IA - AMANA - Hamfest. 38th Ave., Summerfest grounds. 319-247-0558 eves. Email: kc0ek@mchsi.com Web: www.cvarc.rf.org

IL - PEOTONE - Hamfest. Hamfesters Radio Club, 708-756-7984. Email: wb9wfr@arrl.net Web: www.hamfesters.org

IN - GREENTOWN - Hamfest. Kokomo & Grant County ARCs, 765-668-4814. Email: k9nqw@arrl.net Web: www.grantarc.com/greentown.html

PA - MATAMORAS - Hamfest. Matamoras Airport Park. Tri-State Amateur Radio Assn., 570-491-4808. Web: www.qsl.net/k3tsa/

PA - SHREWSBURY - Hamfest. Email: w3pn@yahoo.com

AUGUST 16-17-18

CA - ESCONDIDO - Convention. San Diego AR Council, 858-566-8887. Email: gwroos@aol.com Web: www.ham-con.net/sd2002/index.html

AUGUST 17

FL - FT. PIERCE - Hamfest. Indian River Community College, 3209 Virginia Ave. 561-465-5204, email: KD4SPW@arrl.net

OH - FRIENDSHIP - Hamfest. Portsmouth Radio Club, 740-456-1616. Email: kj8ww@zoomnet.net

AUGUST 17-18

AL - HUNTSVILLE - ARRL Alabama Section Convention. Von Braun Center, 700 Monroe St. 256-880-8004. Web: www.hamfest.org

AUGUST 18

IN - LAFAYETTE - Hamfest. Tippecanoe Country Fairgrounds. Tippecanoe ARA, 765-743-8305. www.w9reg.org

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., email: w1gsl@mit.edu (617-253-3776 9am-5pm.) Web: web.mit.edu/w1mx/www/swapfest.html

OH - WARREN - Hamfest. Trumbull Campus Kent State Univ. Work Force Bldg. Warren ARA, 330-847-8478. Email: mccaman@cboss.com Web: www.onecom.net/wara/

AUGUST 24

IN - LAPORTE - Hamfest. County Fairgrounds. LPARC, 219-324-7525. Web: www.k9jsi.org

AUGUST 24-25

MA - BOXBORO - Convention. Holiday Inn Conference Ctr. ARRL New England Division. http://www.boxboro.org

AUGUST 25

IL - CATLIN - Hamfest. VCARA Communications Center, Harrison Park W. Addition. Email: VCARA@Talk.to

MI - LAPEER - Hamfest. Lapeer Center Bldg., 425 County Center Dr. LCARA, 810-245-3907, email: w8lap@arrl.net Web: www.w8lap.com

AUGUST 31-SEPTEMBER 1

NC - SHELBY - Hamfest. Cleveland County Fairgrounds. SARC, 704-462-4910. Email: w4jl@shelby.net

SEPTEMBER 2002

SEPTEMBER 7

KY - LOUISVILLE - Hamfest. Bullitt County Fairgrounds. Greater Louisville Hamfest Assn., Inc., 812-294-4905. Email: wd4ixl@juno.com Web: www.thepoint.net/~glha

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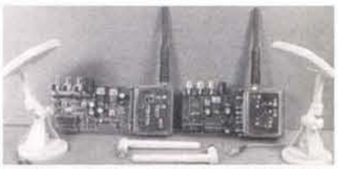

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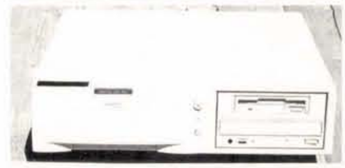

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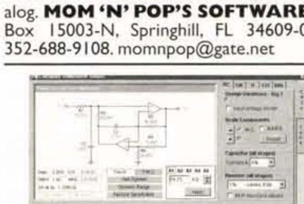

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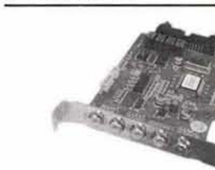

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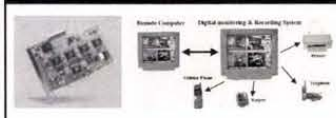

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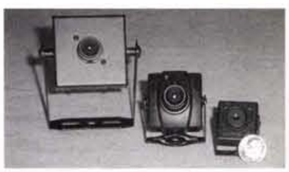

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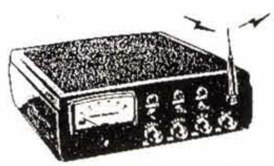

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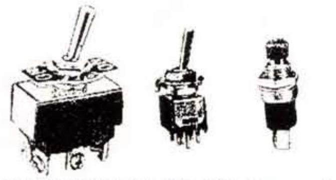

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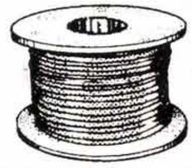

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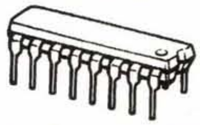

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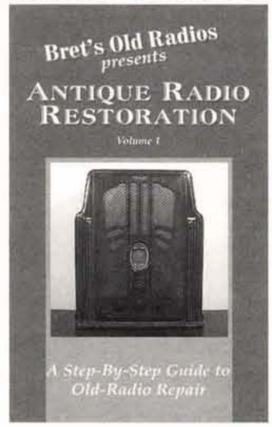

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-Steve Billings, editor, Puget Sound Antique Radio Assoc. Newsletter, June 2001

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Advertiser INDEX

VHF/UHF Super Range Explained

By Gordon West

Cellular and PCS operators brace for compliments and complaints every July.

Cellular and PCS operators brace for compliments and complaints every July. Police and fire department dispatchers prepare themselves for strange voices coming over their radio channels every July and August. The United States Coast Guard operating on marine VHF frequencies prepare themselves for co-channel interference where distant district communication stations may regularly override local frequencies.

"We get hammered with 156.800 MHz marine traffic congesting our Channel 16 radio watch here in New Orleans," comments a vessel traffic system radio operator, complaining that barges and tugs as far away as Key West, FL and Chicago, IL, ride in with the same signal strength as local radio traffic just five miles away.

"I didn't think we would get skip conditions on marine VHF — but every July, our radio system goes nuts," adds the dispatcher, continuously turning his squelch control higher and higher.

Ionospheric skywave "skip" signals reach their greatest occurrence every June. This is caused by ultra-violet radiation and a steady stream of increased charged particles interacting with the ionospheric E-layer as the sun reaches its highest elevation on June 21. The maximum usable frequency may peak each day as high as 100 MHz, but occasionally leap to 200 MHz during periods of intense sporadic-E occurrences. This may cause VHF radio waves in the 140 MHz-170 MHz to be reflected off of highly ionized E-clouds, creating VHF interference from a distant station that may last from three minutes to 20 minutes. Sporadic-E has been noted as high as 225 MHz, but rarely effecting UHF frequencies above 300 MHz.

But it is not "skip" sporadic-E ionospheric reflections causing radio technicians and radio dispatchers interference problems in July. The every-July occurrence of radio interference from stations well beyond line of sight on VHF and UHF frequencies has nothing to do with the ionosphere, solar cycle, sunspots, or ultra-violet, and charged particles emitted by the sun. The problem of co-channel interference has everything to do with the weather.

WEATHER PATTERNS OVER NORTH AMERICA

In July and August, a band of thunderstorms form up at the zero degree Equator. As the sun blisters the temperature at zero degrees, rising moist air from the Tropics migrate north and begin to circulate clockwise (high pressure anti-cyclone) between 30 degrees north to 40 degrees north latitude. As more air feeds in from the Equator, the high-pressure cell becomes so full, it begins to sink toward earth, called subsidence. This sinking air begins to "bottom out" around 1,000 feet above ocean and flatland surfaces, and as more subsiding air gets packed into this high-pressure cell suspended approximately 1,000 feet up, the squashed air gets warmer — just like compressed air gets hot within a tire pump chamber.

The high-pressure cell becomes stratified over several thousand miles between California and Hawaii, and between the east coast of the United States to the west coast of Europe. These two great predictable high-pressure systems are known as the California/Hawaii high, and the Bermuda/Azores high. They predictably intensify every July and August. At the same time, four other predictable high-pressure systems form up in the southern latitudes.

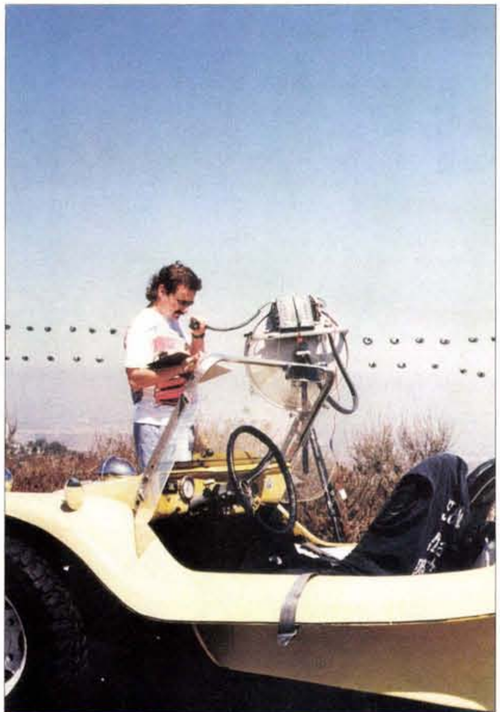
Tropo time out at sea with Gordo completing a 400 mile contact with Jack N6XQ on 10368 MHz!

First ever 2,500 mile ham ATV picture on 426 MHz from Hawaii to California.

The stratification of a high-pressure cell overlying oceans and USA flat-land masses triggers a sharp change in the normal refractive index of air. About 1.000345 to 1.000300, represented by the symbol "n." We subtract 1 from the refractive index value, and then multiply the remainder by 1 million for the equation $N = 10^6 (n-1)$.

On a normal day, the VHF and UHF radio horizon is typically 20 percent greater than the geographic horizon. This is because the refractive index of normal air causes radio signals to slightly bend beyond the geographic horizon. Generally, the shorter the wavelength, the less bending there is. But on radio frequencies near 156 MHz and 460 MHz, a normal day leads to a "4/3 radio horizon" for predictable "line-of-sight" VHF/UHF range.

But during July and August periods of stationary high-pressure systems lying off of each of our coast lines, plus stray high-pressure cells



Dotted lines show an intense southern California tropo duct to Hawaii.

The stacked two-meter Hawaii beacon antennas are at the top of this rusty tower!

slowly migrating from the West Coast to the East Coast, several layers of unmixed air may dramatically change the refractive index, and this may create an upper-air condition known as a tropospheric duct. VHF, UHF, and SHF signals enter the thin stratified layers and become trapped, much like radar waves within a microwave waveguide. Under the right conditions, tropospheric ducting will develop a waveguide effect channeling VHF, UHF, and microwaves hundreds of miles further than their predicted 4/3 range. And there are several over-ocean paths where tropospheric ducting is so predictably intense that signals may go beyond 2,000 miles to be received by the distant station with almost no attenuation.

Air pressure, temperature, and water vapor content normally decrease with altitude in an approximate logarithmic manner. Near the surface of the earth, the change is about one millibar for every 10 meters of altitude. We normally find 900 millibars of air pressure at one kilometer of altitude, and 700 millibars of air pressure at three kilometers altitude. But during periods of intense tropospheric ducting within the walls of a high-pressure system, we may find 1,020 and 1,030 millibars of air pressure at one kilometer of elevation. And within this band of compressed air due to subsidence, ham radio operators like Paul Lieb KH6HME have recorded a 10-degree Fahrenheit temperature increase right in the level of his tropospheric ducting record-breaking experimental station situated at 8,200 feet up on the side of the Mauna Loa volcano.

"When I drive from Hilo Harbor up the side of the volcano, temperature normally gets cooler. Just ask anyone who has visited the Mauna Loa observatory up 11,000 feet on the big island of Hawaii," comments Lieb, and amateur radio operator record-holder for tropospheric ducting. And when we visited his tropo ducting station on the side of the Mauna Loa volcano up 8,200 feet, his records of a 10-degree temperature increase squarely supported the exact dates and times that VHF and UHF radio conditions ducted between California and Hawaii – 2,500 miles!

"It's easy here in Southern California to spot the duct – we just look for a sharp band of smog hanging over the city, double-check the weather map for a high-pressure system between here and Hawaii, and tune into the many ham radio Hawaiian VHF propagational beacons, and chances are in July and August we talk 2,500 miles over a handheld radio that might only talk five miles under normal conditions," adds Bill Alber WA6CAX, a private pilot who many times works tropo ducting from his aircraft.

"Once you're in the middle of the duct, we see an immediate increase in air temperature, and our aviation radio begins to pick up calls hundreds of miles away – literally amazing," adds Alber.

For Alber, it's called the adiabatic lapse rate – air and vertical motion that will change in both volume and pressure and temperature that may spike inversely at a certain altitude. And depending on the vertical width of the stratified air, certain radio frequencies will propagate better than others within the duct. Generally, the tighter the band of stratified air, the higher the frequency, and shorter wavelengths will be propagated over major distances. Just like radar waveguide, the shorter the wavelength, the smaller the waveguide aperture.

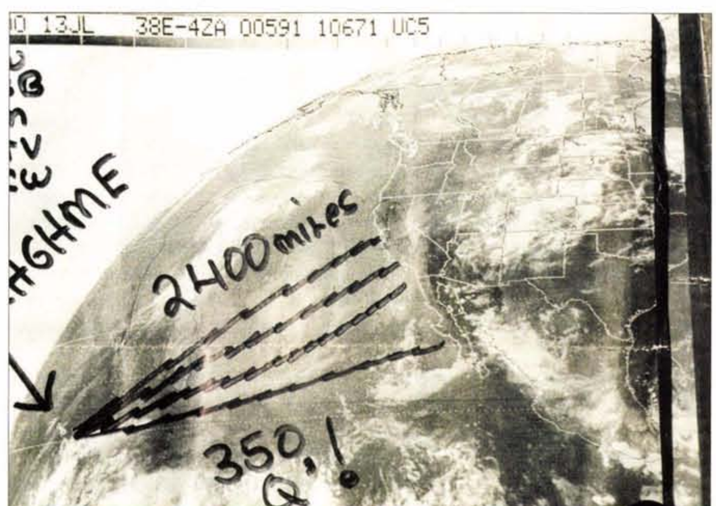
Amateur radio operators have discovered that it may not be necessary to be absolutely in the duct at both ends of the circuit to make a long-range VHF or UHF radio contact. In the California/Hawaii duct, the Hawaiian end of the duct is usually well-defined directly above the local cloud layer with tops at 5,000 feet. Hawaiian ham station KH6HME looks for that telltale cloud layer and 10-degree temperature increase. But at the other end of the circuit, the West Coast of the United States may see a long-range VHF/UHF tropo duct opening anywhere from sea level to 5,000 feet up. West Coasters can usually visualize this duct by simply looking out over the ocean to Hawaii, and looking for coastal low clouds on a very hot day in July and August.

The aperture of the duct along the West Coast slowly changes in latitude, but seldom changes in altitude. The duct from California to Hawaii normally forms up near the Mexican border, giving San Diego, CA, stations easy conversation with VHF stations in Hawaii with Los Angeles hearing nothing. A half-hour later, LA gets the action, and San Diego reception fades out. But hang on, this usually reverses itself about an hour later.

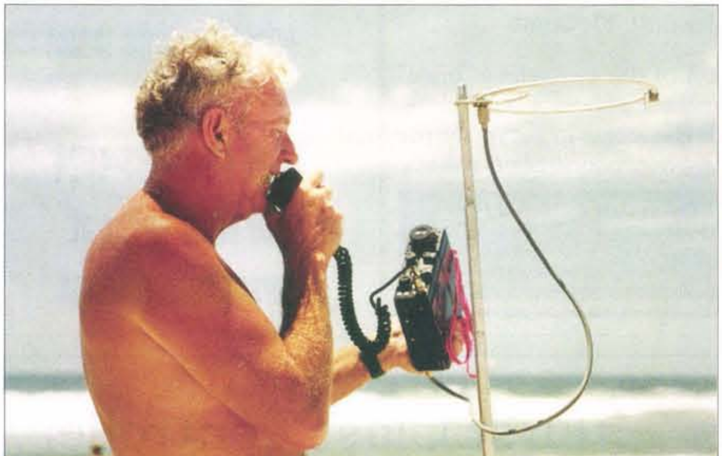
Like tentacles of an octopus, the duct may also simultaneously carry into the San Francisco Bay area, and up the Oregon coast, with the furthest world record VHF contact via tropospheric ducting between northern Washington state and Paul Lieb KH6HME at his experimental transmitting site on the slopes of the Mauna Loa volcano.

ALL OVER THE PLACE

But you don't need to live along the West Coast with all its smog (and those great inversion layers triggering tropo ducting) to get a taste of VHF/UHF long-distance communications via stratified weather systems. There is a regular summertime path between Texas and Florida. The path is so intense that cellular providers and point-to-point microwave systems sometimes swap signals, and what you thought would be a local call to



July California/Hawaii tropo weather chart QSL card.



Gordo chats with Paul in Hawaii 2,500 miles away on a portable two-meter SSB rig.

Paul Lieb KH6HME at his volcano "tin house" beacon equipment.

your better half ends up being a long-distance call from a cell site 800 miles away! Surprise, surprise.

In Texas, UHF fire department medic dispatchers will sometimes hear paramedic calls between Houston and Tampa. One Clearlake, TX, dispatcher remembers a crystal-clear contact with a mobile medic unit arriving at the scene of an automobile accident at the tip of Key West, FL. This was the same time that Key West was getting severe radio interference from stations in New York and Boston. Earlier that week, Chicago taxi cabs accidentally dispatched Virginia Beach cabbies to several streets they couldn't look up on their map book.

The tropospheric ducting conditions may last for a single day to the more common three-day episode, but sometimes with hot windless summer weather last for a week. The long-range radio conditions always occur on hot windless days where a high-pressure system has settled in making for many hot August nights. Tropo ducting continues into the evening, but normally peaks when both stations at each end of the duct get a mutual sun view.

There may also be a strong tropospheric path between the East Coast of the United States to Europe. The well-known Bermuda/Azores VHF/UHF path has been documented many times by airplane pilots at specific altitudes. However, ham radio operators have yet to set this record on 144, 222, or 432 MHz. Yet, early records of British radar journals at 140 MHz indicate consistent radar echoes coming from supposedly USA targets thousands of miles away during brief periods of strong inversion layers between both continents.

It's relatively easy to detect tropospheric ducting conditions. If you have a VHF weather channel receiver hooked up to an outside antenna, check for weather stations coming in on normally unused weather channels. Every five minutes, the weather station usually identifies by city.

In Hawaii, they know that tropospheric ducting conditions are prevalent when they begin picking up stateside FM music stations. Here on the West Coast, we know there's good tropo conditions into Mexico when we begin picking up their VHF and UHF television signals from an outside TV Yagi antenna pointed south.

Family Radio Service half-watt handheld enthusiasts claim over 400 miles contact between a New York City skyscraper and a pal down the seashore south of Virginia Beach. This is believable when you can image the surprise of this author picking up a relatively low-power, 6 MHz wide, amateur radio television fast-scan broadcast from Paul in Hawaii.

So, next time you're out on the open road, dial around with your FM auto radio, and see if you can pick up a station more than 50 miles away. If it is a hot windless afternoon and you see smog hanging on the horizon, chances are you'll be getting FM music radio reception up to 300 miles away! And, if you still have an outside TV antenna hooked up to your 27-inch color tube, see what lies beyond your local channels when normally all you may get is snow on the unused channels. If it is a hot windless day, stations from 500 miles away may pop in for hours on end with full color and stereo sound.

And finally, next time you're going down that lonely highway and see the shimmering blue mirage hovering over the super-heated blacktop, consider this as super-refraction where the blue sky is actually bounced back up to you from the black roadway ahead. Just the opposite occurs when intense tropospheric ducting occurs overhead, sometimes giving viewers along a seacoast an exaggerated view of a distant island that may appear magically hanging upside down over the horizon. These aberrations will slowly come and go as the high-pressure system plays games with radio and visual wavelengths. **NV**

by Robert Nansel

Amateur Robotics

This month, I'll tie up most of the loose ends remaining with the linear actuator project. Alas, I also made a couple goofs last month that need to be corrected this time. I've gained a new appreciation for why commercial linear actuators cost so much — they aren't easy to get right! At the same time, I've identified several improvements and simplifications to the basic design I've been working with these last two months. I haven't tried all of these new ideas out yet, but there's no reason why y'all can't give them a whirl.

This month, I've also got a more detailed discussion of the simple limit switch circuit from last month. I know a few of you may have looked at the schematic and scratched your heads. This wasn't another goof, but a few more words and diagrams will help clear things up.

Finally, I had intended to ease into a basic discussion of color sensing. Do you think you know what color really is? I thought I did, too — until I began digging. That discussion will have to wait until next month.

For now, let's get back to work on the actuator.

Goof Patrol

Okay, the follower nut should be drilled to 7/64" before tapping the threads, not 3/32" as I erroneously called for in the text and in Figure 1 from last month. Though only 1/64" smaller, it could mean the difference between a cleanly tapped hole and a broken 6-32 tap.

A more serious error cropped up in Figure 2b last month: the two square cut-outs in the guide tube (intended for the rollers of the limit switches) got shown in the wrong view. If that wasn't bad enough, the view they should have been in was not even shown. Figure 1 this month is the corrected drawing. Some days it doesn't pay to get out your crayons.

Now to attend to the non-goof loose ends.

Motor Mounts

Figure 1 shows the motor mount bracket details.

Cut two 7/16"-long motor mounts from 1/4" brass angle stock. Use a drop of Muriatic acid flux to clean the brass, then tin one side of each mount, and tin 1/4" of the corresponding mounting areas at the base of the guide tube assembly.

You want the tinned areas to have as thin a coat of solder as you can get. I used a butane soldering iron in conjunction with my propane torch to "squeegee" the excess solder off. Just heat the area with the torch, then rub the tip of the soldering iron across to redistribute and wick away excess solder.

Once the solder is evenly distributed, wipe the excess solder from the soldering iron tip by brushing the tip on a moistened sponge or a piece of cardboard. Repeat this process until the surface is shiny. Cool the pieces and scrape any irregular solder humps away.

Now to solder the pieces together. First, form a length of soft steel wire into a square loop, making the loop just large enough to fit over the end of the guide tube with both mounting brackets tucked in. (An unfolded 1" paper clip will work fine for this job.)

Twist the ends of the wire loop to clamp the pieces together. The brackets will probably shift while you are tightening the wire; reposition them with a light tap from a scrap of wood. Once everything is secured tightly, apply the torch to "sweat" the pieces together. Feed extra solder at the joints as needed, but take care not to move any of the pieces. When you are done, leave the whole thing to cool for five or 10 minutes.

Once everything has cooled down, untwist the wire clamp (it shouldn't stick since you didn't flux it) and examine your work. Scrape or sand the corrosion, crud, and any excess solder from

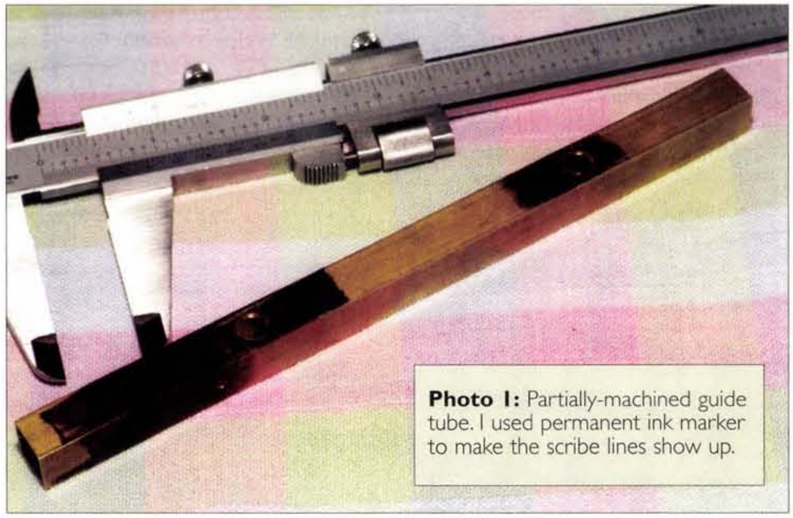


Photo 1: Partially-machined guide tube. I used permanent ink marker to make the scribe lines show up.

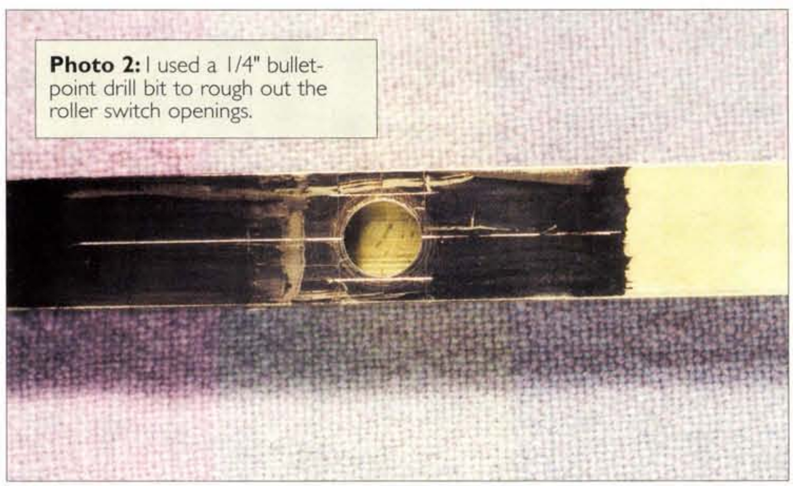


Photo 2: I used a 1/4" bullet-point drill bit to rough out the roller switch openings.

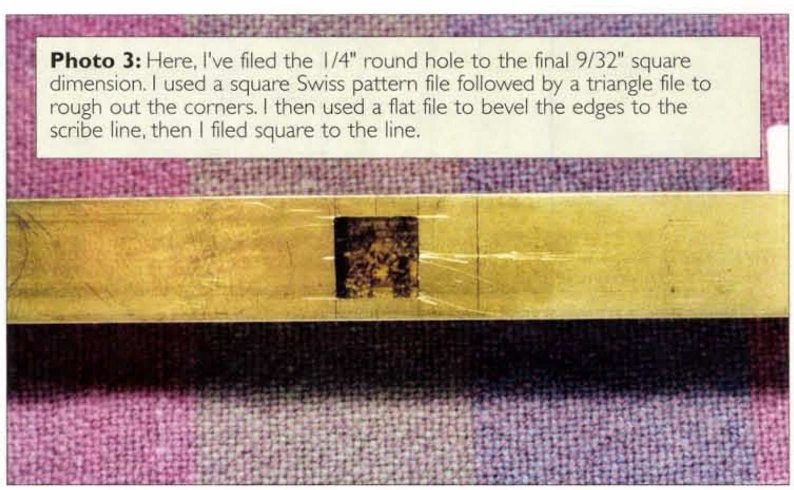


Photo 3: Here, I've filed the 1/4" round hole to the final 9/32" square dimension. I used a square Swiss pattern file followed by a triangle file to rough out the corners. I then used a flat file to bevel the edges to the scribe line, then I filed square to the line.

the metal.

Pivot Pins

Last month, I permanently mounted the upper thrust bearing in the guide tube by center punching dimples to lock the block in place. Now it's time to talk about the removable bearing block and the pivot pins that hold it in place.

When I built my prototype I used a couple 1/4" round 6-32 threaded male/female standoffs from my junk box for the motor-end pivots (Figure 2a). The pivot pins are a straightforward way to link the actuator to the chassis of a robot or other machine. Typically, the pivots would turn in two bronze bushings fixed to the chassis, with appropriate retaining screws and spacer washers. The bearings would be in the form of removable pillow blocks or bearing plates to facilitate installation and removal of the actuator.

However, when I went to find a commercial source for the male/female standoff parts for this article, I came up empty-handed. All the electronics hardware sources with which I am familiar carry only the hexagonal variety. This makes sense, I suppose, because standoffs aren't usually used as pivot pins, and it's much easier to tighten a hex standoff than a round one.

For my application, though, the standoffs must rotate in bearings. A person with a lathe could easily turn a hex standoff into a round standoff, but that's not the point. Some company made the standoffs I got from my junk box (and if any of you out there know of a source, I'd be obliged if you could drop me a line).

Short of this, I've come up with several alternative ways to do the motor-end pivots, two of which are shown in Figure 2b and 2c. I haven't yet tried these alternatives, but they should work.

Alternative Pivot Pins

The first alternative (Figure 2b) involves soldering a threaded brass rod into a mating brass spacer. Unplated 6-32 threaded brass rod costs about 20 cents an inch from Small Parts, and .5" threaded brass standoffs cost about 30 cents each, so the materials cost for two pivots should be less than $1.00.

The second alternative (Figure 2c) uses a shoulder screw. Shoulder screws are also called stripper bolts. For commonly available shoulder screw sizes, you get a smaller diameter bearing surface, but these screws are made of hard steel with a precision ground finish to the shoulder, so they may not be a bad choice. They also eliminate the need for separate washers and retaining screws — a plus. The downside is shoulder screws tend to be more expensive, about $2.00 each.

Some candidate shoulder screws are RAF Electronic Hardware #7016-SS or #7018-SS (available from Allied Electronics, **www.alliedelec.com**) and Small

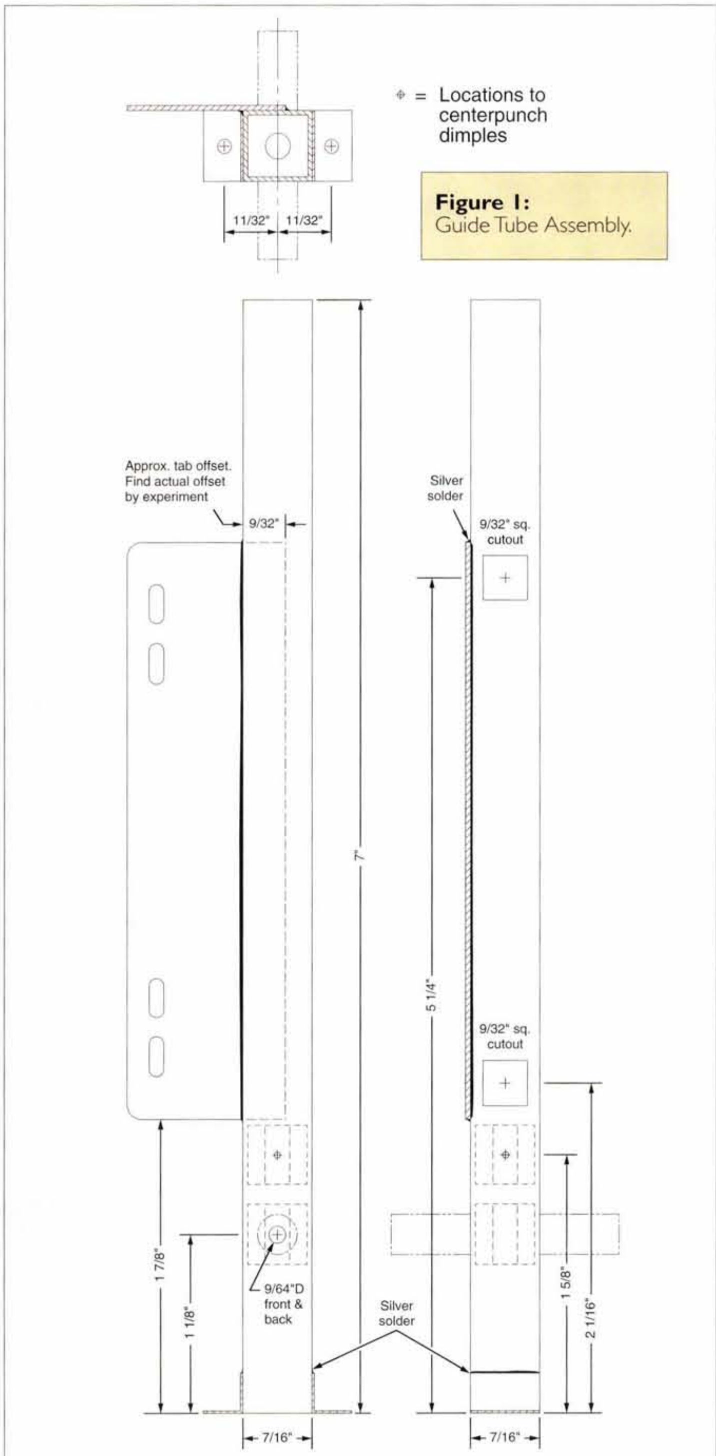


Figure 1: Guide Tube Assembly.

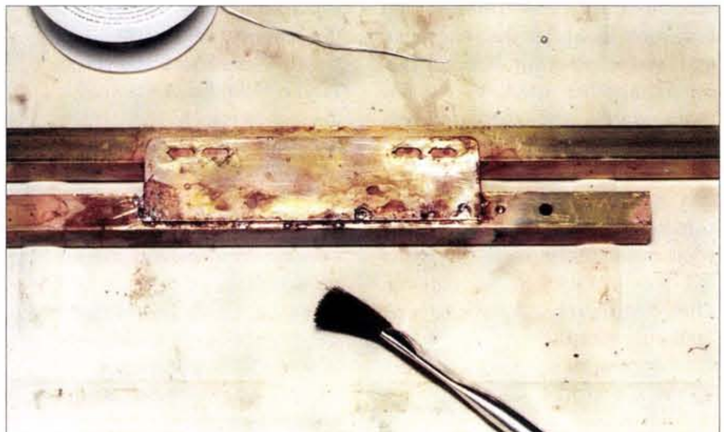


Photo 4: Soldering the mounting tab to the guide tube. The square tube in the upper supports the tab while "sweating" the tab to the tube. I used the back side of a ceramic pizza stone as my work surface.

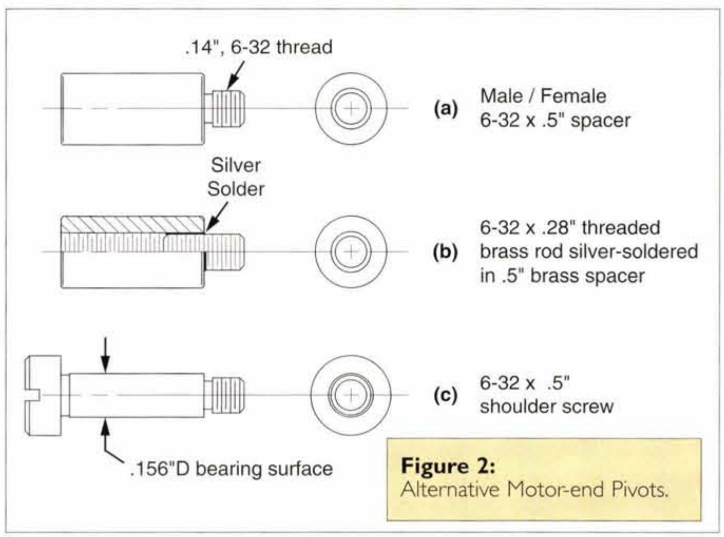


Figure 2: Alternative Motor-end Pivots.

Parts # SHDX-3/3 or #SHDX-3/6 (**www.smallparts.com**).

All of the above methods require you to tap the cross-drilled hole of the lower thrust bearing block. The male threads of the pivot pins must protrude no further than about .14" through the side of the guide tube and into the bearing block (otherwise, they will interfere with the lead screw). I simply filed the threaded section of each pivot pin until it was short enough.

The third alternative (not shown) uses roll pins, also known as spring pins. A 3/16" O.D. x 3/4" length roll pin costs about 10 cents, so this would be the cheapest method, especially when combined with the single thrust bearing block option, which I'll get to in a moment (see Figure 3b).

To use roll pins, you need to drill both the guide tube and the bearing block to 3/16", but you would no longer need to tap the bearing block. You still need to take care once the roll pins are installed that they don't interfere with the lead screw. Perhaps the design of the thrust bearing block would best be modified so the roll pins seat in blind holes drilled no deeper than 0.10". I'm not sure if this would be deep enough to grip the roll pins securely enough to make a durable assembly, but the simplicity and low cost of the approach makes it attractive.

Captive Nut

Solder the captive nut to the 5" lead screw. Soldering steel can be tricky. You need to clean all oil and dirt from the threaded rod and remove any zinc plating, as well. I wound up filing and scraping away the plating for a quarter inch on either side of the nut's position, about 0.7" from the end of the lead screw.

Use a Muriatic acid flux to clean the surfaces, then bring the nut and the threaded rod to temperature with a torch. Move the flame away and apply silver-bearing solder. In your first few tries, the solder will probably form little balls that won't stick to either the nut or the threaded rod. Squeeze a few drops of the flux over the heated section to chemically clean it. Do this in a well-ventilated area, and be sure not to breathe the vaporized flux fumes. Rinse the pieces in water to cool.

The technique I finally worked out was to tin the threaded rod as best I could, clean it with flux, then scrape away most of the solder blob with a knife. I then threaded a "chaser" nut onto the rod and ran it over the tinned section a few times to chase the threads. I used a couple hex nuts jammed together on the other end of the lead screw so I could hold onto it with pliers without damaging the threads. This was necessary to keep the lead screw from turning while I turned the chaser nut with another set of pliers.

Unthreading the chaser, I fluxed and reheated the tinned section just enough to make the solder melt, tinned it a little more, and repeated the process until I had a section of shiny, tinned threaded rod. I then threaded a new nut in place over the tinned section.

You'll want an unplated nut, if you can find one. If you can't find an unplated nut, just let the nut sit in a few drops of Muriatic acid for five or 10 minutes, then rinse it in clean water and dry it. The nut won't be shiny anymore, but you'll have a much easier time getting solder to stick to it.

A No-Solder Method

If you just don't have any luck soldering steel, I have worked out another thrust bearing arrangement that doesn't require soldering. Figure 3a shows my original two-block thrust bearing system, which requires a captive nut soldered to the lead screw as described above.

If the upper, permanently mounted bearing block ever needs to be replaced, I'll have to drill out the dimples. Then I'll have to drive the block out with a hammer and steel rod, not the most friendly maintenance regime.

The alternative thrust bearing, shown in Figure 3b, uses only one machined thrust bearing block. The block is not permanently-mounted, so it's easy to replace, and you adjust the axial play of the lead screw by tightening or loosening the top and bottom nylon-insert lock nuts. My next actuator will be built this way.

Motor Modification

The guide tube is about .015" too small to fit over the motor's brass bushing. The bushing is 0.390" diameter, while the inside of the guide tube is 0.375" square. You could ream the base of the guide tube to 0.390", but the easier thing to do is to file four flats on the brass bushing.

Photo 5: The other side of the guide tube assembly. It's not pretty, but it works.

First, cover all the motor ventilation slots with tape to keep out metal filings. You need to remove about .008" at each flat until the flats are about .10" wide. Don't be alarmed if the brass bushing rotates while you are filing the flats. It is swaged to the motor case, so as long as you don't pull it out of its hole, it should be fine. The motor mounts themselves will hold everything rigid when we're done.

Attach the actuator mechanics to the motor with two M2.5 x 12mm socket-head cap screws. You can find these screws in hobby shops that carry Du-Bro products (Du-Bro #2115). Failing that, try Small Parts (#MSHCX-25-12).

It will be a tight fit between the screw head and the guide tube mounting bracket, so you may need to file or grind reliefs into the brackets to allow the screws to seat.

Limit Switches

Last month, I gave a schematic for a simple limit switch circuit, but I didn't enumerate all the possible switch and motor drive states. The way the actuator is built, there are only three possible combinations of limit switch closures and openings. Last month's schematic showed both limit switches in the normally closed (NC) position. This corresponds to the fully extended state (shown in Figure 4c).

For intermediate actuator positions, the retract switch will be

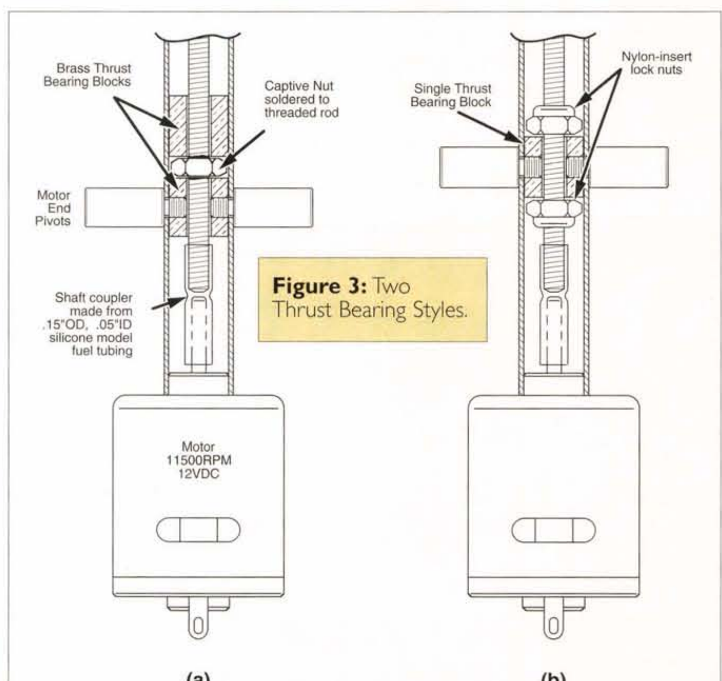


Figure 3: Two Thrust Bearing Styles.

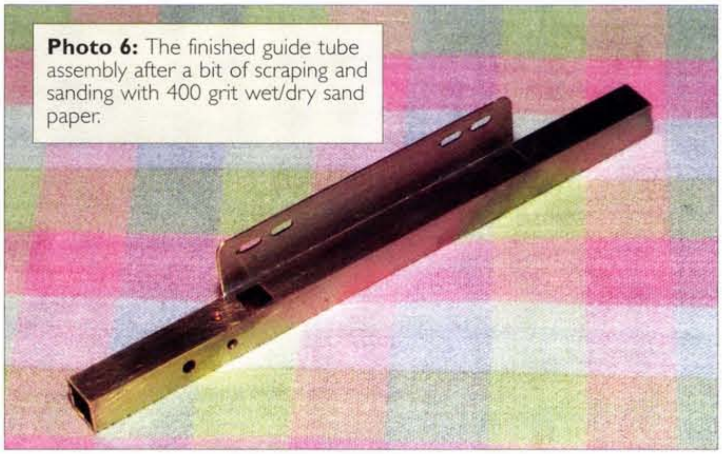


Photo 6: The finished guide tube assembly after a bit of scraping and sanding with 400 grit wet/dry sand paper.

in the NC position and the extension switch will be in the normally open (NO) position (Figure 4b). The fully retracted state has both the retract and extension switches in the NO position (Figure 4a). (A fourth combination, where the retract switch is in NO and the extension switch is in NC, can only happen if the retract switch is jammed or malfunctioning.)

Since the lead screw is threaded right-hand, turning the lead screw clockwise (as viewed from the base of the actuator) will pull the follower nut toward the base. In this case, the actuator will retract, and turning the leadscrew counterclockwise will make it extend.

As viewed from the motor's end bell — the plastic part opposite the shaft —the motor turns clockwise when the voltage applied to the terminals is positive with respect to the terminal markings (each terminal is marked with a molded "+" or "-" next to it). It turns CCW if the applied voltage is negative. Hence, with positive voltage the actuator retracts, and with negative voltage, it extends.

Suppose the actuator is fully retracted, the case depicted in Figure 4a. Since the retract switch is in the NO position, the only path current can take is through the extension switch NO contact and from there through the left bypass diode. This can only happen if negative voltage is connected to the M1 and M2 terminals. The motor turns CCW, and the actuator extends.

As soon as the retract switch returns to the NC position, the current flows exclusively through the switches. The practical effect of this is the motor will run slightly faster, since the retract switch has shorted out its bypass diode, effectively removing the 0.7V diode drop from the circuit. Current can flow either direction, and the actuator can retract or extend, the situation depicted in Figure 4b.

If the actuator extends far enough, the extension switch opens and the motor stops, the situation in Figure 4c. The only way current can flow is through the extension switch bypass diode, corresponding to a positive

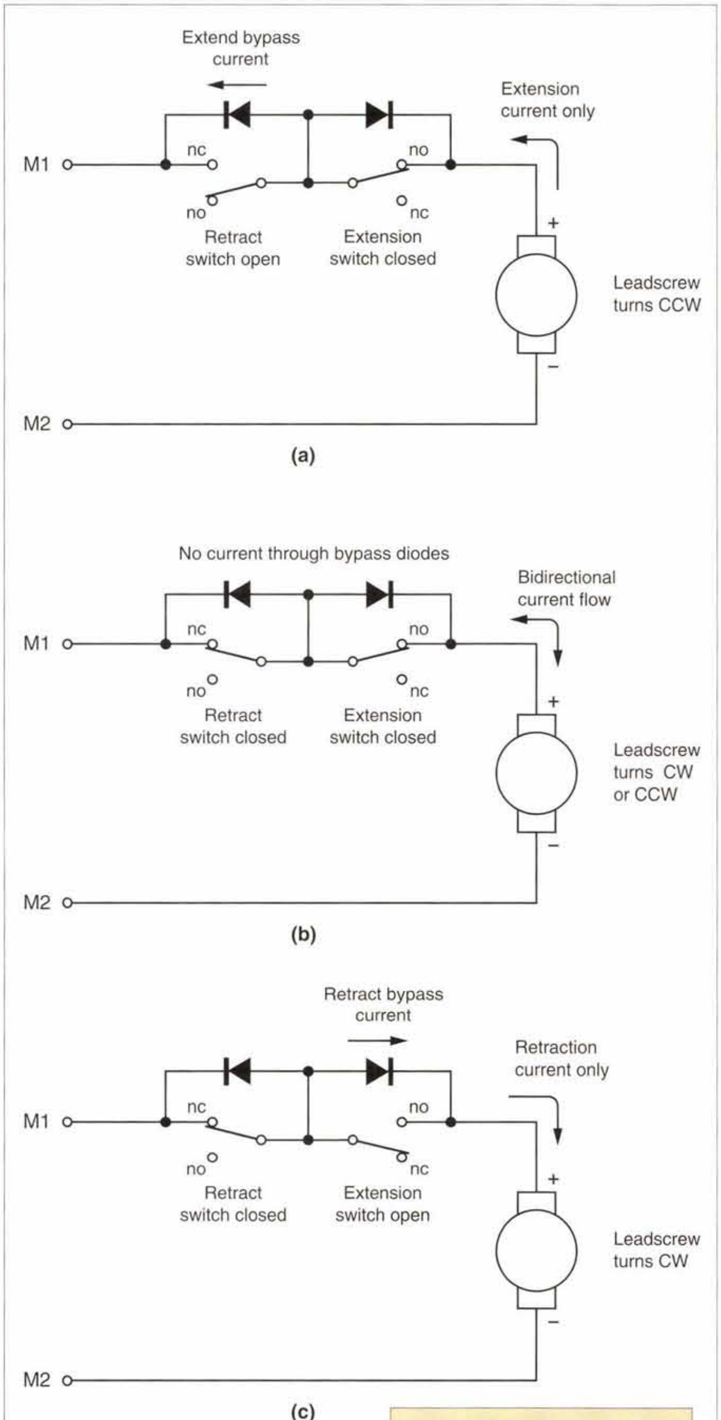


Figure 4: Limit Switch States.

voltage across M1 and M2, and the actuator retracts once more.

Next Time

There are other ways to handle limit switches, but I'll save that and a few final tidbits on the actuator for next month. As I said in the lead, I'll also be diving into color sensors. It being summer, if I have space, I'll show you some solar-powered robot subsystems. Until then, be careful out there soldering with those torches! **NV**

If you have suggestions, questions, or comments about amateur robotics, you can reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003
E-Mail:
bnansel@nauticom.net

TECH FORUM

QUESTIONS

I'm no electrical engineer, but I am very interested in doing research on Schumann Resonance. I understand that the frequencies that I am interested in are in the .1 to 40 Hz range. I want to be able to feed the info into my computer so that I can do a Fourier transform analysis on it for frequency and spectral analysis, etc.

What is the best approach? How about making a resonant circuit with a coil and a capacitor and feed it into an A/D converter into my computer? What values of the coil and capacitor would I need? Any thoughts about an antennae?

#7021 **Jesse Stoff**
Tucson, AZ

Years ago, before the advent of complex counter chips, dividing a frequency was accomplished with RS or JK flipflops. It's easy to divide by a multiple of two. Dividing by 3, 5, or 7 required special configurations of the FFs. Being lazy, I wonder if anyone has retained these odd configurations so I don't have to reinvent them.

#7022 **Bill Hawes**
via Internet

I'm looking for a diagram to connect a recording sound module (kit CAS64 from **www.electronics123.com**) to the phone line, in order to clearly play my recorded message and, if possible, to also be powered from the same phone line.

#7023 **Dan Zillbermann**
via Internet

I need to build a power supply that will have an output of 9.6 volts DC current at 1800mA. Could someone tell me how to do that?

#7024 **Robert Ritchey**
Vandalia, IL

We had our dog implanted with an AVID pet ID micro chip and I wondered if it would be possible to make a scanner to read it? Possibly using a BASIC stamp or something. Could this be used to warn us if our dog was to leave our yard?

#7025 **Robert North**
via Internet

I'm trying to build a remote control circuit to toggle four relays on/off using a Linx Technologies Keyfob CMD-KEYX-418 transmitter/encoder and a matching Linx RXD-418-KH receiver/decoder. I was wondering if someone could design a circuit to do this or give me some suggestions.

#7026 **James**
via Internet

I have a bunch of amps made by Fairchild Semiconductor, #A00-6. They are made of discrete parts and have two circuit boards. I need schematics and application notes, they look like late 70s vintage.

#7027 **richmix@erols.com**

I am looking for a source for parts for a projection dial radio from the 1930s. I know about Fair Radio Sales, but they do not carry the projection dial film or other parts. I remember the name "Antique Electronics Supply" from a few years ago, but I do not know if they are still in business and have what I need.

#7028 **Don Sands II**
Davenport, IA

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!

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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 email 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

All questions should relate to one or more of the following:

1) Circuit Design
2) Electronic Theory
3) Problem Solving
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.

ANSWERS

[5028 - MAY 2002]

Is there a way to connect a terminal with a female 25-pin parallel printer port to a printer with a "B" USB connector?

About a year ago, I had the same need. Our church had a fax, scanner, printer multi-function terminal (MFT) that was donated to replace an obsolete fax machine. The church computer already had a printer connected to its parallel port, so the parallel port printer function (which I wanted use as a backup) of the MFT was not connected.

There are a number of suppliers of equipment to meet this need. Some units are basically a parallel connector and a USB jack (with the electronics in between) which requires a separate USB cord. The most cost-effective ($23.99) unit was from **Roger's Systems** (a regular *Nuts & Volts* advertiser), which has an integrated 6' cord with a USB plug. It came with Windows 98se/2000 compatible software driver, and continues to work well. Check their website for details. **www.rogerssystems.com**.

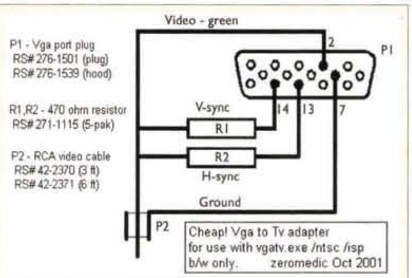
Ray Mueller
Surf City, NJ

[5026 - MAY 2002]

I have an old router that uses a CGA/EGA monitor. The

[40210 - APR. 2002]

I am looking to build a simple VGA-to-TV composite video converter. I need the convert to work in DOS only and be able to convert plain (25 lines) monochrome text only.



This diagram is for a simple, straightforward VGA-to-TV converter.

It correctly converts text information from a DOS system into a composite output, provided the proper TSR (terminate and stay resident) drivers are loaded ahead of time (i.e., in your AUTOEXEC.BAT file). If anyone interested will contact me at **mrmagnet@bellsouth.net**, I will gladly email the small (~10k) driver and info file to them.

I am currently using this setup at the shop, and it has been working great for the past year now.

Derek Tombrello
Columbiana, AL

[5021 - MAY 2002]

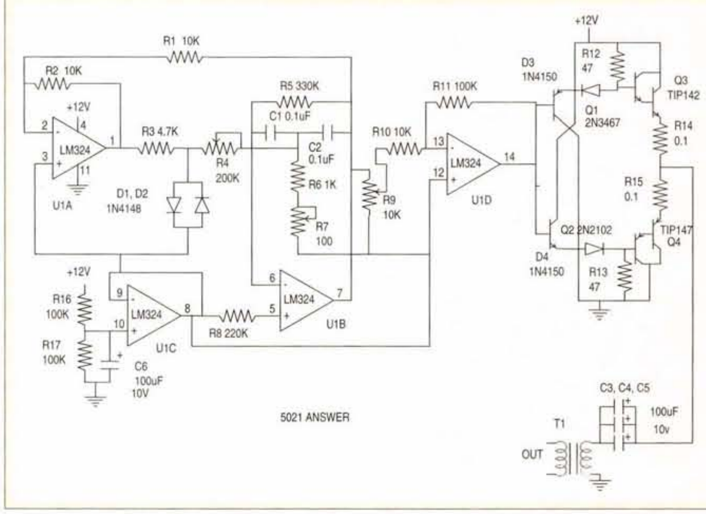
I am looking for a circuit that uses a 12-volt source input and can generate an 80 Hz sinewave with an adjustable amplitude. The amplitude needs to be adjustable from 0 to 150 Vpp with no DC offset. I also need the output capable of 16 watts. Any ideas?

Part	Description	RadioShack.com
U1	LM324 op-amp	#900-6317
Q1	2N3467 PNP	#900-5439
Q2	2N2219 NPN	#900-5427
Q3	TIP142 NPN	#900-5165
Q4	TIP147 PNP	#900-5166
D1, D2	1N4148	#900-2906
D3, D4	1N4150	#900-2907
C1, C2	0.1uF, 5%	#3013PH-ND*
C3, 4, 5, 6	100uF, 10V	#900-1900
R4	250K pot	#900-7911
R7	500 ohm pot	#900-7902
R9	10K pot	#900-7907
R12, R13	47 ohm 1 watt	#900-0658
R14, R15	0.1 ohm 5 watt	#900-0874
T1	10VAC/120VAC xfmr	#900-2705

* digikey.com part number

In this circuit, U1A and U1B comprise the oscillator. The amplitude is limited by the diodes D1 and D2 to one volt peak-to-peak. R4 is the regeneration control, too much feedback will cause distortion, so adjuste it so the circuit just barely oscillates. R7 is the frequency trim, to compensate for component tolerance. C1 and C2 should be poly film or other stable type. U1C provides six volts bias for the circuit. U1D is a gain of 10 amplifier. It may be possible to connect R11 to the output for higher fidelity without causing oscillation, but since I have not built this circuit, I opted for the more conservative connection to pin 14 of U1D. R9 is the amplitude control. The output power amp is designed to operate class A, drawing one or two amps quiscent current. If the current is too high, or you want to save power and operate class AB, then change the 1N4150 diodes to a higher current type, like 1N4000. The output capacitors are paralleled to carry the load current of about five amps. The power supply must be capable of six amps minimum. T1 is a 10VAC to 120VAC power transformer. 1/4 watt resistors are OK, except those listed. The transistors, including Q1 and Q2, will need heatsinking.

Russell Kincaid
Milford, NH



monitor has gone bad.

Is any way to adapt a VGA monitor to this system. The computer is a VME custom system so changing the video card is not an option.

A changer for HD15 to DB9 connector can be had from **MCM Electronics**, 650 Congress Park Drive, Centerville, OH 45459-4072.

The old VME Systems I've seen came with BNC video connectors not IBM PC CGA/EGA connectors, so double check, but MCM has several different connectors that may or may not work for you.

One possibility is part number 83-0400, many others are also available, they will be more than happy to assist you.

Larry Heath Wheeler
via Internet

[5025 - MAY 2002]

None of the surge protectors that I've seen for AV equipment accept a video input. I would like to protect my expensive home-theatre system from a lightning strike on the camera that I use to watch the pool. I could use a wireless transmitter/receiver, but that seems ridiculous.

This video buffer, figure 1 above, will survive a 2000-volt pulse at the input. At higher voltages, the diodes will short, but still protect the output circuits. There is no protection from a direct hit, other than a long RF link. The 10K resistor is one watt to withstand higher voltage. The IC is available from **RadioShack.com**, #900-6324.

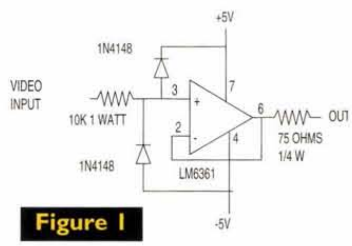


Figure 1

Russell Kincaid
Milford, NH

[5023 - MAY 2002]

I need to make a graph on a computer of a potentiometer's resistance against time as it is turned. I tried a RadioShack digital multimeter cat #22-805 with PC interface as an analog-to-digital converter to input the resistance. It works fine except it is too slow. Are there converters about 15 times faster?

www.computerboards.com has the CIO-DAS08/JR for about $150.00. It is an ISA board.

www.mpja.com/ has the 8412 KT for about $30.00. It plugs into the parallel port of a PC.

Geoff Probert
via Internet

[4022 - APR. 2002]

I support a network containing analog Public Switched Telephone Network (PSTN) dial modems. These modems are used for dial out capability only and never need to answer a call.

For security reasons, I need to prevent the modems from answering calls received from the PSTN network. Due to the nature of the network and type of modem, the auto answer feature cannot be disabled. Therefore, I need a circuit design or know of a commercial equivalent that will pass the analog and -48DC on-hook/off-hook components, but block the 20Hz, 80Vac ringer component of the telephone signalling.

The first telephones used a capacitor in series with the ringer coil connected across the line to ring the bell. The 20Hz 80Vac (or large noise spike) would cause the ringer coil armature to vibrate, ringing the bell.

Current modem design uses a capacitor in series with an LED inside an opto-isolator (4N35, etc.). The opto-isolator sends a series of 20Hz pulses to the control circuits to generate the ring detect signal. A reverse polarity diode is placed across the LED connections of the opto-isolator to prevent reverse voltage across the LED.

Removing the capacitor should have the stated effect. The capacitor should be about .47uF 350V, unpolarized. Check to make sure that one end goes to the line input, and that the other end goes to an opto-isolator. It will probably be the only unpolarized capacitor in the modem.

Applying a TTL lever 20Hz signal burst through a 510-ohm current limiting resistor to the modems opto-isolator LED should cause it to go "off hook" and answer if it is programmed to answer on the first ring. It would be desirable to have the modem answer on the first ring.

If eliminating the modems response to the ringer signal solves Mr. Crawley's problem, that's great. However, I suspect that more is required.

The usual protocol to establish a modem connection on the PSTN is for the originating modem to go "off hook," detect dial tone, dial the number of the answering modem, and wait for synchronization/training tones. I am not sure if detection of "ring-back" is necessary in the sequence, it may be. If a "busy signal" is detected the originating modem goes on hook, the connection has failed. The answering modem will go "off hook" and place the synchronization/training tones on line after detecting a programmed number of rings. The modems then determine between themselves a common mode and rate that is compatable to both units. Subcarriers are then brought on line and the connection is complete. If there is no compatable mode and rate between the modems, the connection fails.

There may some minor varitons to the protocol for differing systems. The sequence and time

[5024 - MAY 2002]

What is the best way to switch video inputs of security cameras using a PIC such as a BASIC Stamp.

Maxim makes a chip that should work, but it's surface mount technology, so I cannot use it.

I could always use a bank of relays, it's simple but primitive.

#1 You could use video op-amps with disable inputs like Analog Devices' AD8041, which is available in the good ol' plastic DIP package (AN suffix), and just bus the outputs together as described in their application literature.

Another good approach to this problem uses garden-variety 4066 CMOS quad analog switch ICs. See figure 1. The switches are arranged in a "T" configuration to achieve very high isolation at baseband video frequencies. The circuit is extensible to any reasonable number of inputs, limited primarily by total capacitance on the output bus.

You can even tie the video inputs to additional input modules and create an X/Y matrix style array, if desired, but you should add input buffers if you carry this to extremes. Don't duplicate the 75-ohm input termination resistors (R1) if you do this.

The output buffer/amplifier (U2) in this circuit can be any decent video op-amp, such as Elantec's EL2044 or the AD8041 shown — its disable input isn't used. Current feedback devices may require different feedback resistor values, but their ratio should always yield a gain of two as shown.

The 4066 power supply pins must be tied to +5 and -5 volts. Power supply bypassing isn't shown, and it's important to do this well on fast amplifiers like the AD8041. Video input module wiring could be rearranged to make the control input high true, but all of the input channels would be active simultaneously at turn-on, until your microcontroller completes its initialization routine. That's not a great idea because damaging currents could flow through the 4066 analog switches. For the same reason, your control code should never activate more than one input module on any output bus.

Mike Hardwick
Decade Engineering

#2 I use the Maxim video switches, and am extremely pleased with their performance.

You simply provide the control signals at TTL/CMOS levels. The video connections are direct, and only a few resistors and caps are needed for filtering and gain selection.

The only drawback is that they do require a bipolar supply. I simply built up a small supply with a center-tapped transformer, a full-wave bridge rectifier, a few filter caps, and 7805 and 7905 regulators. If the supply is clean, the video signals suffer no noticeable degradation.

I built mine into a cast aluminum enclosure to reduce outside interference.

I checked at **www.digi-key.com** and found the following in DIP form:

MAX453CPA-ND, two-channel, eight-pin DIP package; $9.43, currently out of stock.

MAX454CPD-ND, four-channel, 14-pin DIP package; $12.59, currently 161 in stock.

MAX455CPP-ND, eight-channel, 20-pin DIP package; $20.96, currently 1620 in stock.

If you're really building a "wide" system, you might even want to order an eight-input, eight-output video multiplexer. It simply allows each of eight monitors (or VCRs) to select from any of eight available inputs. These can be cascaded for even more inputs and outputs.

The MAX456CPL-ND provides this, in a 40-pin DIP package. For just a bit over $50.00 each, it's a compact solution for whole-house video switching. (currently out of stock, but worth ordering if it's what you need).

In any case, I'd terminate each input with a 75-ohm resistor to GND, whether you're using that input or not.

Lyle Hazelwood
Morganton, NC

#3 This solution uses the DG508, eight-channel analog switch multiplexer, but the circuit could be adapted to the MUX16FT, 16-channel multiplexer. The switch resistance is in the order of 240 ohms, therefore a buffer is required at the output. The 75-ohm resistors are to properly terminate the 75-ohm coax normally used for video.

Instead of the BS1 stamp computer, which would have been overkill, I designed an 8/3 binary converter. See figure 2. All the parts are available from **RadioShack.com.**

Russell Kincaid
Milford, NH

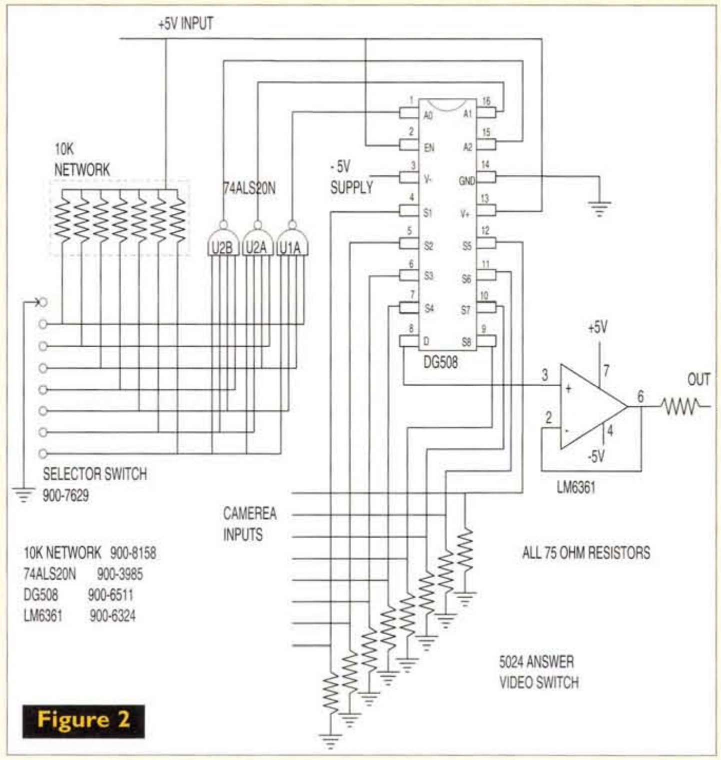


Figure 2

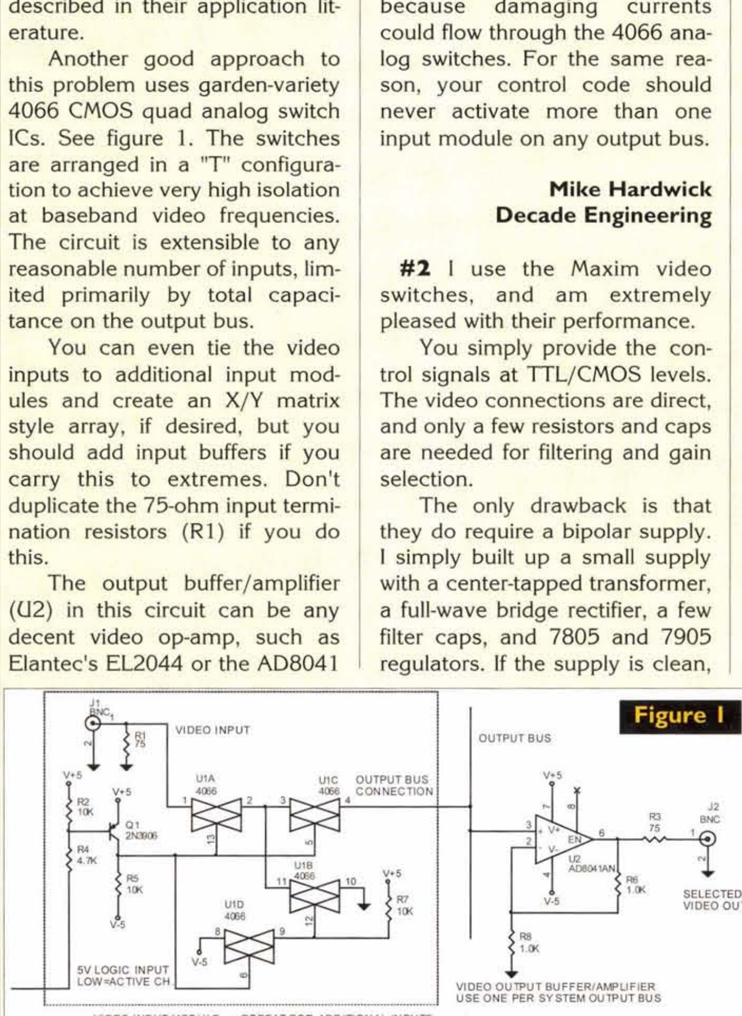


Figure 1

delays between events and modes of operation are mostly controlled by software in the host systems. A modem may be allowed to "fall back" to a lower rate/mode in order to synchronize with a slower modem.

The set-up and sequence of events commands will take the form of a script, and may come from a script file, or a file of sequential commands and variables. This file must be identified and located so that the delay from answer to synchronization can be increased to allow time for request/authorization voice communication. The modem driver software provider may provide the necessary information, if it is not in the software documentation. Otherwise good hacker skills may be required.

If the modem is external on a serial port, there is an alternative that should work, I'm not quite 100% sure. On the serial cable, route the terminal end of the ring detect conductor to a box where it can be pulled to a space level, 1K ohm current limiting is recommended. Pulling the conductor to a mark level should should cause the computer to command the modem to answer. Some experimentation may be in order to confirm proper mark-space response.

I have probably provided more information than Mr. Crawley needs, but better too much than too little. Knowing nothing about his system and it's environment, I have tried to keep my suggestions generic so that they would apply to any system, PC, VAX, SUN, Mac, Windows, UNIX, LINUX, etc.

If things work out okay, he might consider automating the process with "Caller ID." if available in Northern Ireland.

It could be a good PIC project.

Larry Chason
Cairo, GA

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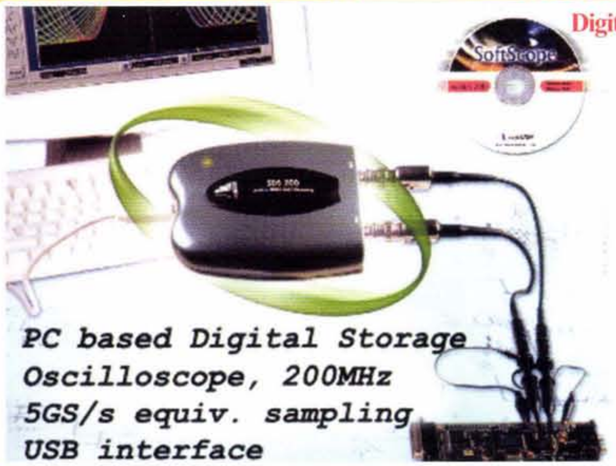

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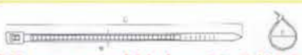

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the Toddler

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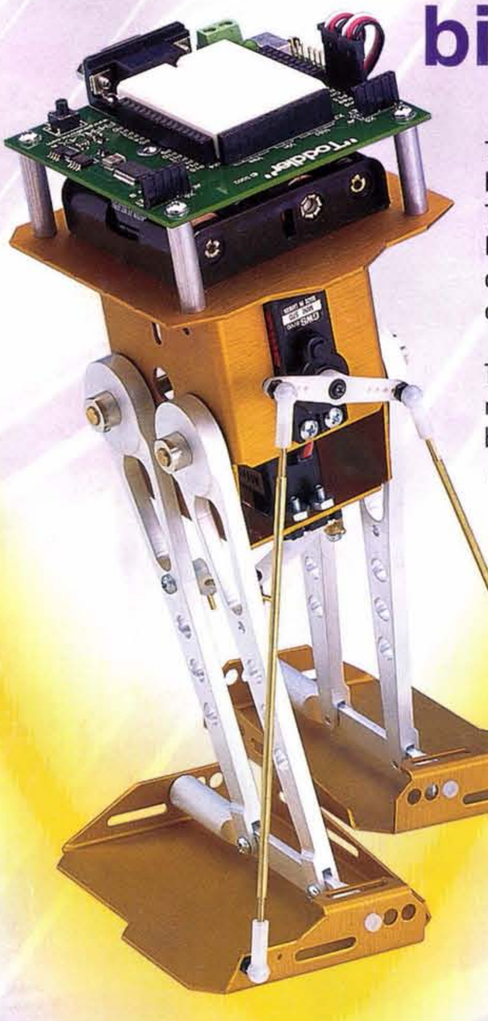

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