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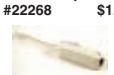

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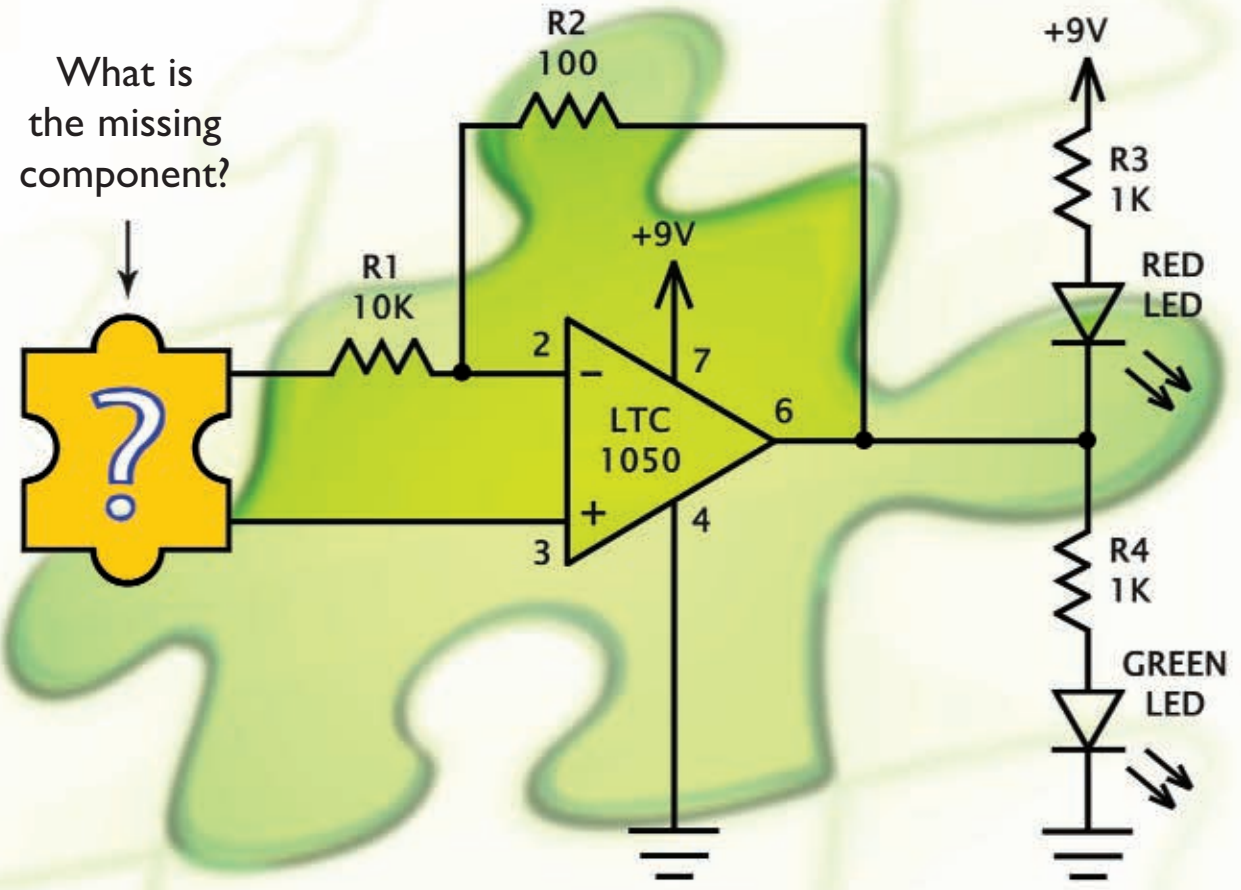

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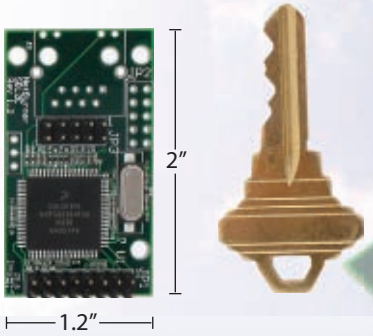

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DEVELOPING PERSPECTIVES

Speaker Break-In

Although I like to keep up with the latest innovations in electronics, my personal taste is toward vintage tube amps and musical instruments. I rarely take out the plastic for a new model of anything. However, I was checking out a new 100W tube amp recently and I asked for a demo. The sound was surprisingly harsh to my ears.

The salesperson's response was that this was a new floor model and that the speakers hadn't been broken in yet. Not only that, the speaker cables and the power cord were new, as well. He was confident that it would take about 30 hours of continuous use to burn in the cables, and perhaps double that for the speaker to reach "full fidelity."

This wasn't the first time I'd heard about breaking in speakers, but it was a first for the cables and power cord. When I expressed doubt about the speaker cables, he showed me a national audiophile magazine with ads from companies selling pre-broken in audio cables. The more expensive cables were broken in 100 hours or more. According to the full page ads, both the insulation and copper wires require breaking in, again to reach "full fidelity." I thanked the well-meaning salesperson and headed home to do a little research.

It turns out that some — but not all — high-end speaker manufacturers recommend breaking in speakers. For example, Celestion (**professional.celestion.com**) — which manufactures high-end speakers for guitar amplifiers — recommends breaking in speakers. They suggest warming up a speaker and then playing 10-15 minutes at full volume to get it up to spec in the shortest time. Some boutique amplifier manufacturers include burn-in as part of their production process.

Breaking in a speaker makes sense, given that it's an electromechanical device. I can understand the need to get things moving to loosen up the cloth and other materials. Even so, there is no universal consensus that breaking in a speaker is needed or that it even works.

If you check the blogs, you'll see that a common perception is that the break-in period is the manufacturer's ploy to get customers used to their speakers so they won't return them. So, as far as speakers go, I'm leaning toward the break-in side.

However, I put the concept of cable break-in in the same category as multi-dimensional time travel with a phone booth. I've never seen a rational explanation for breaking in speaker cables, much less power cords. And yet, there are businesses that advertise on the web offering break-in services for your high-end cables.

For only $39 per cable, you and your family can avoid the inconvenience of breaking in your own. Or, another company will sell you a cable cooker so that you can break in and periodically recondition your cables in the comfort of your own home.

I have no problem with someone trying to make a living by offering products and services that, while questionable, don't actively harm anyone. However, it's a disservice to well-meaning salespeople and the general public to popularize voodoo electronics.

In pulling together the articles for *Nuts & Volts*, we do our best to validate the science behind each article. But we also rely on you, the reader, to take an active role in commenting on our content — positively or negatively. The laws of physics won't be changed by group consensus, but opinions and perspectives can be shifted in the right direction. **NV**

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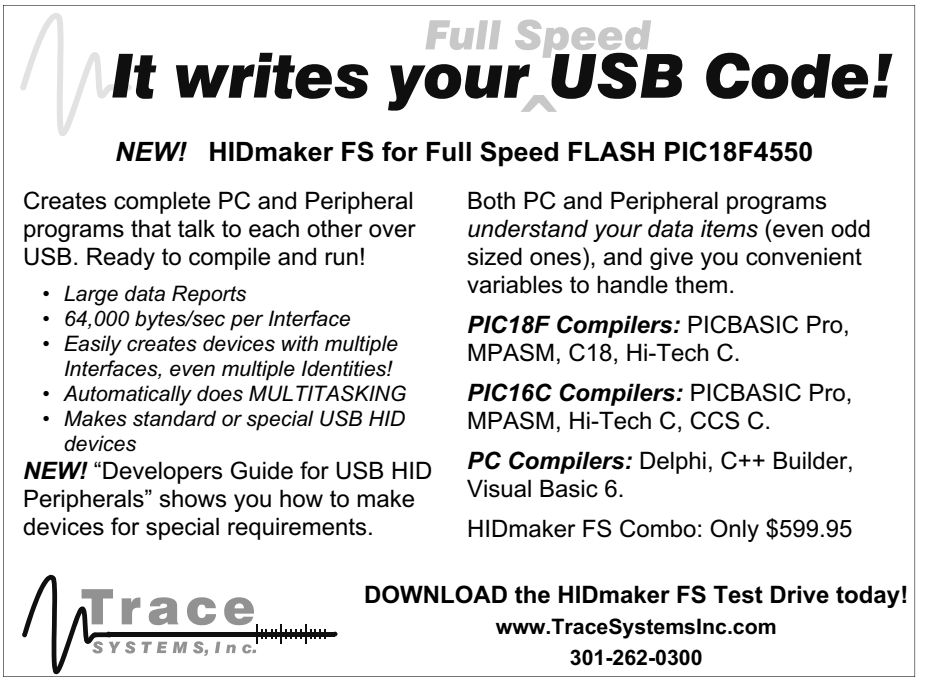

TECH KNOWLEDGEY 2009

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

GaN + Si HYBRID CHIPS COMING

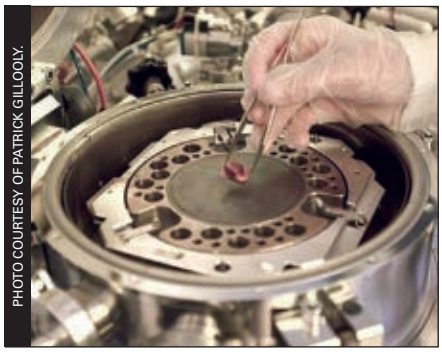

PHOTO COURTESY OF PATRICK GILLOOLY.

■ The hybrid chip under development at MIT.

It's no secret that we're approaching a dead end in terms of how small we can downsize silicon and, in fact, some other materials offer better performance. But the industry has spent billions of dollars on silicon technology and isn't overly eager to start over with something else. An obvious solution would be to combine different but complementary semiconductor materials on a single chip, but despite decades of research no one has been able to do it — until now. Apparently, MIT (**www.mit.edu**) researchers have come up with a solution that could help overcome some of the size and speed barriers faced by contemporary silicon technology.

Whereas you can easily put a billion transistors on a silicon chip, the technology for similar integration with other materials does not exist. It turns out that perhaps only five to 10 percent of the transistors are involved in computations and need to run at maximum speed; speed isn't so critical for the others, e.g., ones that store information. So, if you could piggy-back the faster, more exotic materials on top of silicon, you could have the best of both worlds.

Enter Prof. Tomas Palacios and grad student Will Chung, who have created a silicon/gallium nitride hybrid chip, as described in the October issue of the IEEE journal *Electron Device Letters*. Instead of trying to grow the high performance material on top of a silicon chip as others have attempted, they embedded a GaN layer into a standard silicon substrate. This produces a faster chip that is also highly efficient — having most of the transistors operate at slower speeds minimizes power consumption. Best of all, the chips can be manufactured using standard commercial silicon technology. According to one analyst, the concept could "enable a new class of high performance, mixed signal, and digitally controlled RF circuits for use in a wide range of Department of Defense and commercial applications." In addition, the technology may be applicable to things like hybrid chips that combine lasers and electronic components on a single chip and energy-harvesting devices that can use ambient pressure and vibrations to produce enough power to run the silicon components. So far, the researchers have been able to make chips that are only about one square inch in size, so a challenge is to find a way to scale it up to match the eight- and 12-inch wafers used in conventional chip manufacture. In addition, they need to work on issues of device reliability and thermal management in the GaN transistors. Nevertheless, they hope to have it ready for commercialization within about two years.

TAPPING TREE P OWER

In a development likely to make tree huggers apoplectic, some folks from the University of Washington (**www.washington.edu**) have figured out a way to power (very) small electronic devices from trees, according to an article recently published in the IEEE *Transactions on Nanotechnology*. "As far as we know, this is the first peer-reviewed paper of someone powering something entirely by sticking electrodes into a tree," said co-author Babak Parviz, a UW associate professor of electrical engineering. Inspired by an earlier MIT study revealing that plants generate up to 200 mV when one electrode is plugged into the plant and the other into the soil, Parviz and co-author Carlton Himes spent the summer poking nails in trees in search of promising specimens. In the process, they discovered that bigleaf maples generate a steady stream of up to a few hundred millivolts. The next step was to have another co-author, Brian Otis, build a boost converter that stores incoming voltage until it can be discharged at an output of 1.1V — enough to run low power sensors.

Note that the tree power concept is not the same thing as the "potato effect," in which a current flow is created by a chemical reaction on two different metals. The tree power setup uses the same metal for both electrodes. So, how does it work one might ask? "It's not

■ This custom circuit collects and stores enough power from trees to run a low power sensor.

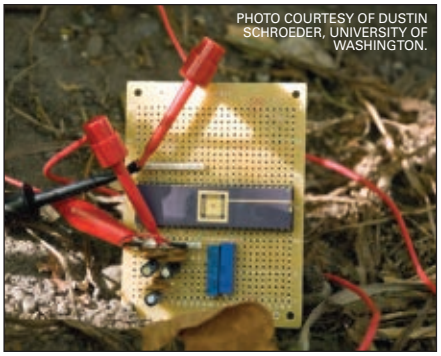

PHOTO COURTESY OF DUSTIN SCHROEDER, UNIVERSITY OF WASHINGTON.

exactly established where these voltages come from," admitted Parviz. "But there seems to be some signaling in trees, similar to what happens in the human body but with slower speed. I'm interested in applying our results as a way of investigating what the tree is doing. When you go to the doctor, the first thing they measure is your pulse. We don't really have something similar for trees." In terms of practical applications, tree power is unlikely to intrude into the realm of solar power, but it provides a low cost option for powering sensors that monitor environmental conditions. In fact, the concept has already been patented by Voltree Power LLC (**www.voltreepower.com**). Their first tree-powered product is the Early Wildfire Alert Network (EWAN), consisting of thousands of humidity and temperature sensor nodes distributed over remote forests.

COMPUTERS AND NETWORKING

DUAL MONITOR LAPTOP

Sometime between now and Christmas, a new laptop from a new source — gScreen Computer Corp. (**www.gscreencorp.com**) — is scheduled to hit the market. Based in Anchorage, the company has been around since 2003 but is only now coming out with its first hardware product. This isn't the first dual screen laptop to emerge, but it is the first one focused primarily on the needs of filmmakers, photographers, video and graphics designers, and CAD engineers. According to the company, "We do not yet know the exact release date, price, or specs that will be available on the first Spacebook model. We do know the specs that we are planning at the current time, but those can change and will solidify when we go into production at the end of 2009."

Some specs are available though, and both 16 inch and 17 inch models will be in the initial offering, with smaller ones to follow. Features include an Intel Dual Core2 processor (2.53 or 2.80 GHz), the Mobile Intel PM45 Express Chipset ICH9M-Enhanced, NVIDIA GeForce 9800 GT graphics with 512 MB VRAM, a 250 or 500 GB drive, an optical drive, and various I/O ports. No official price has been announced, but rumor has it that the machines will cost you somewhere in the range of $3,000.

■ The Spacebook dualscreen laptop, designed for high-end graphics users.

DUAL MONITOR, NO LAPTOP

■ The EVGA Interview dual display.

Also geared for people who want to see double is the EVGA Interview™ Display, which features two rotatable, thin, high-res 17 inch displays supported by a single desktop stand. Designed for "business presentations, researchers, physicians, financial consultants, or creative professionals," the unit's 1440 x 900 resolution screens will flip 180 degrees on the horizontal axis and automatically invert the onscreen image to show it correctly for viewers on either side of the desk. The screens also fold 90 degrees from closed to fully open to allow workspace flexibility. It comes with two keyboards and mice so viewers can work with their image on one side while others can watch on the other side. It also sports a built-in 1.4 Mp webcam and a microphone for video conferencing. The base features three USB 2.0 ports and controls for monitor settings, the microphone, power, and DMS connections. MSRP is $649.99, with Internet prices about $25 less. For details, visit **www.evga.com/interview**.

INDUSTRY AND THE PROFESSION

"MIRACLE ROBOT" INVESTMENT OPPORTUNITY: STEP RIGHT UP

If you're sniffing around for a long-shot investment, take a whiff of an offer from Suram Robotics, an Indian firm that's looking worldwide for investors in its plan to build and market a "miracle robot." According to CEO and Project Chief Ashish Sood, "This is going to be one of the unique robots in the world." He informs us that it can (a) be remotely controlled, e.g., functioning in the USA at the direction of an operator in India; (b) create other robots like itself, free of charge; (c) do all types of household and office work; (d) talk to any person on Earth and provide instant answers to questions; and even (e) look after your kids when you're away from home. According to Sood, "These robots will not charge anything for the work you require them to do, so you save a lot of money." Details about the robot itself are available at **http://raj6781.googlepages.com/miraclerobot**.

You can invest as little as $100 in the project, for which you will receive a company shareholder certificate. Investors will draw an "appropriate" portion of the profit when the robot goes on sale in world markets. Sood predicts that his aspirations (which ostensibly do not consist of a quick retirement in Brazil) can be accomplished within three months if sufficient investment capital is raised.

Curiously, interested investors are directed to **www.mukeshambani.com**, which doesn't seem to exist. But FYI, Mukesh Ambani is an Indian engineer and businessman, chairman and largest shareholder of Reliance Industries, and reputed to be the wealthiest Indian in the world, the wealthiest in Asia, and the seventh wealthiest in the world. One has to wonder why he hasn't kicked in enough to get the ball rolling.

ONE TOUGH H D

PHOTO COURTESY OF HITACHI GLOBAL STORAGE TECHNOLOGIES.

■ Hitachi's SimpleTOUGH drive, built for rough environments.

For people who work in harsh environments, tweet while bungee jumping, or just get drunk and fall down a lot, Hitachi has introduced the SimpleTOUGH portable USB 2.0 drive. According to the manufacturer, it is the "only water- and shock-resistant external drive available today from a global hard drive manufacturer." Engineered to sustain a 3 m (9.8 ft) drop and able to withstand being run over by a one-ton-class commercial truck, the SimpleTOUGH drive can take a beating that's worse than a date with Chris Brown. It also includes a "never-lose" foldaway USB cable, ergonomic sides for easy carrying, and a topside power status LED. Inside is a Travelstar drive that can withstand shocks of 400 G in operation and 1,000 G when shut down. SRPs are $99.99 for the 250 GB version, $119.00 for the 320 GB, and $149.99 for the 500 GB. Details are available at Hitachi Global Storage Technologies (**www.hitachigst.com**).

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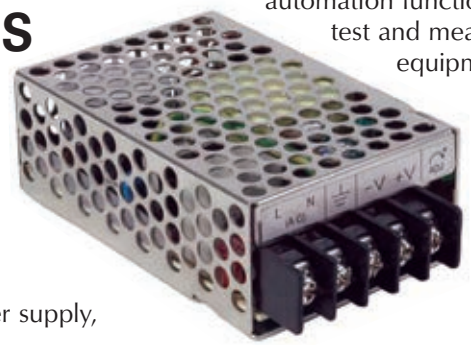

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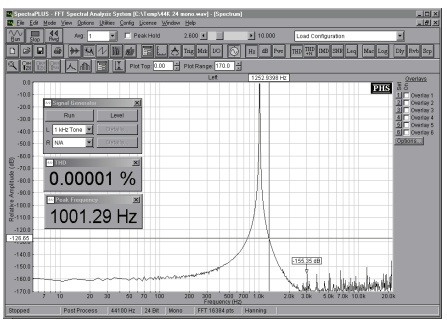

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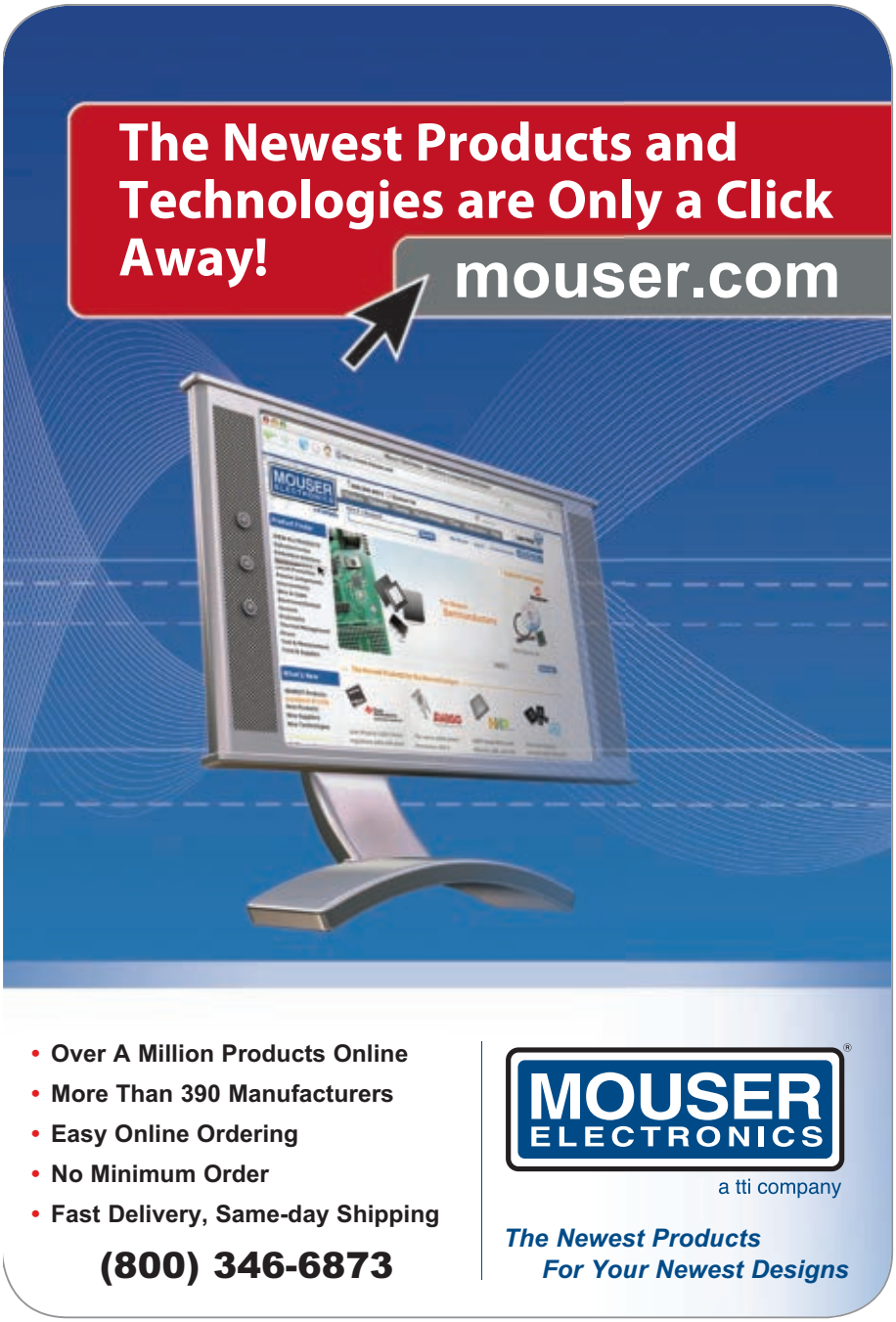
SUBMINIATURE PUSHBUTTON SWITCH

■The new SSP 129T subminiature pushbutton switch.

A new subminiature pushbutton switch has been introduced by Knitter-Switch, a Munich-based manufacturer of switches ranging from toggles to membranes to tactile switches. The SSP series is designed specifically for use with mobile multimedia devices, portable medical devices, and a variety of test and measurement instruments. The SSP 129T is a large travel alternative to existing tactile switches that usually have a travel of only 0.25 mm and, in fact, match the PCB layout of the knitter-switch TSS309/TSS310 series tactile switches. With a footprint of just 7 x 3 mm and a longer travel of 1.6 mm, the switch is a surface-mountable device supplied in T/R packaging for automatic pick-and-place systems. Available in normally open and momentary contact versions, the SSP 129T provides a 100,000 cycles operating life and incorporates a gold-plated contact plate for the reliable small-current switching. The company offers the switches through a network of European distributors but doesn't appear to have any North American outlets. Interested parties are advised to contact the home website at **www.knitter-switch.com**. **NV**



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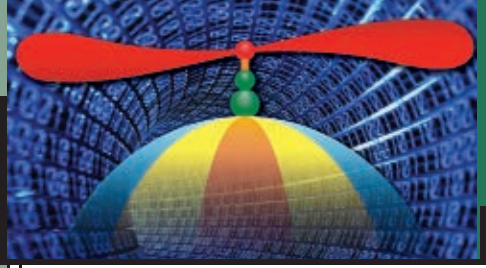


■ BY JON WILLIAMS

DO IT UP WITH DMX

Even if you've never heard of DMX512-A (DMX), chances are you've seen it in action. Where? At any large stage production. Concerts and plays are big users of DMX-controlled lighting. So, what if you're not one for concerts or the theater? Well, have you ever been to a night club with lots of crazy, dancing, pulsating lights? Then you've seen the magic of DMX.

So, what is DMX? It is, in fact, a very simple, half-duplex (one direction, controller to fixture) serial protocol that runs over a standard RS-485 hardware link. The protocol was originally designed for controlling stage lighting, but as it is so easy to implement it has been put to use in a variety of show control applications.

We can break down the protocol into four essential elements:

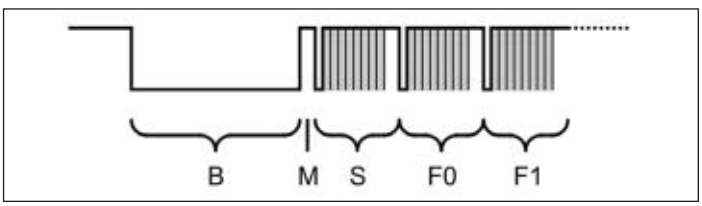
- Break (B)
- Mark After Break (MAB)
- Start Byte (S)
- Packet of Frames (Fx)

Figure 1 visualizes these elements as seen on the DMX RX pin of the Propeller.

The *Break* is what allows all receivers on the system to synchronize themselves with the packet; this is a space (0) on the line that lasts 88 µs or longer. The *Mark After Break* is a short rest with the line at idle (1); the MAB is (8 µs) or longer. The first byte that follows the MAB is called the *Start* byte; it is typically zero and ignored in many systems (though it really shouldn't be). DMX bytes are transmitted in 8N2 (eight data bits, no parity, two stop bits) format. After the *Start* byte is the *Packet* of channel values called *Frames* (0 to 255, also 8N2) which could be up to 512 bytes.

Light fades and motion are created by a master controller that streams the DMX data at a pretty swift clip: 250K baud. At this rate, the *Break*, *MAB*, *Start* byte, and 512 *Frames* can be transmitted every 22.7 milliseconds (per the DMX specification).

■ FIGURE 1. DMX Signaling.



I've written DMX receiver code for the SX28 but it is a challenge, especially when one needs to do brightness control of LEDs as we intend to do here — there's not a lot of room left in the interrupt when running an RX UART VP at 250K. With the Propeller and a dedicated DMX receiver cog, however, it's really very simple — so much so that it makes me shake my head and smile.

What we're going to build this month is a generic DMX I/O add-on for the Propeller platform with three channels of medium current output to control devices like 12V LED circuits and small DC lamps. This will let us create a simple DMX lighting fixture using a high brightness RGB LED.

DMX HARDWARE

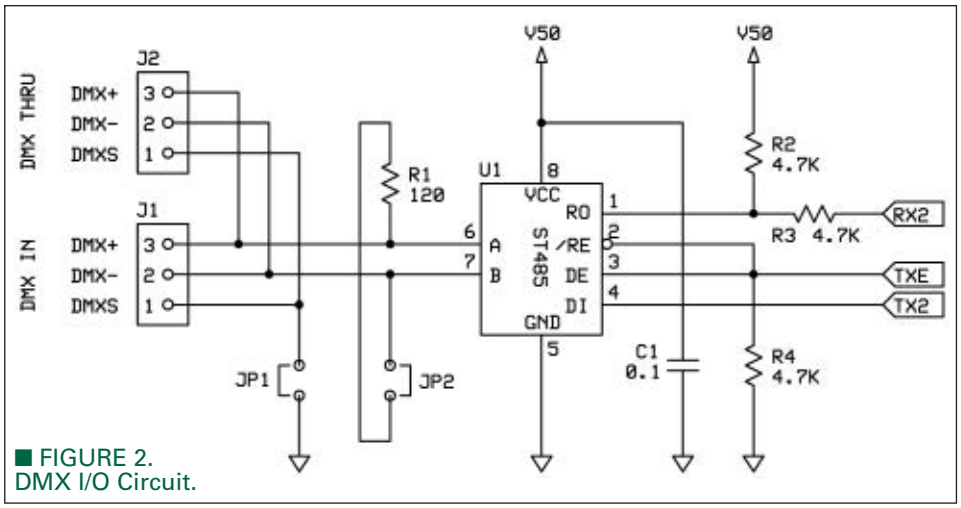
Figure 2 shows the schematic for a generic DMX interface — yes, this circuit can transmit, as well as receive. It would have been silly to design an add-on module for the Propeller that couldn't transmit as well, especially since the "cost" of this upgrade was a resistor and a single I/O pin. Pretty cheap price for the flexibility, don't you agree?

A quick note about JP1 and JP2: JP1 is used only when the node is the master (transmitting) and only one node will ever use JP1 (for receiver devices we leave this out). JP2 is for the end nodes (transmit or receive) on a DMX network; this resistor prevents reflections. So, if your DMX project using this circuit is the last on the DMX line then JP2 needs to be installed. For a lot of really great information on RS-485 hardware, please see Jan Axelson's book, *Serial Port Complete*.

For what it's worth, my design does, in fact, violate the DMX specification in that I'm using three-pin XLR connectors instead of the five-pin units that are normally called for. But guess what? I have a mini DMX console and a popular DMX lighting fixture here in my office, and both use three-pin XLR connectors; this "violation" is

pretty commonplace.

The circuit is a standard, half-duplex RS-485 interface that defaults to RX mode by pulling the /RE and DE lines low through resistor R4. You may be wondering why I went with a 5V device when a 3.3V device is available. Cost. There is a 5V supply on the Propeller platform and the cost of the 5V ST485BN plus resistor R3 is about half of the 3.3V device. R3 limits the current into the RX2 pin (DMX RX input) of the Propeller. R2 holds the line high (idle state) when the ST485BN is set to transmit mode and the RO output goes Hi-Z (this resistor is required for projects that will do bi-directional comms). Finally, we don't have to worry about direct control of the TXE line with the Propeller as the minimum V_{IH} level of the ST485BN is 2.0 volts.



■ FIGURE 2.
DMX I/O Circuit.

Okay, let's have a look at the code. The heart of the object will, of course, run in its own cog, happily receiving DMX data on the assigned pin and writing it to an array that we can read from our top-level application. I've also added an activity output LED; this lights when receiving a frame byte so we know the line is active.

From the top, here's the setup and code that monitors the DMX RX line for the Break period.

```
dmxin           andn            outa, ledmask
                mov       dira, ledmask

                mov       ctra, NEG_DETECT
                add       ctra, rxpin
                mov       frqa, #1

waitbreak       waitpeq   rxmask, rxmask
                mov       phsa, #0
                waitpne   rxmask, rxmask

shortpacket     waitpeq   rxmask, rxmask
                cmp       BREAK, phsa      wc
        if_ae   jmp       #waitbreak
```

On entry, we make the LED pin an output and off, and then set up **ctra** to count (at the system clock rate) whenever the DMX RX pin goes low (negative detect mode). This is an easy way to use the counter for pulse width timing; we simply check or reset the counter whenever the RX pin is high.

At waitbreak, we begin by waiting for the RX line to go high using **waitpeq**. When it does, we reset the **ctra** accumulator (**phsa**) and then wait for the RX line to go low. After it goes high again (so we've seen a high, low, then high), we can compare (**cmp**) the value in the counter's accumulator with the minimum timing for a break. If the pulse was short, i.e., not a valid break, the program will loop back to waitbreak and try again. Why would we have a short Break? We wouldn't, but we could power on in the middle of the Packet and we don't want to move unsynchronized values into our array. By waiting for the next Break, we can get into sync with the DMX stream.

After we've detected a valid break, we set up to receive up to 513 serial bytes. The first is the Start byte and will usually be zero. Still, we shouldn't ignore this byte; we should make it available to the application to check.

For review, a serial byte will have a start bit, eight data bits, and one or more stop bits; in DMX512-A, each byte has two stop bits. **Figure 3** shows the signal going into the DMX RX pin of the Propeller. The idle state of the line is high, a start bit is low (0), the data bits arrive LSB first and are read directly from the line. The stop bits are at the line's idle state (1). The value in the diagram is $CF.

Another task to deal with is handling a short packet, that is, less than 512 frame bytes. A typical DMX controller will transmit the Start byte plus 512 frames, but it doesn't have to. For example, I have a mini, six-channel controller that sends the Start byte plus six frames, at a very low rate (every 100 ms). What I'm getting at is we'll have to smarten-up our serial receive code to detect a new break, even when we don't expect one.

```
getpacket       mov       bufpntr, buf0
                mov       count, PACKET

rxbyte          mov       phsa, #0
                mov       rxwork, #0
                mov       rxcount, #8
                mov       rxtimer, US_006

                waitpne   rxmask, rxmask
                add       rxtimer, cnt
                or        outa, ledmask

rxbit           waitcnt   rxtimer, US_004
                test      rxmask, ina      wc
        if_c    mov       phsa, #0
                shr       rxwork, #1
                muxc      rxwork, #%1000_0000
                djnz      rxcount, #rxbit
```

■ FIGURE 3. DMX512-A Byte Format.

```
breakcheck      waitcnt     rxtimer, #0
                test        rxmask, ina      wz
                andn        outa, ledmask

        if_z    jmp         #shortpacket

                wrbyte      rxwork, bufpntr
                add         bufpntr, #1
                djnz        count, #rxbyte

                jmp         #waitbreak
```

At the top, we set *bufpntr* to the hub address of the array that will hold the DMX data and count to the number of bytes to receive (513). At rxbyte, the Break timer (**ctra**) is reset and we prep for receiving a serial byte that has a bit timing of 4 µs (250K baud). The bit timer is initially set to 6 µs (1.5 bits) so that we can position the bit sampling in the middle of the first bit; this timer will be activated (via syncing with **cnt**) on detection of the start bit. Note, too, that when the start bit is detected the LED is turned on to indicate DMX activity.

The bulk of serial receive code is at rxbit. After the bit timer expires, the DMX RX line is sampled with **test** and the RX bit value is moved into the C flag. If the C flag is set (1), then we can restart the Break timer — remember this is set up to auto-increment whenever the DMX RX line is low. After the Break timer is dealt with, the output value in *rxwork* is shifted right by one bit and we move the new bit from C into bit7 using **muxc**. If there are more bits to receive, then the code loops back to rxbit; otherwise, it will drop through to breakcheck.

The program waits one more bit period (4 µs) and then samples the line again, saving the result into the Z flag. At this point, we should be sampling a stop bit which is high. If, however, we have a new Break period then the line will be low (0) and the Z flag is set. When this happens, the program jumps back to shortpacket which completes and validates the timing of the new Break period.

Most of the time, though, we have a valid byte which is moved into the DMX array using **wrbyte**. Once the entire DMX packet has been received, the program jumps back to waitbreak and starts all over.

So, there you have it, a DMX receiver engine in under 40 [working] lines of code. Of course, there is an interface in Spin which lets us set the RX and LED pins, and takes care of setting all the timing parameters to match the system clock. After the init() method, we'll use the read() method to grab a byte from the DMX stream. Remember, byte 0 will be the DMX Start byte; bytes 1 through 512 will be the DMX frames.

Before moving on, let me point out that there is a DMX object in the Propeller Object Exchange by Tim Swieter (**www.brilldea.com**) that is very advanced, providing all kinds of interesting statistics about the DMX stream (e.g., the length of the break, length of MAB, actual number of frames transmitted, etc.). If you're feeling brave, please have a look — you're sure to learn some new Propeller tricks. Tim's code will, of course, work on the P/P DMX I/O board, and is very useful for creating a DMX diagnostics device.

LED MODULATION WITH BAM

So, what is BAM? It's a Bit Angle Modulation that is a modulation strategy that uses a bit's position within a value as the basis for the timing of that position. For example, bit 0 is output and then we wait one 'period.' Next, we output bit 1 and hold for two periods. After that, we output bit 2 and wait four periods. You should start to see the pattern: The timing for a given bit is $2^{bit\#}$ periods. Following this pattern, the final bit in a byte, bit 7, has a timing value of 128 periods. In the end, the complete timing for one byte will be 255 periods, but we only had to deal with eight cycles (one per bit). The fact that we only have to deal with eight cycles (versus 256 with traditional PWM) is the source of most of the hoopla you'll find surrounding BAM.

Figure 4 shows the weighted timing in a four-bit BAM value. As you can see, bit 3 gets eight timing periods, bit 2 gets four periods, etc. In **Figure 5**, you can see what the output looks like when the BAM value is set to 10. I think it's the asymmetrical output (for most values) that helps BAM get around the LED PWM patent. (Yes, there is a patent for this.)

Most of the code you'll find on the Internet shows how to set up a variably-timed interrupt to handle the bit timing. The Propeller doesn't have or use interrupts so we're going to take another route — one that turns out to be deceptively easy. Here's my implementation of BAM for the Propeller.

```
bamrgb          or          dira, rmask
                or          dira, gmask
                or          dira, bmask

                min         TIX_001, #121

bamstart        mov         bitmask, #%0000_0001
                mov         bitperiod, TIX_001
                mov         bittimer, bitperiod
                add         bittimer, cnt

                mov         tmp1, #0
```

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JP1-JP2	0.1 M-STRT	Mouser 517-6111TG
Jumpers		Mouser 517-950-00
LED1	3 mm Green	Mouser 859-LTL-4231
Q1-Q3	2N3904	Mouser 863-2N3904G
Q4-Q6	TIP125	Mouser 512-TIP125
R1	120	Mouser 293-120-RC
R2-R4	4.7K	Mouser 291-4.7K-RC
R5-R7	470	Mouser 291-470-RC
R8-R10	1K	Mouser 291-1K-RC
R11	330	Mouser 291-330-RC
RN1	10K x 9	Mouser 71-CSC10A01-10K
SW1	DIP x 9	Mouser 611-BD09
TB1-TB3	5 mm Term Block	Mouser 571-2828362
U1	ST485BN	Mouser 511-ST485BN
X1-X4	0.1 M-STRT	Mouser 517-6111TG
PCB		GadgetGangster.com ExpressPCB.com
Parts Kit		GadgetGangster.com

```
getlevels       rdbyte     rlevel, rpntr
                rdbyte     glevel, gpntr
                rdbyte     blevel, bpntr

bamloop         test       rlevel, bitmask wc
                muxc       tmp1, rmask
                test       glevel, bitmask wc
                muxc       tmp1, gmask
                test       blevel, bitmask wc
                muxc       tmp1, bmask
                mov        outa, tmp1

                shl        bitmask, #1
                and        bitmask, #$FF   wz
        if_nz   shl        bitperiod, #1
        if_z    mov        bitmask, #%0000_0001
        if_z    mov        bitperiod, TIX_001

                waitcnt bittimer, bitperiod

        if_nz   jmp        #bamloop
                jmp        #getlevels
```

On entry, we make the RGB pins outputs and do a quick check to ensure that the timing period is long enough to get the work done. You'll recall that using **waitcnt** is easy and convenient, but if we are short of the value and get a rollover, we end up waiting nearly a minute — not what we want to have happen here. The **min** instruction takes care of fixing a value that the user may have mismanaged in the interface section. I found the value of 121 estimating (counting cycles) and then empirical testing until it "broke."

At bamstart, we create a mask for bit 0, set the timing for bit 0 (one "period"), start a timer, and initialize a value that will hold the new outputs for each cycle.

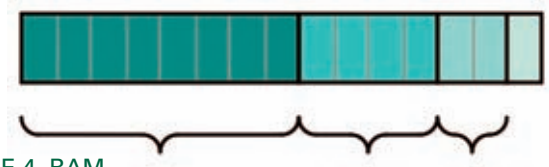
The real work begins at getlevels where we read the RGB values from the hub. At bamloop, we test each color value against *bitmask*, writing the current bit value to the C flag. Using **muxc** and the channel mask for the color, the bit value is written to *tmp1* which is finally moved to the outputs. By using *tmp1*, all outputs are simultaneously updated.

The bit-under-test mask is then shifted left and **and**ed with $FF — if the result of the **and** operation is zero, then we're done with the loop; all eight bits have been processed which means we can reset the test mask and the bit period. Until this happens, we shift the value of *bitperiod* left by one which doubles its value; this is exactly what we need for the next higher bit.

After the timer expires, it is reset with *bittimer* and we jump back to bamloop for the next bit or to getlevels if it's time to start a new cycle. Done! Of course, you can add channels if you like. Just be sure to update the minimum timing for a bit period so that you can get all the work done within the cycle.

A SIMPLE DMX RGB LIGHTING FIXTURE

With the hard work (which really wasn't very hard) out of the way, we can create a simple, three-channel DMX lighting fixture. For this, we'll need a device address



■ FIGURE 4. BAM Bit Weight Timing.

switch which corresponds to the first of our three channels — **Figure 6** shows a nine-position DIP switch wired to P0..P8 of the Propeller. No need to worry about the reverse bit order (which was done for PCB layout convenience); Spin has a neat trick which will take care of this for us.

For my first project, I wanted to drive a 1W RGB LED that a friend gave me, but I also wanted to run small DC lamps for other projects. In order to accommodate both, the circuit uses a moderate-current, high-side driver (**Figure 7**) on each output. Some of you will quickly point out that the final output transistor is missing a pull-up to Vin. Not so. This transistor is actually a TIP125 Darlington and, as you can see in **Figure 8**, the base has an internal 8.12K path to the emitter — we're covered, and with the TIP125 we can control plenty of current.

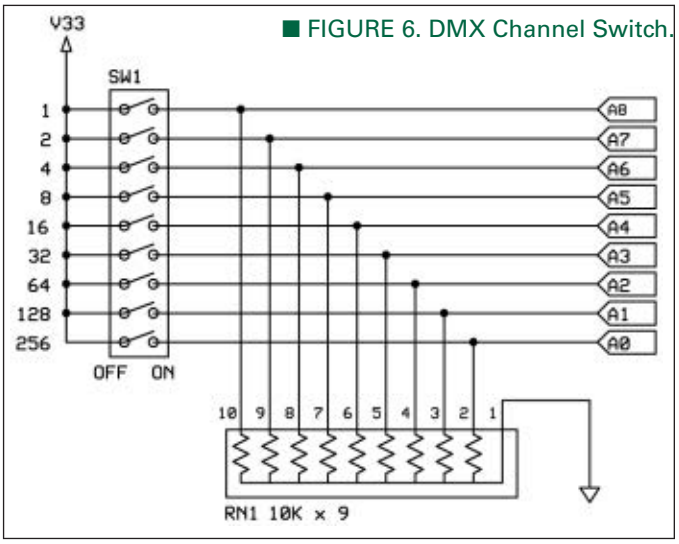
Okay, here's the code for the three-channel DMX fixture.

```
pub main | dmxstart, chan, level

  dmx.init(24, 16)
  rgb.init(9, 10, 11)

  repeat
    chan := ina[0..8]
    if (chan > 0) & (dmx.read(0) == 0)
      level := dmx.read(chan++)
      rgb.setred(rgb.ezlog(level))
      level := dmx.read(chan++)
      rgb.setgreen(rgb.ezlog(level))
      level := dmx.read(chan)
      rgb.setblue(rgb.ezlog(level))
    else
      rgb.setall(0)
```

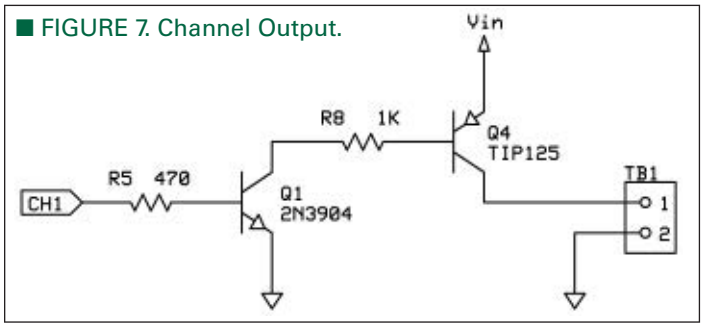
I'm not kidding, that's all we need to knit the DMX receiver and BAM output objects together to create a DMX-compatible lighting fixture.

We start by initializing the DMX and BAM objects, and then drop into a **repeat** loop. The first line in the loop is really cool. What this does is read bits 0 through 8 of the inputs, masking off the others, and flipping their order (bit 0 to bit 8, bit 8 to bit 0). In one fell swoop, we've read the switch bits and put them into the correct order, giving us the current channel setting. Come on, you've got to think that's cool! Just so we're clear, we know that the bit

■ FIGURE 5. BAM Output OA.



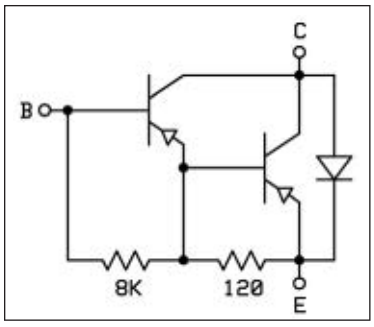
■ FIGURE 6. DMX Channel Switch.



■ FIGURE 7. Channel Output.

order is reversed because the LSB (0) is in the MSB position within the brackets. Another bonus that the switch could have used any set of I/O pins; so long as the group was contiguous. The only pins read are those defined within the brackets, and the result bits are flipped and shifted (to zero-align) if required. We can use this technique to read any parallel inputs and get a value that is immediately usable.

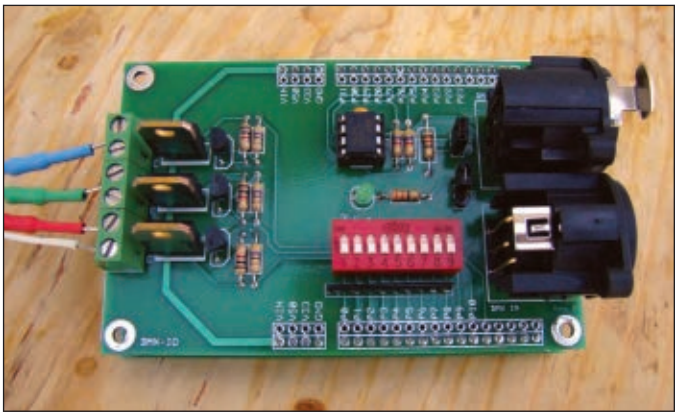
If the channel switch is valid (not zero) and the DMX



■ FIGURE 8. TIP125 Schematic.

Start byte is valid (zero), then we read the channel values from the DMX array and move them to the outputs using BAM to handle the brightness modulation. You can see that Spin borrows heavily from C in that we can use the post-increment operator (++) on *chan*; this lets us read the current channel and then update that variable before moving on.

Visually, LEDs can seem a little harsh when using straight linear values as we'd get from the DMX stream.



■ FIGURE 9. DMX I/O Board.

A friend showed me a cute trick that creates a logarithmic curve: you simply square the value and then divide it by 256. Doing this makes the LED brightness output much more appealing. The math for this trick is wrapped up in a method called .ezlog() that is part of the BAM object. For you advanced users, there is also a method to read a value from a table which allows you to map the DMX input value to an output value as desired.

IF THREE IS GOOD, FOUR MUST BE BETTER!

My original design (see the prototype in **Figure 9**) was oriented toward RGB lighting control and as I was building it, a post in the Propeller forum vis-à-vis stepper motors got me thinking: If I added one more channel, I could control a unipolar stepper motor with the TIP125 outputs. Then, I thought: Why not add servo headers on the outputs, as well? So, for those of you who purchase the PCB or kit through Gadget Gangster (recommended; see **BOM**), you'll get the four-channel version which gives you more options for outputs. Of course, if you want to roll you own I've included the four-channel files in the PCB download at **www.nutsvolts.com** so you can use them as you please.

Okay, then, how about adding a little DMX to your holiday lighting arsenal? It could be a lot of fun and really make the neighbors jealous! Until next time — and next year! — here's to spinning and winning with the Propeller. **NV**

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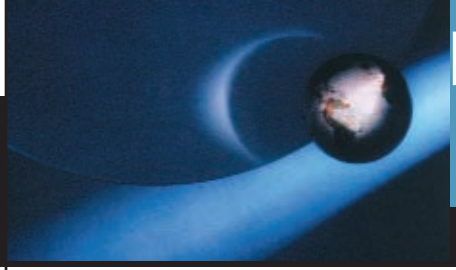


BY L. PAUL VERHAGE

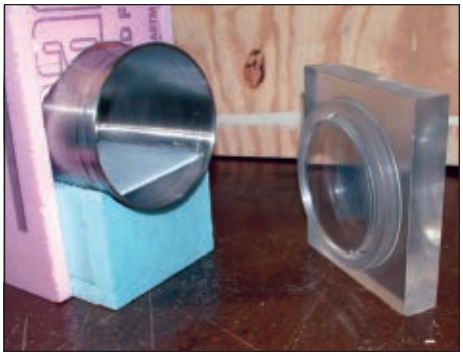
A NEAR SPACE ENVIRONMENT CHAMBER UPDATE

Sometimes it's difficult to leave things well enough alone. Occasionally, this is to my detriment as I can makes things worse off than they were originally. Other times though, I end up with something better than when I started. This is the case with the near space environmental test chamber from my September column. Along with the improvements discussed in this month's column, you'll also find the results of a near space environmental test and a new vacuum pump I discovered.

BEEFING UP THE LID

During the original construction of the environmental test chamber, I experimented with three variations of vacuum chambers. They all worked except that their lids appeared to be weak. Therefore, instead of using these three chambers as they were, I settled on beefing up the lid of my largest canister. Not wanting to waste my other canisters, I later asked Dale at the Washburn Institute of Technology if he or his machining class could create a new lid for my smallest stainless steel flour canister. Boy, did he — the new lid is one inch thick plastic. This is one serious lid. Since it's machined to the same diameter as the original wimpy lid, it uses the canister's original silicone gasket. The new lid is heavy enough that it must be held against the test chamber for a few seconds while the vacuum pump gets started.

■ I was concerned that this flour canister's orginal thin lid would implode under vacuum. Dale, the machining instructor, made sure I'd have one that wouldn't implode even if a truck ran over it. Best of all, it's clear and well polished. So, I can safely watch my tests under vacuum conditions.

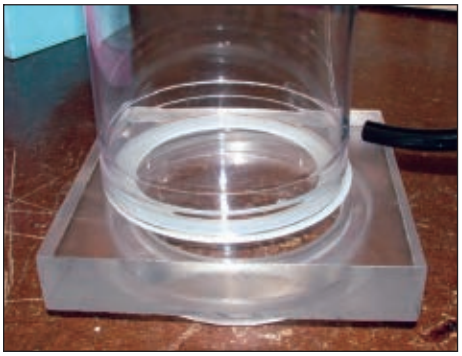


DUAL USE

The first canister I tested when I built the environmental test chamber was a clear plastic flour canister with 1/8 inch thick walls. The cylindrical body appears to be strong enough to safely withstand a vacuum, but its thinner flat lid developed fine cracks under vacuum. Dale recommended I use the same lid he machined for the small stainless steel chamber for this chamber. The new lid sits flat on the table and the plastic flour canister sits on top of it like a bell jar. Since this vacuum chamber is made entirely of plastic, it's not safe to chill with dry ice. Because of that, this vacuum chamber only performs vacuum tests at room temperature. However, since it's entirely clear, it's a great chamber for observing vacuum effects. After a dozen tests, I have yet to see cracks forming in the plastic, so I suspect it's safe. Just to be sure though, I won't let anyone stand next to it without wearing safety glasses.

NO MORE SWITCHING HOSES

Hose barbs are designed to prevent hoses from pulling loose. So, I can push a hose on a barb with very little difficulty, but man, it's so tough to pull the hose off that I have to resort to cutting the hose off in

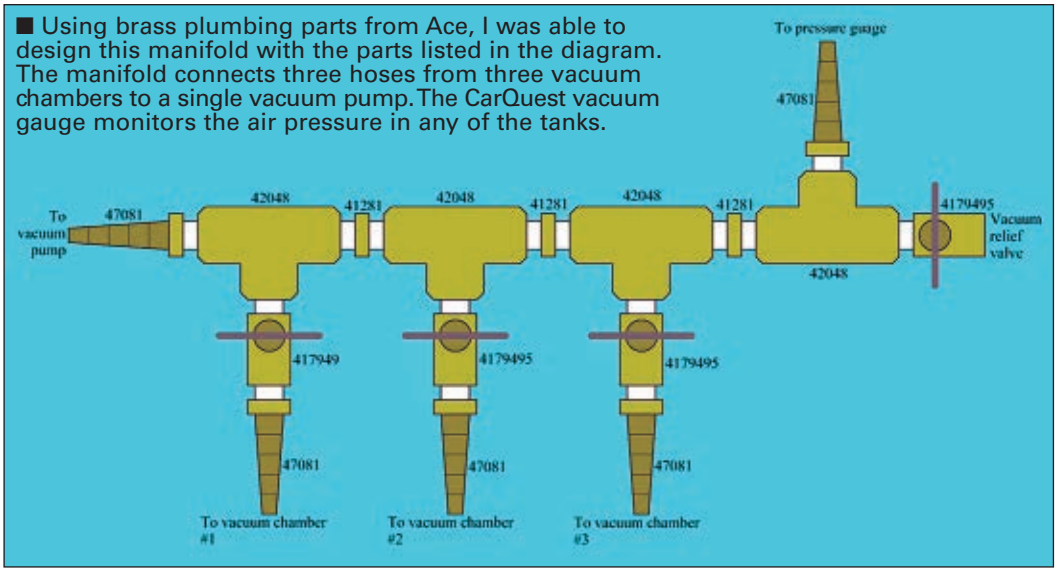


■ The plastic bell jar with the thick lid as a base. The cylindrical shape of this canister makes it pretty resistant to atmospheric pressure.

tiny little pieces. Rather than waste good fuel hose every time I switch vacuum chambers, I decided to make a manifold. All the brass threads were wrapped in Teflon tape before screwing them together with a wrench (I don't plan to take this manifold apart). Since the manifold connects several vacuum chambers to a single vacuum pump, I just have to open and close the valves to evacuate the proper chamber.

To use the manifold, I turn two of the three needle valves clockwise to close off their chambers and turn the third needle valve counter-clockwise to open up its chamber. After completing the experiment, I shut off the vacuum pump and open the fourth needle valve on the very right to bleed air back into the system.

■ Using brass plumbing parts from Ace, I was able to design this manifold with the parts listed in the diagram. The manifold connects three hoses from three vacuum chambers to a single vacuum pump. The CarQuest vacuum gauge monitors the air pressure in any of the tanks.



PUTTING IT ALL TOGETHER

Organizing the three environmental three test chambers into a compact and easy to carry apparatus requires the Masonite, plywood, and pine rig you see in the **photo**. The vacuum stand has a base consisting of two sheets of Masonite pegboard separated with 3/4 inch thick pine. Two diagonal pine boards keep the pegboard backboard perpendicular to the base and create convenient grips for hauling it around. The manifold is nylon zip-tied to the backboard where it's easy to operate it and monitor the pressure.

MY FIRST ENGINEERING TEST

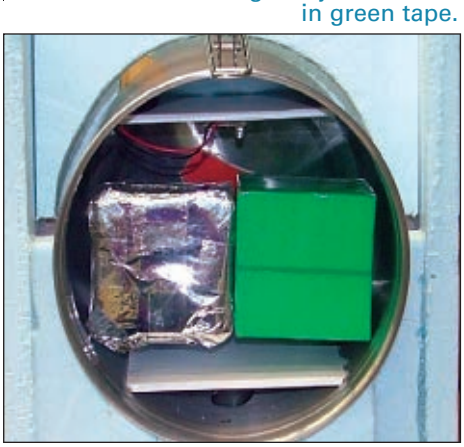
Satellite electronics need to stay warm if the satellite is to properly function for 10 years or more. To maintain the proper temperature, satellites use electric heaters and insulation in the form of alternating layers of aluminized Mylar and scrim. This alternating sandwich of aluminized Mylar and scrim is called multilayer insulation (MLI) and it acts like a lightweight thermos bottle. The design of MLI helps keep the satellite warm in three ways.

First, the scrim sheets minimize contact between the Mylar sheets so very little heat flows from the warm satellite interior to the cold vacuum of space. Second, the vacuum of space removes air from between the layers to prevent heat flow via the movement of air. Finally, the thin coating of aluminum on the Mylar sheets reflects infrared radiation back into the satellite (and it keeps the intense heat of sunlight out of the satellite).

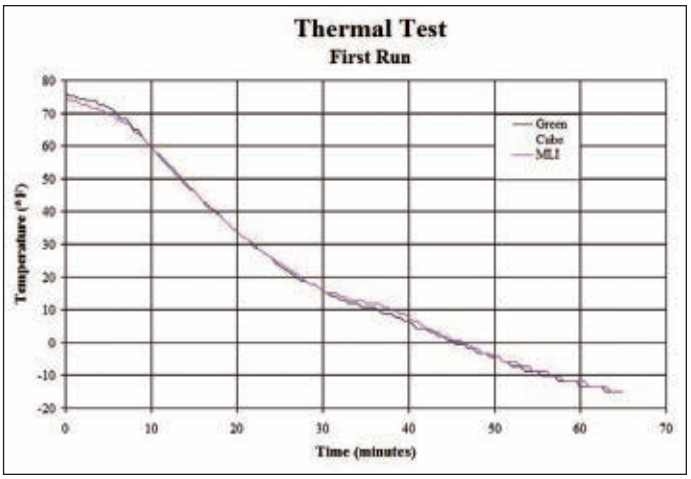
I've often used the same kind of insulation for my near spacecraft. Rather than using aerospace rated materials though, I use plastic wedding veil material for the scrim and a space blanket for the aluminized Mylar. Typically, I wrap three layers around an airframe and then tape it down with a little packaging tape. I have discovered that the layers of space blanket and wedding veil material are tough enough that I can sew them together in a blanket that I can wrap about the airframe.

MLI works in outer space with its extreme vacuum to protect satellites and it works on earth to insulate cryogenic lines and containers. However, I want to know if it really works well in near space where the vacuum isn't quite as high and the

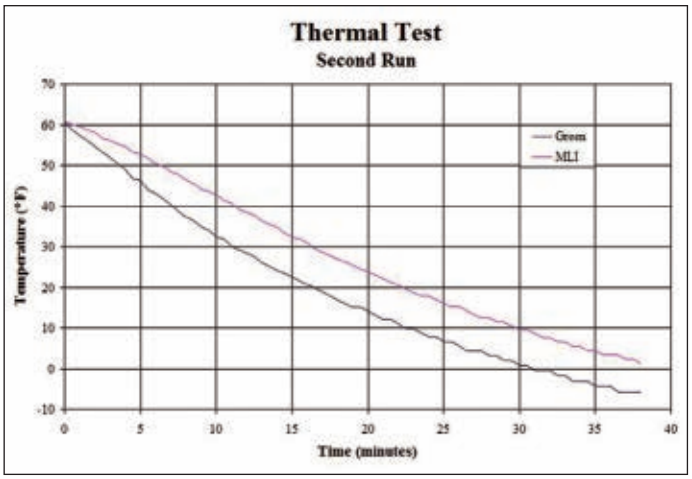
■ The base and backboard of this vacuum stand creates a unified environmental test chamber from lots of loose parts Have vacuum will travel.



■ Two nearly identical cubes ready for their test. The one on the left is covered in three layers of MLI, while the one on the right is just covered in green tape.



■ On the first run, both Hobo dataloggers recorded nearly the same temperature changes. So, it appears that the MLI is a waste of time and materials for near space experiments.



■ But then again, maybe it's not a wasted effort. This chart shows that the MLI covered cube is nine degrees warmer after 35 minutes in the environmental test chamber.

temperatures are not quite as low. To find out, I did a little experiment with my new environmental test chamber.

For this experiment, I built two identical cubes from 1/2 inch thick Styrofoam. One cube has a wrapping of green tape and the second a wrapping of three layers of MLI. The cubes were hollow, so a Hobo datalogger could sit inside and record the interior temperature. After loading the Hobos, the cubes were tightly taped shut. The big environmental chamber was then loaded up with dry ice and allowed to chill in preparation for the test. Both cubes were loaded inside the chamber, the door was closed, and the chamber pumped down. The test ran for about 30 minutes before the cubes were removed.

Because of the possibility that the dataloggers wouldn't record the same temperature under identical conditions, the cubes were allowed to warm up and the dataloggers were switched between cubes. The process was run a second time for about 30 minutes. Afterwards, the Hobos were removed and their data downloaded. You can see from the **charts** that it was a good thing my classroom ran the experiment a second time.

Looking at these results, I suspect the Hobos are not calibrated quite the same. Perhaps it would be appropriate to average the two tests and claim the MLI covered cube remains four to five degrees warmer than a cube without MLI. I'd like to think this is the case because of the amount of time I spent covering my airframes in MLI. Before I try this test again, I'll set the Hobos out and verify that they record the same temperatures.

The only problem I ran into during this experiment is that the lid on the large environmental chamber is loose enough that air pressure outside can shift it just enough to the side to break its seal. Eventually, I'll have to have a new lid machined for the large chamber that fits a bit more snuggly.

■ Running a test on the Handi-Vac vacuum chamber. Inside the sealed zip lock bag is the Rubbermaid container with a pressure sensor.

THE HANDI-VAC

I was out grocery shopping when I saw Reynolds (maker of aluminum foil) developed what might be a convenient vacuum pump. Handi-Vac is a food storage system. Food is loaded into a zip-lock storage bag and then a battery-operated handheld pump evacuates the air inside. So, I thought this would make a great vacuum pump for science experiments. I purchased one and an extra set of bags in the name of science.

The Handi-Vac pump has a rubber seal in its nose (it's called the suction tip) that's placed in contact with a specific region marked on the zip-lock bags. This area has a series of tiny openings that allow air to be pulled out, but seal when air tries to flow back in.

Now, I've observed vacuum bagging before. After removing the air, the contents inside the bag are crushed by atmospheric pressure. This is good when you need to apply pressure all around an object, like when curing a composite set-up. But the crush is a disaster for the experiments I want to perform. To prevent the crush, I purchased some large Rubbermaid ™ cube shaped plastic storage containers. The vacuum bag can't crush a storage container inside of them, but experiments inside the container will still experience a vacuum if holes are drilled through the container and its lid. I selected roughly cube shaped storage containers to

THE TRANSFER OF THERMAL ENERGY

Thermodynamics is a big and complex science subject. A small part of this big science that the near space community is interested in is how to keep our experiments warm during a mission. We want to keep our near spacecraft warm using lightweight, passive methods as opposed to using batteries and heaters. As this article alludes to, there are three ways to transfer thermal energy in a system and MLI helps to minimize all three.

Conduction is the net flow of heat by the physical contact of two substances that are at different temperatures. When you pour cold water in a warm cup, heat flows out of the warm cup and into the cold water. The result is that the cup cools down as the water warms up. Note that energy is really flowing in both directions between them. It's just that a lot more heat flows into the cold water than the warm cup. It actually gets a little more complicated because different substances require different amounts of thermal energy to change their temperature. So, just because a metal cup and the water inside are at the same temperature, it doesn't mean there's an equal amount of energy flowing between them to maintain their equal temperatures.

Convection occurs when matter carries energy from a hot volume into a cold volume. A good example occurs when you open the door of a hot oven. The hot air inside the oven carries some of the heat from inside the oven into the kitchen.

Radiation is like convection, but instead of the moving thermal energy by the movement of matter, thermal energy moves by the movement of photons (light). If you've ever placed your hand near an incandescent bulb (like a heat lamp), your hand has experienced heating due to radiation.

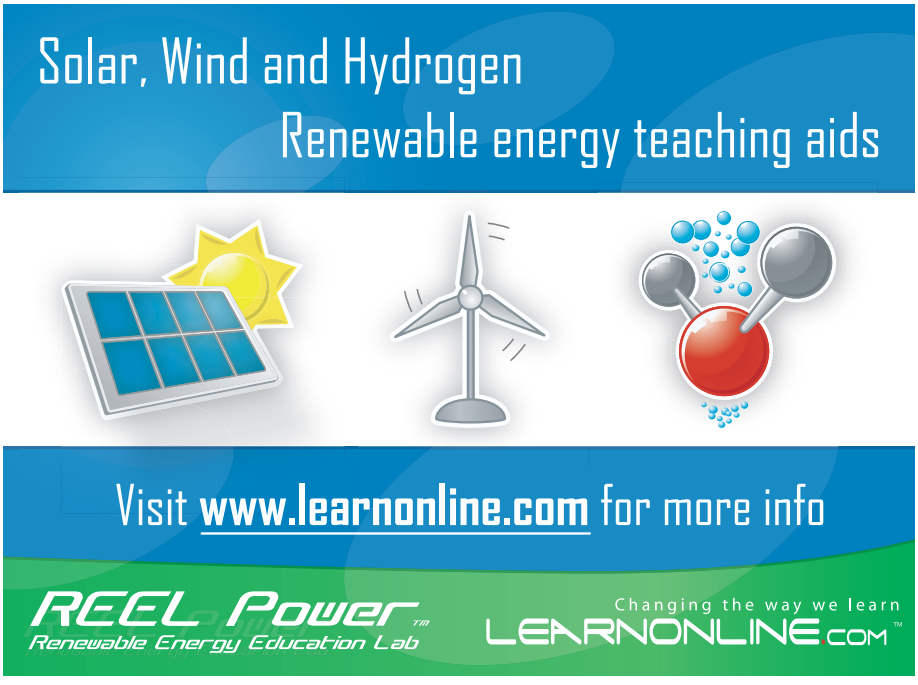
There's a lot more to heat flow and events like a phase change add additional complications. However, you don't need a Bachelor of Science in engineering to limit the amount of cooling your near spacecraft experiences on a mission. You just need to insulate it properly.

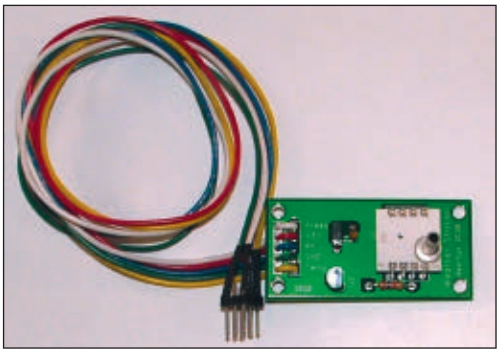
maximize the volume I would have for experiments.

To test the effectiveness of the Handi-Vac, I loaded a pressure sensor inside the container, sealed the lid over the container, placed it inside the storage bag, sealed the zip lock bag, and pumped it down. Here's the result.

The Handi-Vac pumped the zip lock bag down to just under half an atmosphere. That's not bad for a $20 vacuum pump. However, a pressure of 500 mb is only equivalent to an altitude of 18,000 feet, so this vacuum chamber can only reach the mid to low 20,000 feet.

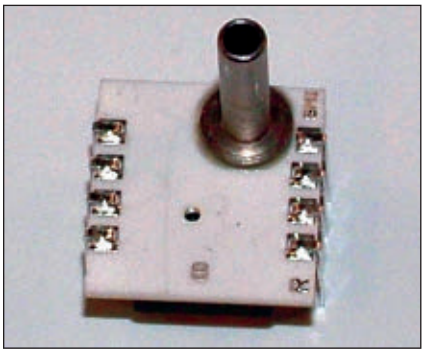
Therefore, I can see someone testing a rocket flight computer with the Handi-Vac. The pump removes the air, simulating the ascent of the rocket. After reaching peak altitude, the bag is opened slightly to let the air back inside,





■ The NearSys Weather Station. Its PCB measures one by two inches and the kit doesn't cost much more than the pressure did originally.

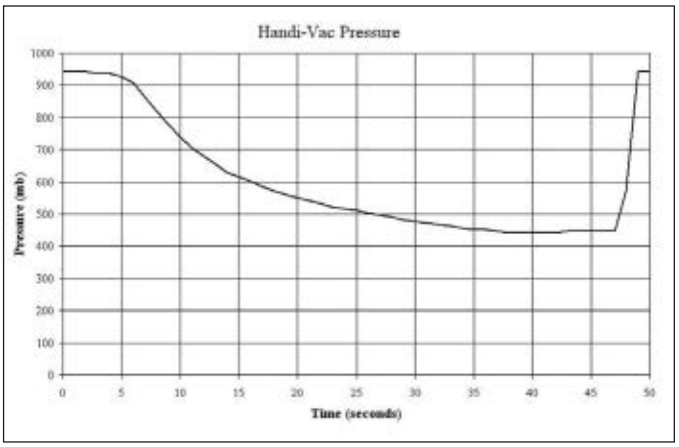
simulating the descent. The bag is clear, so if the container is also clear, you can observe the experiment during the test. Events like the firing of an ejection charge can be observed if the charge is replaced with an LED indicator.



■ This is one really sweet unit. Amplified output for a pressure swing from 0 to 1,000 mb — an entire near space mission.

THE PRESSURE SENSOR

I used a Silicon Microstructures (**www.si-micro.com**) SM5812 pressure sensor for my vacuum chamber tests and near space experiments. The sensor operates over a pressure range of zero to just over 1,000 millibars (mb), or from vacuum to the average pressure at mean sea level. The output voltage swings from 0.5 volts to 4.5 volts (a four volt swing) over this pressure range, so the SM5812 needs no amplification. This is one of the few pressure sensors I have ever found capable of producing an output over the entire range of a near space flight. Almost everything else operates over a smaller pressure range or needs amplification.



■ The pressure sensor experienced a minimum of 450 mb of pressure after pumping it down. That's over half way to a vacuum.

Alas, the SM5812 is at the end of its life because SMS no longer manufactures them. I managed to pick up the remaining units and have developed a near space weather station kit with this sensor. The weather station provides measurements of relative humidity, temperature, and pressure as voltage levels. Combine the weather station with a datalogger with three ADCs and you've got yourself a small, stowable, weather station. If you're interested in the weather station, the complete kit is available from NearSys for $40 plus $4 shipping and handling. Check **NearSys.com/catalog** for details and assembly directions.

Onwards and Upwards,
Your near space guide **NV**

You can watch a video on the updated environmental test chamber on my YouTube channel at **www.youtube.com/nearsys**.

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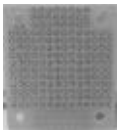

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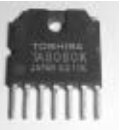

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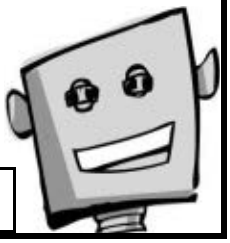

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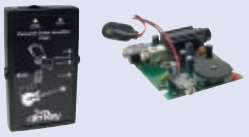

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ECG1C ECG/EKG Kit $44.95

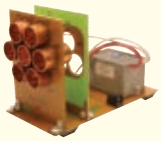
Plasma Generator

Generate 2" sparks!

Produces a stunning and shocking 25kV at 20kHz from a solid state circuit! Build your own plasma bulbs, light fluorescent tubes without wires and more! A great learning kit. Runs on 16VAC, order our PS21 power supply.

PG13 Plasma Gen Kit $64.95

HV Ion Generator



Make a blast of fresh air!

Generates a steady state DC voltage at constant non-pulsed current at 7.5kV DC negative, 400uA. That's a LOT of ions! Learn how modern spacecraft use ions to accelerate through space. Runs on 12VDC or our AC125 PS.

IG7 Ion Gen Kit $64.95

20W SubMini Audio Amp

20 watts and no heat!

Delivers a super clean 20W output from one SMT package! Ultra efficient class D design produces no heat. PCB can be snapped into a small circle for special applications. Runs on 18VDC for rated output, use our SPS18 PS.

UAM2 20W SMT Amp Kit $34.95

Digital Voice Storage

Multiple message storage!

The *Bullshooter-II* provides up to 8 minutes of digital voice storage that can be broken down into 8 separate stored messages! Great for announcements, etc. Built-in mic plus external input. Runs on 12VDC or our AC125 PS.

BS2C Bullshooter-II Kit $69.95

Speed Radar Gun

Now YOU can be the cop!

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. 1/8th mile range is typical. You supply two coffee cans! Runs on 12VDC or our AC125 power supply.

SG7 Speedy Radar Kit $69.95

Doppler Direction Finder

Find that transmitter quick!

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

DDF1 Dir. Finder Kit $169.95

40W Stereo Micro-Amp

40 watts of stereo in 2½"!

The big brother to the UAM2, it delivers 40W of crisp clear stereo power all in a 2½" board! One single SMT device operating 87% efficient creates virtually no heat! Selectable gain, pop filter and a lot more! Runs on 10-18VDC.

UAM4 40W SMT Amp Kit $69.95

Signal Magnet Antenna

Pulls in distant stations!

Super Hi-Q ferrite rod antenna with Faraday shield eliminates noise from power lines, dimmers, static and more! Great results from 500kHz to 15MHz. Super for AM broadcast band! Includes power supply.

SM100 Sig Magnet Kit $89.95

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- ✔ *A lot of our kits are also available "factory assembled and tested", if you don't want to build it!*
- ✔ *We have over 350 products currently available, and all those don't fit here!*

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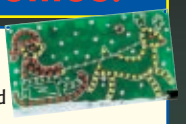
LED Animated Santa



Animated Santa and reindeer display has 126 dazzling colored LEDs! Makes a great holiday sign! Animated motion makes it come alive. Runs on standard 9V battery or external power supply.

MK116 LED Santa Kit $16.95

LED Christmas Tree

Electronic Christmas tree features 134 bright colored LEDs in the shape of a tree with 18 random flashing blinking "candles"! Runs on a 9V battery or PS.

MK117 LED Christmas Tree Kit $18.95

LED Animated Bell

This holiday bell is animated to simulate swinging back and forth! 84 bright colored LEDs will dazzle you with holiday cheer! Includes an on/off switch. Runs on 9V.

MK122 LED Bell Display Kit $16.95

3D LED Christmas Tree

Not your average LED display! 4 branch sections give this tree a 3D look! 16 red LEDs light it up with yellow LED's for you to customize your tree! 9V battery base.

MK130 3D LED Tree Kit $7.95

SMT LED Christmas Tree

Build this subminiature Christmas tree and learn SMT at the same time. Small enough to wear as a badge or pendant! Extra SMT parts are included so you can't go wrong! Runs on Li-Ion cell.

MK142 SMT LED Tree Kit $10.95

SMT LED Smiley Face

This is a great attention grabber and also teaches you the basics of SMT construction! Display your "smiley" as a pin or badge! Extra parts included!

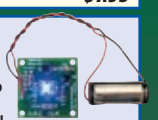
MK141 SMT LED Smily Kit $9.95

LED Traffic Signal

Impress your friends with this neat 4-way traffic signal! Operates just like a standard signal, and features adjustable delay. Red, yellow, and green LEDs are used just like the real thing! Runs on 9V battery.

MK131 LED Traffic Signal Kit $7.95

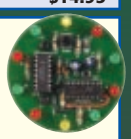
LED Switcher Blinky



Run a 3V LED from 1.5V! Learn power supply switching and end up with a super bright blue Telux LED blinking at 140kHz! Runs on a single AA battery not included.

LSW1 LED Switcher Blinky Kit $14.95

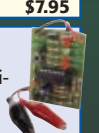
Wheel Of Fortune



Just like the casino game! Just push the button and the LEDs "rotate" and slowly come to a stop, displaying the "winner"! Push it again to start over. Runs on 9V battery.

MK152 Wheel Of Fortune Kit $7.95

Cable Polarity Checker



You get a home theatre system for the holidays, you run cables throughout the house, how do you identify polarity? It's easy with the MK132!

MK132 Cable Polarity Checker Kit $8.95

Water Sensor Alarm

The sump pump quits, the snow melts, the basement floods! Don't let it happen with the simple water sensor alarm. 9V battery operation with remote sensor.

MK108 Water Sensor Alarm Kit $6.95

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Fun Stuff For The Holidays!

Digital Controlled FM Stereo Transmitters

- ✔ Rock stable PLL synthesized
- ✔ Front panel digital control and display of all parameters!
- ✔ Professional metal case
- ✔ Super audio quality!
- ✔ 25mW and 1W export models!

For nearly a decade we've been the leader in hobbyist FM radio transmitters. When it became time for a new model, we started from the ground up! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!

The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export-only market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use. Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC 110/220VAC plug in power supply. The stylish black anodized aluminum case measures 5.55"W x 6.45"D x 1.5"H. and is a great match to your other equipment.

(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)

FM30B	**Digital FM Stereo Transmitter Kit, 0-25mW, Black**	**$199.95**
FM35BWT	**Digital FM Stereo Transmitter, Assembled, 1W, Black**	**$299.95**

Professional Synthesized Stereo FM Transmitter

- ✔ Built-in audio mixer!
- ✔ 2 line inputs, auto mic ducking!
- ✔ Dual LED bar graph meters
- ✔ Drift-free synthesized operation
- ✔ Precision brick wall audio filter!
- ✔ 25mW and 1W export models!
- ✔ Professional metal case!

The true professional workhorse of our FM Stereo transmitter line, the FM100B has become the transmitter of choice for both amateurs and professionals around the world. From the serious hobbyist to churches, drive-in theaters, colleges and schools, it continues to be the leader. Not just a transmitter, the FM100B is a fully functional radio station and provides everything but the audio input and antenna system.

This professional synthesized transmitter is adjustable directly from the front panel with a large LED digital readout of the operating frequency. Just enter the setup mode and set your frequency. Once selected and locked you are assured of a rock stable carrier with zero drift. The power output is continuously adjustable throughout the power range of the model selected. Audio quality is equally impressive. A precision active low-pass brick wall audio filter and peak level limiters give your signal maximum "punch" while preventing overmodulation.

Two sets of stereo line level inputs are provided with front panel level control for both. Dual front panel LED bargraph meters provide left and right channel audio level metering. In addition to the line level inputs, there is a separate microphone input with a built-in mic mixer to control the level.

Not enough? How about unattended microphone ducking! When enabled, the presence of mic audio automatically reduces and overrides the line level input! Just like the professional units at a fraction of the cost. The FM100B is truly a complete radio station!

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FM100B	**Super-Pro FM Stereo Radio Station Kit, 5uW-25mW**	**$269.95**
FM100BEX	**High Power Version Kit, 5uW-1Watt Output**	**$349.95**
FM100BWT	**Export Only Transmitter, 5uW-1Watt, Assembled**	**$429.95**

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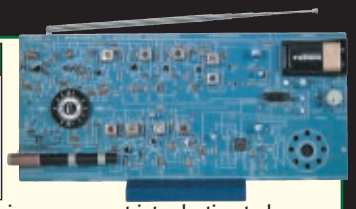


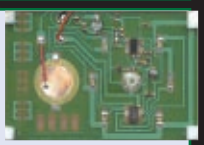
These Superhet AM and AM/FM radio kits give you a great introduction to how AM and FM radios actually work! Plus, they are designed using integrated circuits rather than standard discrete components.

The unique design includes an integrated circuit (IC), 9 transistors, 4 diodes, and other related resistors, capacitors, coils, and misc. parts. Learn all about IC design, theory, and troubleshooting! And when you're done you have an AM or an AM/FM radio that has really great reception...that you made yourself! IC's, transistors, resistors, capacitors, coils and other parts are easily identified, and described in theory. The comprehensive manual includes step-by-step assembly and test procedures, and complete theory. The final alignment section is also provided to make sure you have a great sounding receiver! 9V battery required.

AMFM108K	**AM/FM Integrated Circuit Radio Learning Kit**	**$34.95**

Surface Mount Soldering Course & Kit

- ✔ Learn SMT soldering the easy way!
- ✔ Learn all about those tiny parts!
- ✔ End up with a neat "Decision Maker"!



You're going to have to go there some day, so it might as well be now! Virtually all electronic designs have gone to Surface Mount Technology. SMT components are small, at times the size of a pin head, and require very special skills to assemble and solder. This kit takes you through all that, including soldering, desoldering, removing, and component placement. hen you're done, you have a neat electronic Decision Maker!

SM200K	**SMT Practical Soldering Course & Kit**	**$22.95**

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- ✔ Super comprehensive training manuals!

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PL130	**130 In One Learning Lab Kit**	**$49.95**
PL200	**200 In Super Fun Learning Lab Kit**	**$69.95**
PL300	**300 In One Complete Learning Lab Kit**	**$89.95**
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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Fish Feeder
- ✓ Ferrite Core Search
- ✓ Bat Detector

■ WITH RUSSELL KINCAID

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, comments, or suggestions.

Send all questions and comments to:
Q&A@nutsvolts.com

TRANSISTOR QUESTION

Q I was curious about basic semiconductors like diodes, rectifiers, and transistors. I knew that a switching transistor was an NPN junction and that diodes are PN. I was wondering if you could make an NPN transistor out of two diodes (NP-PN)? This should make a NPPN junction which would be the same as NPN.

— A. Lingenfelter

A I am sure that what you really want to know is why that does not work. Here is why: The P region has to be very narrow so electrons can transit across it. Current from the emitter (N) to the base (P) enables a greater current from the emitter (N) to the collector (N).

FLASHING LIGHT ALARM

Q Would you please tell me how to change a digital alarm clock from the existing piezo electric buzzer to a flashing 60 watt bulb? We are very hard of hearing and our existing KEN-TECH clock quit. It used to flash a screw-in bulb. New clocks we've seen don't have an outlet for a bulb. Thanks for any help you can give.

— Frank Lemon

A Opening the clock and finding the switch that turns on the buzzer might be difficult, so I think the best solution is a microphone sensor to operate the bulb. A VOX kit from Ramsey Electronics will do the job but you will also need a power supply, power socket, and relay. If you have a 12 VDC, 200 mA wall wart in your junk box, that will do, and you may find the power socket and relay at RadioShack. Otherwise, the parts list below will work.

VOX kit $9.95 part no. VS1
www.ramseyelectronics.com

Wall wart $13.89
418-TR1512-01-12 (2.5 MM plug)
Power socket $0.87
16PJ221 (2.5 MM)
Relay $3.58
817-FTR-MYAA012D
www.mouser.com

CYLINDER HEAD TEMPERATURE MEASUREMENT

Q Several years ago, I read an article on how to use a silicone diode attached to an airplane engine cylinder head for temperature measurements. I can't remember what publication I read the article, or what year it was, and Google doesn't find any information.

Do you have any ideas on how a standard diode could be used to measure temperature while it is physically attached to a cylinder head? I always enjoyed the Q&A section by TJ Byers, and you are doing a fine job following his lead. Please keep up the good work!

— Larry Kraemer

A A silicon diode has a temperature coefficient of about -2 mV per degree C. For best accuracy, you would measure the diode voltage at several temperatures and draw a curve or use a lookup table.

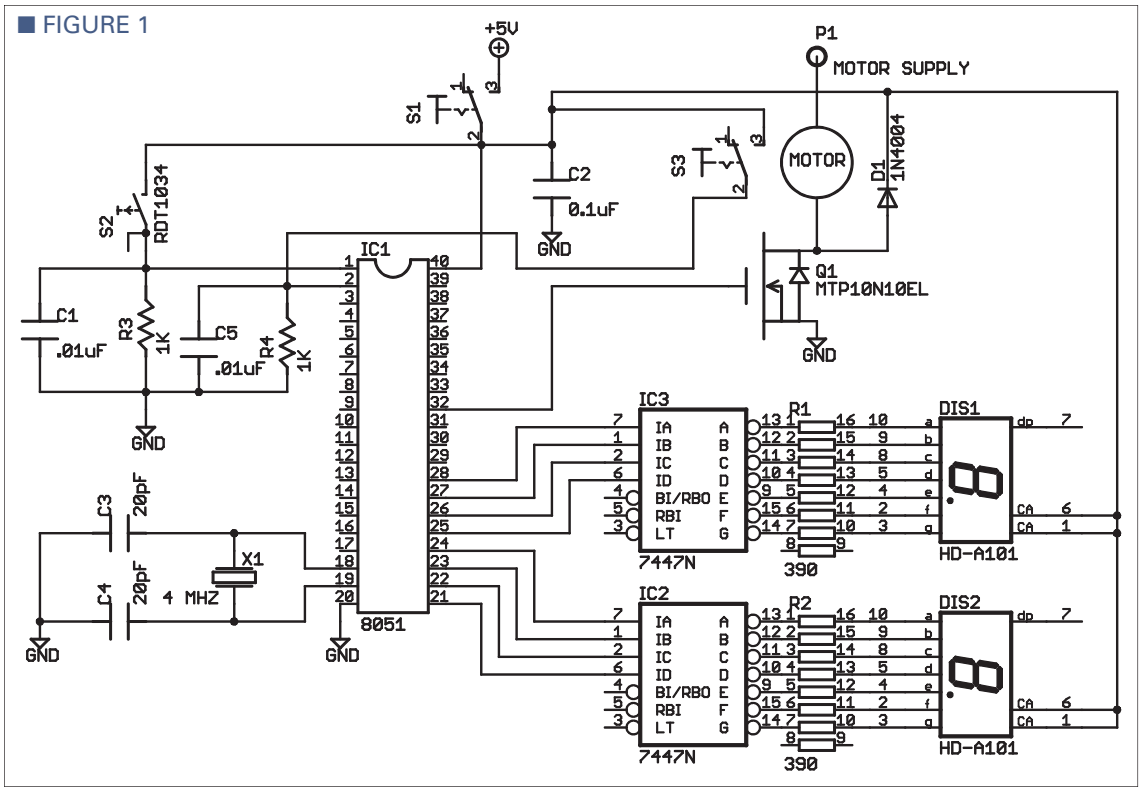
Another option is to use an LM34 (10 mV per degree F) or LM35 (10 mV per degree C) temperature to voltage sensor. You can read the temperature directly on a DVM. The operating range is -50 to +300 degrees F.

FISH FEEDER PROJECT

Q I have to build an automatic fish feeder for my final project. I am using an 8051 microcontroller, seven segment to display the time, pushbutton to set the time, toggle switch for on-off, and a DC motor. I am now confused to build the circuit and hope you can help me.

— Naim Romero

■ FIGURE 1



A The 8051 is a 40-pin DIP with four 8-bit ports; you will have plenty of outputs for your project. The circuit is no problem, the program is what will take time and study; I can't help you with that. You only want to feed the fish once per day and the fish don't care what time it is, so I don't see the need for a display. However, if it is part of the project, you could use a 7447 BCD to seven segment decoder/driver or code the driver in software. The pushbutton could advance the time in hour increments until you get to the desired time to start the feeder. You will need two digits for a 24 hour display. How you drive the motor will depend on the means of delivering the food. I would expect the motor to only turn once to dump a load, so a cam and microswitch could signal that the motor should stop. A gear reduction motor that turns very slowly is indicated.

A possible circuit diagram is **Figure 1**. I show two 7447s assuming you will code the two seven segments separately rather than multiplex them because there are plenty of ports. I show inputs to port 0 because my limited perusal of the datasheet indicates that port 0 can be an input. Q1 is a 100V, 10A logic level MOSFET (overkill but cheap). Your program will have to acknowledge that S3 (the microswitch) is closed and wait for it to open and close. There is an Intel forum that may be helpful, and the 8051 code set can be found here: **www.atmel.com/dyn/resources/prod_documents/doc0509.pdf**.

Good luck on your project.

FERRITE CORE SEARCH

Q I am looking for Philips ferrite core, part number RM8RA250-3B9. Could you please help me find a source to get that core or a replacement?

— S. Karas

A Philips ferrite operations were bought by Yageo which also owns Ferroxcube, so I queried Juan Carlos Gardea of Ferroxcube. He says the RM8R number is not good and 3B9 material is obsolete. Juan suggests that RM8/I-3H3-A250 or RM6R-3H3-A250 would be equivalent. Apparently, 250 is the Al in nH per turn and 3H3 is the material which is low loss and good for filter applications below 2 MHz. Unfortunately, there is no distributor for small quantities but you may be

MAILBAG

Dear Russell:

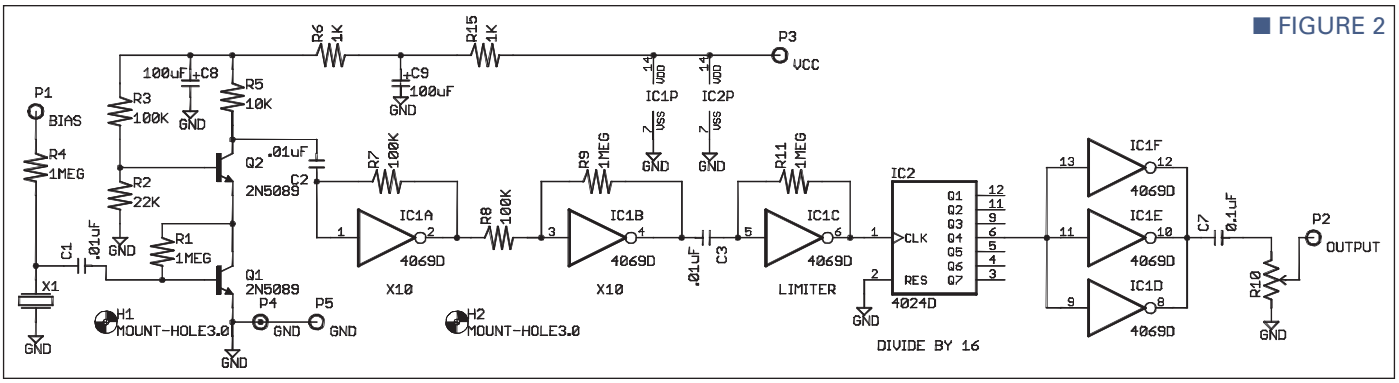
Re: Antenna Question, September, '09, page 30. The answer given to the question about "passive" AM antenna (boosters) kind-of strayed from the mark! What the originator was doubtless referring to was the large coil/tuning capacitor in a box that you place next to an AM table or portable radio.

This is simply a re-radiating, resonant, L/C circuit where the large coil can intercept more signal off the air than a small radio's internal loopstick. Inductive coupling sends this larger signal into the radio. Tuning the capacitor in the booster peaks the desired station's signal. The comments about a "quarter wave dipole" (non-existent) made me grin. The answers about digi and high tech stuff are usually right on point, but antenna and RF basics???

Respectfully,

— John W. Davidson
Certified Wireless Technician
ETA International CET
Amateur Extra Class Ham

Response: Thanks for writing. I admit my answer did not answer the question; I had never run across such a thing as a passive signal booster and doubted that it would work. After reading your message, I built one to try it. I wound 20 turns #24 insulated hookup wire on an oatmeal box (five inches diameter). The tuning capacitor was a variable, 65 to 650 pF. I put the coil (horizontal) next to my portable radio and tuned in a weak station near 1400 kHz. Surprise! It works! I got a noticeable increase in signal by tuning the variable capacitor.



■ FIGURE 2

able to get a few from your local sales rep; see **www.ferroxcube.com/cont/nasals.htm**.

■ FIGURE 3

BAT DETECTOR PARTS LIST

PART	DESCRIPTION	PART #
R1 – R11	CARBON FILM, 5%, ¼ W	291-(value)-RC
R10	10K AUDIO TAPER	313-1510F-10K
C1, C2, C3	0.01 µF, 50V, 10%	80-C322C103K1R
C7	0.10 µF, 50V, 10%	80-C3220C104K5R
C8, C9	100 µF, 16V	871-B41827A4107M000
Q1, Q2	NPN, HI GAIN, 2N5089	512-2N5089TF
IC1	HEX INVERTING BUFFER	512-CD4069UBCN
IC2	CD4024 seven STAGE COUNTER	595-CD4024BE

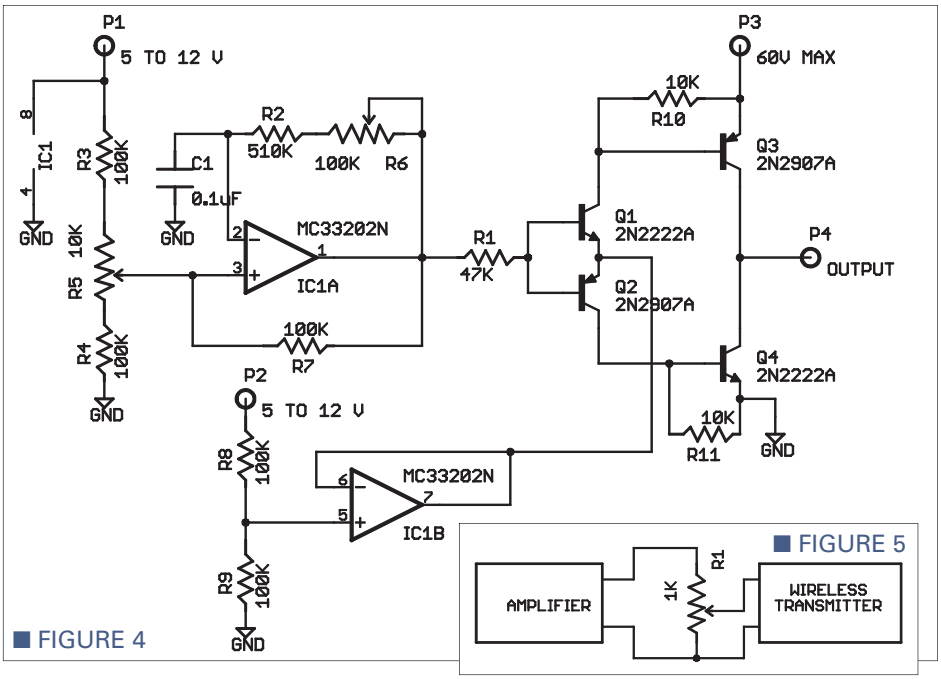
BAT DETECTOR

Q I'm trying to build an ultrasound bat detector. I've located a reasonably priced electrostatic transducer (SensComp 600 series; **www.senscomp.com**) with good frequency response and sensitivity. What I haven't been able to find is a suitable bias circuit (manufacturer recommends 200V) and preamp. I want to use a limiter and 16:1 frequency divider to bring the received calls down to audible range. This will be a portable detector with a 12V battery so power use should be minimal.

— Richard Duncan

A I built an ultrasound detector many years ago but it used a mixer to beat the frequency down to audible range. Dividing by 16 provides a wider audible frequency range but you lose some of the characteristics of the original sound. The electrostatic transducer output will be proportional to the bias voltage and should be adequate at 12 volts. I built the circuit of **Figure 2** using nine volt battery power (a separate battery for the transducer bias) but did not have time to test it. I had to tweak the value of R1 to get the DC voltage at the Q2 collector in a linear range (3 to 5 volts). I looked for the proximity detector lamp that I used for the deer scaring circuit but did not find it. I planned to remove the sensor and use it in this circuit.

The electrostatic transducer is a current source so a current amplifier is indicated. The preamp is a cascode circuit because the low input impedance gives minimum noise and the gain-bandwidth is better than a single transistor. I expect the signal at the Q2 collector to be 10 millivolts with the lowest amplitude input. The CD4069 is a simple inverter that is stable with feedback and makes a good, low noise op-amp. I paralleled three of the inverters to provide more drive to the output. Each inverter is only guaranteed to drive one TTL load. I expect you will use high impedance earphones, 8 ohm earphones; won't work very well. The parts list is **Figure 3** (all Mouser part numbers). The circuit I built was all surface-mount but the parts list is all through hole parts.



■ FIGURE 4

■ FIGURE 5

SQUARE WAVE GENERATOR

Q I have a question: How do I generate a square wave-form with 24V (not pk-pk), 15 Hz by using an op-amp? I have used an op-amp push-pull amplifier, but the frequency response of IC741 is limited. What to do?

— Anonymous

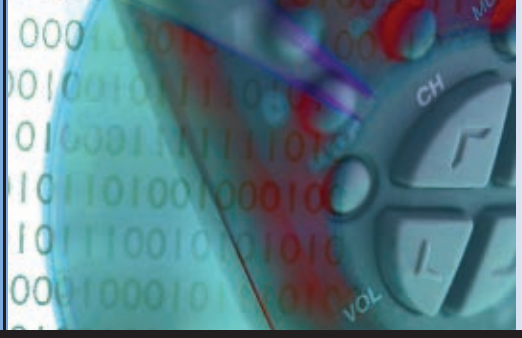
A The frequency response of the 741 is not limited at 15 Hz unless you are trying for very high gain. The 741 is no doubt slew rate limited at 24 volts amplitude. I assume you want zero to 24 volts signal which will require a VCC/2 DC reference as in **Figure 4**. The IC1A circuit is a square wave generator. If the op-amp output is positive, C1 charges through R2 until it reaches the bias voltage on pin 3. When the charge on C1 reaches the bias voltage on pin 3, the op-amp output goes negative and the positive feedback through R7 pulls the bias voltage lower. C1 now charges down to the bias voltage on pin 3 at which point the op-amp output switches high. The high and low of the op-amp output has to be symmetrical about the bias voltage set by R5 in order to have a symmetrical square wave. The MC33202 has rail to rail output so the R5 trim is minimum, but if an LM358 or UA741 is used, more trimming of R5 will be needed. R6 is a frequency trim to compensate for component tolerance.

SIGNAL ATTENUATION

Q I would appreciate your assistance with my problem in using a Sennheiser TR130 wireless headphone with a Philips DVD Micro Theatre MCD708 set which does not have a headphone outlet. The problem is in attenuating the output from the speaker outlet to the normal level for headphones. The volume control is inadequate for this purpose. Ideally, I need a self-regulating circuit for use between the speaker outlet and the headphone transmitter.

— Bert Williams

A I suggest a volume control between the amplifier output and the wireless transmitter (Mouser part #31VJ301-F); see **Figure 5**. NV



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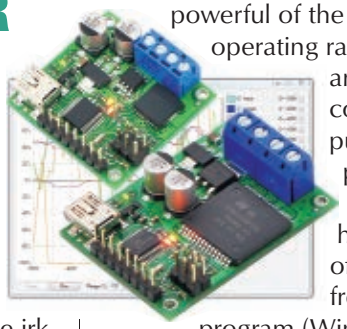

Pololu announces the release of the jrk line of USB motor controllers: highly configurable, versatile devices that make it easy to add open- or closed-loop control of brushed DC motors to your computer- or microcontroller-based project. The jrk supports four interface modes: USB for PC-based control; logic-level (TTL) serial for use with embedded systems; analog voltage for simple potentiometers and joysticks; and RC pulse for radio control systems. It can perform open-loop speed control, closed-loop position control with analog voltage feedback to make your own servos, and closed-loop speed control with frequency feedback from a tachometer. The jrk 21v3 — the smaller of the two units currently available — has an operating range of 5-28V and can deliver 3A continuous output (5A peak). The jrk 12v12 — the more powerful of the two — has an operating range of 6-16V and can deliver a continuous output of 12A (30A peak). Both devices can handle transients of up to 40V. A free configuration program (Windows XP and Vista compatible) is available for calibrating your system. Real-time plots of variables such as control input, feedback, motor output, and current draw make it easy to fine-tune settings such as PID constants, acceleration, and current limit for your application.

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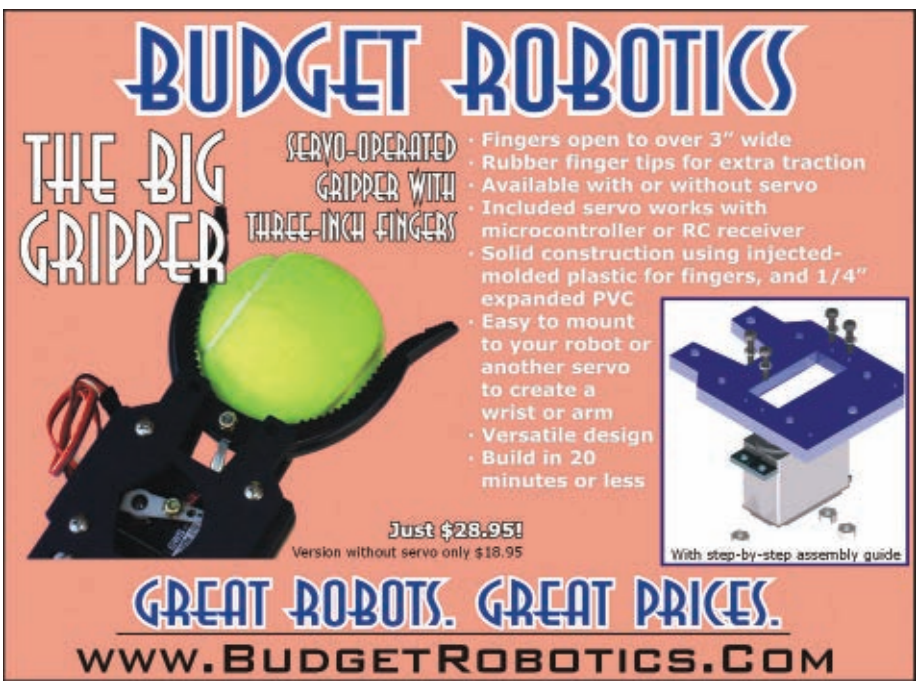

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COMPUTER TO COMPUTER LINK USING LASER POINTERS

BY ED RINGEL

Readers of this magazine know that broken stuff can sometimes be an inspiration, not necessarily a disappointment. So it was with a giveaway laser pointer from a drug company. The plastic housing broke, leaving the laser module and a primitive switch mechanism. Hmmm…

It turns out that it is extraordinarily easy to establish serial communication between computers (or microcontrollers) over the low power red laser modules used for pointers, carpenter's levels, and the like. It is also very inexpensive. Easily sacrificed, the modules from these pointers can be readily extracted and used for this purpose.

Aside from the laser module, each half of the communication module requires only three bipolar transistors, a phototransistor, a few resistors, one pushbutton switch, and a cheap mainstream IC.

This is a fun project, but be safe!

As with all laser projects, a word of caution is in order. The modules used are classified as Class IIIa lasers, with output fixed at < 5 mW. These are pretty safe as lasers go. Nonetheless, misuse can cause injury to the eye and can be illegal. Staring at the beam can cause retinal injury. *Never, ever* further focus the beam using optics unless you really know what you are doing. Shining a laser at an airplane is illegal and aiming a laser at a car is stupid. Safety goggles are appropriate. Enough said.

What do we need to know before we start?

Laser modules consist of the laser diode, power regulating circuitry, optics, and the casing. Laser diodes are operated at the extremes of the thermal and power curves for the semiconductor. There is usually a photodiode in the unit that monitors the output of the laser and provides feedback to the power regulation circuitry to prevent runaway. Optics collimate the beam (usually just a cheap plastic lens), and the metal casing dissipates heat. My initial concern in this experiment was that the on/off time for the laser unit would be too long, but it is possible to achieve 4800 baud communication. All that internal output regulation occurs very, very rapidly. The unit stays cool, and the waveforms are sharp enough to meet serial port encoding standards.

The other piece of background has to do with phototransistors. This class of semiconductor develops current with illumination. Illumination of a phototransistor with a red laser produces a very robust response which under my experimental conditions dropped effective resistance by at least a factor of 10 (and sometimes more) in room light. This is more than enough of a change to be easily detected by a comparator. The rise time and fall time of current across the semiconductor junction with application of light is fast and can meet serial port encoding standards with the correct choice of parts.

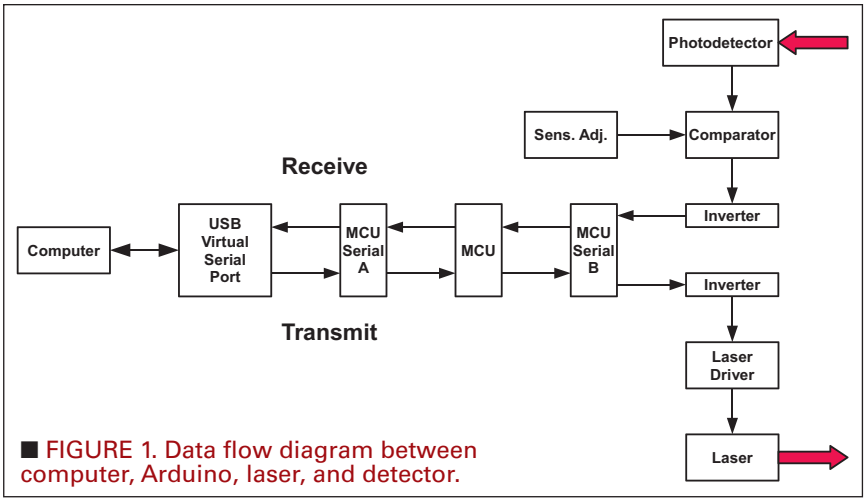
The Basic Layout

I chose to implement communication using the conventional serial port/RS-232 encoding protocol. There were several reasons for this. First, both computers and microcontrollers have extensive hardware and software for this protocol and I would not need to reinvent the wheel. Second, speed of transmission was easily varied; if there were difficulties with maintenance of communication I could simply slow down the speed of transmission. Third, it was binary. The protocol requires no analog modulation of the signal (amateur radio types — no frequency modulation or phase modulation a la PSK-31, and much, much faster), improving reliability and ability to detect a low level signal.

I also chose to route the communication through microcontrollers. There were three major reasons for this. The first was protection of the computer. If I bungled this, I'd trash the Arduino, not the Dell. The second was extensibility. If I could establish communication between the microcontrollers, there would be a general solution that could be applied to both microcontrollers and computers. Third, use of the microcontroller permits addition of some extra functions that would require significant additional programming on a computer. These extra functions

(discussed below) simplify alignment of the units and initiation of communication.

Data flow is shown in **Figure 1**. Using a terminal program on the PC, the information is communicated through a true or virtual serial port to the microcontroller. Data is handed over within the microcontroller from the UART serial port in communication with the PC to the UART serial port in communication with the laser. The TX pin is connected to a simple bipolar transistor. I used a 2N3904 which is appropriate for radio frequency, low level signals; it certainly could handle this task. The transistor is essentially slammed on and off producing current flow which, in turn, drives the laser module. A second transistor is configured as a discrete components inverter. This reduces the duty cycle of the laser considerably. No other circuitry is required for transmission. TX/RX signals go high (zero) to low (one). Thus, the quiescent state of the laser is on which uses energy and increases the likelihood of misadventure with the beam. By placing an inverter in the signal path, the quiescent state of the laser is off, and a logical one is high.



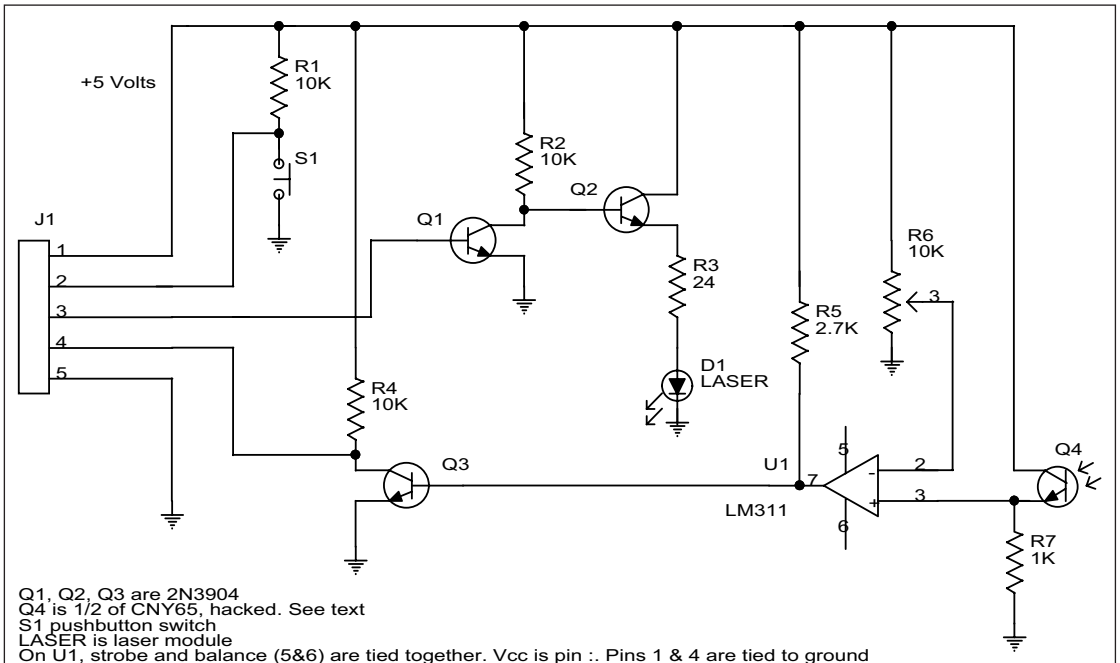
■ FIGURE 1. Data flow diagram between computer, Arduino, laser, and detector.

Reception is somewhat more complicated. The phototransistor acts as the sensor. The phototransistor is in series with a resistor, effectively creating a light modulated voltage divider. The voltage is monitored by a comparator: an LM311. The LM311 has ample bandwidth. The output of the LM311 is a TTL level signal that is fed to another discrete component's inverter to reverse the effect of the transmitting inverter. The signal is then fed to the RX pin of the receiving microcontroller. Information is handed over to the UART serial port in communication with the computer and relayed to the terminal program on the PC.

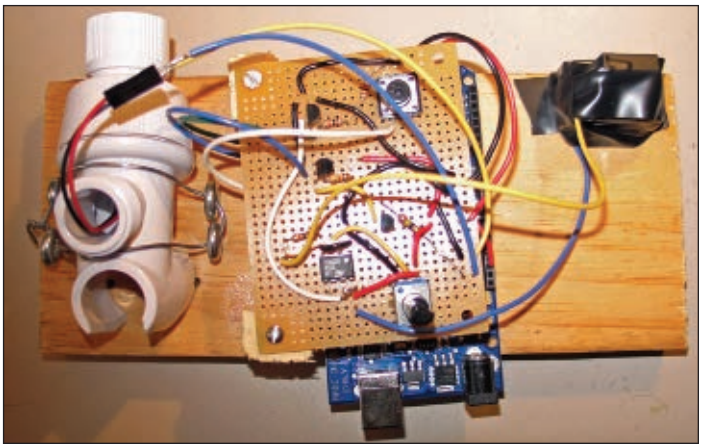
Obviously, all forms of information can be relayed; the application is not limited to a terminal program. Additionally, there is no requirement for a computer. The two microcontrollers can easily just talk to each other. **Figure 2** is a schematic of one half of a communication link using an Arduino board.

Why Arduino? Several reasons. First, I really have no objection to C and its derivatives. Folks don't like C because hot dog programmers can write incomprehensible code if they want to. However, if the author so chooses, it is possible to write code in C that is as clear as a Pascal program written by Nicklaus Wirth. Second, people don't like C because it is associated with down and dirty coding; if you are writing in C you must be manipulating data bit by bit.

The Arduino environment provides a very high level of abstraction that permits the programmer to complete the task rather than code. Second, there is a huge open source community that shares code, tips, and tricks. It is a very rich environment. I have learned a lot of both



■ FIGURE 2. Schematic for transceiver. Two are required for communication.



■ FIGURE 3. The transceiver board. The transceiver circuitry is in the middle, mounted above the Arduino. Wiring — rather than pins and headers — was used to maintain greatest flexibility possible. On the left is the laser, mounted in a showerhead and secured to the transceiver board with wire. On the right is the photodetector, mounted with electrical tape. See text for other mounting options.

practical and theoretical information from this very friendly, extended family. Finally, from a practical level, the Arduino uses a USB virtual serial port with an FT-232RL chip to provide the serial translation. A full featured USB port on a computer guarantees five volts, 500 mA to an attached device for the device's own use. This project uses much, much less power than that so no other power source is required.

Some may be concerned that the original Arduino boards only have one hardware serial port. This project requires two serial ports and an older soft serial library didn't work well. While this is true, a newer software based serial port (NewSoftSerial) is very robust. Code is provided online at **www.nutsvolts.com** for the original Arduino (one hardware, one software port) and the Arduino Mega (two hardware ports).

In Practice

If you are not familiar with the Arduino, check out Smiley's Workshop that runs in *NV* each month. It will introduce you to this system. To use the communicator without further modification, build the board, install the Arduino software, let Windows install the virtual serial port, and choose the target board. Hook up the target board. Copy or enter the code, press compile, and then press download to board. Software setup is less than 30 minutes.

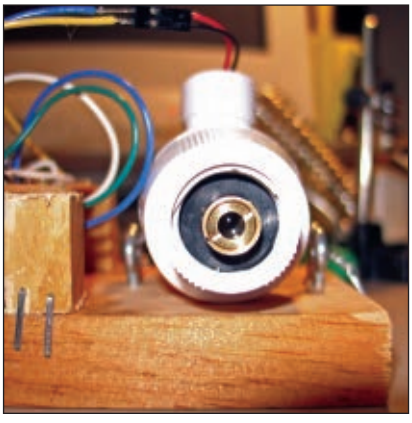
The system requires two adjustments in order to function. The first — and by far the most difficult — is aiming the laser to hit the phototransistor square on. I do not have a foolproof method for doing this. I mounted my communication units on some scrap lumber (**Figure 3**), then I mounted the laser unit within a ball joint type plastic shower head for even more control (**Figure 4**). Consideration could be given to mounting the unit on a camera tripod for even greater aiming control.

The other adjustment is setting an offset for the comparator. Depending upon ambient light, the baseline current of the phototransistor may vary considerably, and depending upon the distance from the laser to the detector, excitation may vary considerably. The negative input of the comparator is attached to a potentiometer which permits setting the comparison voltage, which enables extraction of the data. This is a simple adjustment.

Building It

The electronics are easy. I recommend point-to-point wiring on a piece of perf board. The component count is so small that the work involved does not justify a printed circuit. If you wish to be particularly careful (which I heartily recommend), attach a five volt source to Vcc and Vgnd and sniff for smoke before hooking up the Arduino. Apply a five volt signal to the base of Q1 and make sure the laser is working. If you have a multimeter, set the negative input of the comparator at approximately 1-1.5 volts. Even with the laser on, total current draw should be well under

■ FIGURE 4. Close-up of laser mounted in showerhead. The showerhead articulates in a ball and socket fashion. This particular model of showerhead had a gasket which permitted a press fit of the laser unit without further modification. Other heads may require glue or creation of a sleeve around the laser to allow a press fit. Wires follow the water path.



■ FIGURE 5. Close-up of photodetector consisting of hacked CNY65 optocoupler. With chip text correctly oriented for reading, as you face the chip the left side of center houses the emitter and the right side contains the detector. Using a tiny burr or milling tip, carefully start on the left of center of the chip and remove the black plastic until a white matrix is identified. On the left side of the matrix, continue to remove material until a small translucent cube is identified. This is the emitter. The detector looks almost exactly the same. Now that you know what to look for, carefully remove as much white matrix from around the detector as possible without destroying the detector plastic. This is actually quite easy, and the end result should be similar to the photo here. Only the two right side pins need to be connected. The upper right pin is high. Other optocoupler chips likely have a similar mechanical construction, but I cannot confirm that (follow schematic for appropriate hookup).

Laser Serial Arduino Mega.txt

```
// Use with Arduino Mega and other Arduino
types that have multiple hardware serial ports

//used for receving/sending characters
int  scratchByte;

void setup () {
//Initialize Arduino<->Computer port
  Serial.begin(9600);
// Intialize Arduino <-> Arduino port
  Serial1.begin(4800);
// Attach interrupt routine to Interrupt 0 on pin 2
  attachInterrupt(0, Align, CHANGE);  // this is pin
2; use 4.7k pullup resistor
}

void loop () {
  // if data from computer available, pass to laser
  if (Serial.available() > 0){
    scratchByte = Serial.read();
    Serial1.print(char(scratchByte));
  }
  // if data from LED available, pass to computer
if (Serial1.available() > 0){
    scratchByte = Serial1.read();
    Serial.print(char(scratchByte));
  }
}

void Align(){

  pinMode(2,INPUT);
  while (true)
  {
  Serial1.println("ABCDE");
  Serial1.println("FGHIJ");
  Serial1.println("KLMNO");
  Serial1.println("PQRST");
  Serial1.println("UVWXY");
  Serial1.println("01234");
  Serial1.println("56789");
  if (digitalRead(2)==HIGH)
    break;
  }

}
```

50 mA. The Arduino board has clearly marked Vgnd and +5 volt sources and they should be connected appropriately.

Output of the comparator should go to your RX pin via Q3, and Q1 should be connected to Q2 which, in turn, should be connected to the TX pin. Specific pins may vary depending upon the Arduino (or your favorite microcontroller) and how you configure your software serial port. I deliberately did not construct this unit as a shield because of the wide variety of board formats now available.

When I thought of this project, I did not have a phototransistor on hand. However, I did have a couple of optocoupler ICs left from another project. Careful work with a Dremel tool permitted me to remove the plastic and I was able to expose the semiconductor; it took all of about five minutes to do and worked very well (**Figure 5**). I also completed the project using a conventional phototransistor. Interestingly, the hacked optocoupler (CNY65) was much easier to adjust, and was my ultimate sensor. After reviewing product specs, I concluded that the key design parameter is rise/fall time. The hacked optocoupler is a digital, high speed device, whereas the phototransistor is a sensor. Faster is better.

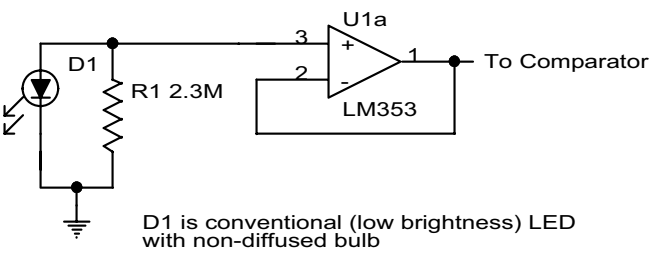
Mechanical construction is a bit more challenging. If you are just going to do this over a tabletop, aiming and aligning the two units is not a big deal. If you are going to try this over several hundred feet, you need to be able to aim your laser with some precision. I suggest attaching the Arduino board and your communication board to a photo tripod. The laser itself is mounted in a plastic showerhead. This permits further manipulation of the beam independent of the tripod which may be necessary for the best signal. Depending upon the laser unit you use, some ingenuity will be necessary to provide firm mounting while retaining the ability to aim. Other ideas I entertained included a pair of helping hands.

Using It

Once you have built the two units, place them so that they are aligned as best as possible without turning the units on. If you are doing this over a distance, you may want a friend to help, and you may want to use a cell phone or short range radio to communicate with the friends. Binoculars can also be helpful. *Don't look at a laser beam coming at you using binoculars; use them only for locating the laser spot in relation to the phototransistor.*

Once manually aligned, attach the Arduino to the computer and the communication board to the Arduino. Start the terminal program of your choice and establish communication through the virtual serial port with the Arduino at 9600 baud. Now, press the button you labeled

■ FIGURE 6. This is an alternative front end for the photodetector. Use a conventional, low luminance non-diffused LED (can be colored, but clear) that emits the same color as the laser. The LED — when illuminated with the laser — produces a very robust voltage but miniscule current. A 2.3 megohm resistor provides enough connection to ground so that the LED is not floating. A very high input impedance FET front end op-amp buffers the signal which is then passed along to the comparator. I used an LM353 for this purpose. While this is a very robust detector, it is even more sensitive than the phototransistor, so it requires a precise direct hit of the beam — an all or nothing affair.



align on the communication board. This causes the Arduino to send 35 characters to the laser: the first 25 letters of the alphabet and number characters 0 through 9. Every five characters a new line command is issued, as well.

The laser will appear to be continuously on. Aim the laser at the phototransistor of the far unit so that you see the phototransistor clearly and brightly illuminated. At that point, the receiving computer should receive the character stream. If it shows nothing or gibberish, adjust the potentiometer and send another character stream. You may need to do this several times.

If difficulty persists, you need to troubleshoot. Issues

Laser Serial Arduino Due.txt

```
//Use for Arduino Duemilanove

//NewSoftSerial Library available as a
download from the Arduino website

#include <NewSoftSerial.h>


//Instantiate a new instance of the New-
SoftSerial Object
NewSoftSerial LaserSerial(4,5);


//used for receiving characters
int  scratchByte;


void setup ()
{
//Initialize Hardware serial port
  Serial.begin(9600);
//Initialize Software serial port
 LaserSerial.begin(4800);
//Attaches the interrupt routine below to
Interrupt 0, on pin 2
//There is now no need to poll for  button
activity. If the switch is pressed (voltage
goes to zero)
//And then released, the interrupt routine is
invoked with no further programming on
your part.
 attachInterrupt(0, Align, CHANGE);
  // this is pin 2; use 4.7k pullup resistor
  }

  void loop ()
  {
  // if data from computer available, pass to
laser
  if (Serial.available() > 0)
{    scratchByte = Serial.read();
LaserSerial.print(char(scratchByte));   }
// if data from LED available, pass to
computer
if (LaserSerial.available() > 0){
  scratchByte = LaserSerial.read();
  Serial.print(char(scratchByte));
  }

  }

  void Align(){

   pinMode(2,INPUT);
  while (true){
   LaserSerial.println("ABCDE");
   LaserSerial.println("FGHIJ");
   LaserSerial.println("KLMNO");
   LaserSerial.println("PQRST");
   LaserSerial.println("UVWXY");
   LaserSerial.println("01234");
   LaserSerial.println("56789");
   if (digitalRead(2) == HIGH)
     break;
   }

  }
```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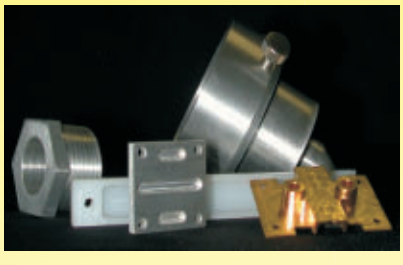

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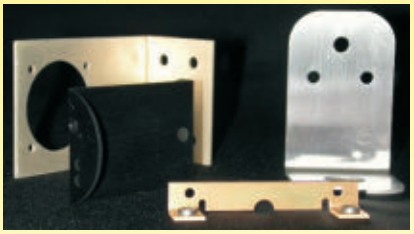

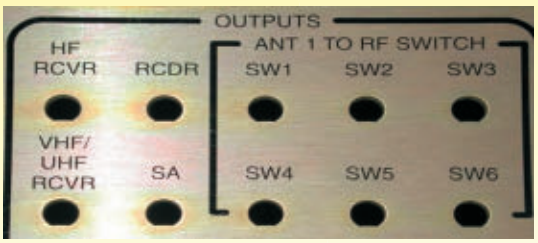

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can include misalignment of the laser (shine the laser on the other unit's receiver at close range at least once so you can see what the phototransistor looks like when it is getting properly excited by the laser), electronic malfunction, or distance is too great. Most likely, a back and forth between alignment and comparator adjustment will give you a signal if the two units are less than 100 meters apart. Once aligned, the unit is simply ready to accept serial input data. The default speed of the lasers is set in the code is 4800 baud. Remember that Arduinos do not detect communications settings and both units have to have the laser ports set at the same speed. I have no idea how far apart these things will work.

Code

Code is very, very simple. I used the interrupt feature of the Arduino to detect the button press. This is appropriate for a situation where button presses will be infrequent. For efficiency, I did not want the main loop looking for a state change on the button's pin upon every iteration when activation would be so infrequent. As indicated previously, there are two versions of code: one for the Arduino Mega with multiple hardware ports; and one for the Duemilanove which uses a hardware UART and a software serial port created by the NewSoftSerial library (available by download from the Arduino site).

Areas of Further Investigation

One early experiment was to use an LED as the sensor. Excitation of a conventional (i.e., low) brightness red LED with a red laser beam created a ~1.3 volt potential. From the standpoint of electronics, it worked quite well, requiring a high impedance amplifier to buffer the voltage generated (current generated was tiny). The signal — when present — was quite robust, and once buffered was easy to pass to the comparator (**Figure 6**). However, from a use/construction standpoint, the LED required a "direct hit" from the laser to generate a voltage. Revisiting this design may be of interest to some builders.

Other ideas to expand on include:

- What is the maximum distance over which this system can be used?
- Can the electronics be refined to increase sensitivity?
- Can the mechanics be improved to ease alignment procedures?
- What is the maximum data transfer speed?
- Would an array of phototransistors work better (increase target area)?
- Is analog signal modulation possible?

Just remember the whole "point" of this project is to have fun!! **NV**

PHONE RING-A-THING CONTROL

BY JOHN MASTROMORO

Several years ago, a friend asked me about the possibility of having a light turn on at his dock site when coming in from night fishing on Lake Ontario. He mentioned using a preset 'timer' but ideally preferred a remote-controlled device and, since he always carried a cell phone, the idea of using that medium for infinite transmission and range was certainly ideal. The question now was providing an appropriate *receiver/decoder.*

Having a phone installed at his site allowed for the installation of a touch-tone decoder, but this would be over-kill since it was only necessary to turn a light on and/or off. The method I chose was to provide a ring detection device that simply counts the number of rings to perform the on and off functions. The project discussed here has really worked quite well. It simply dials the phone number at the dock site and immediately hangs up as per the ring numbers selected (with "#N: on" and "#F: off").

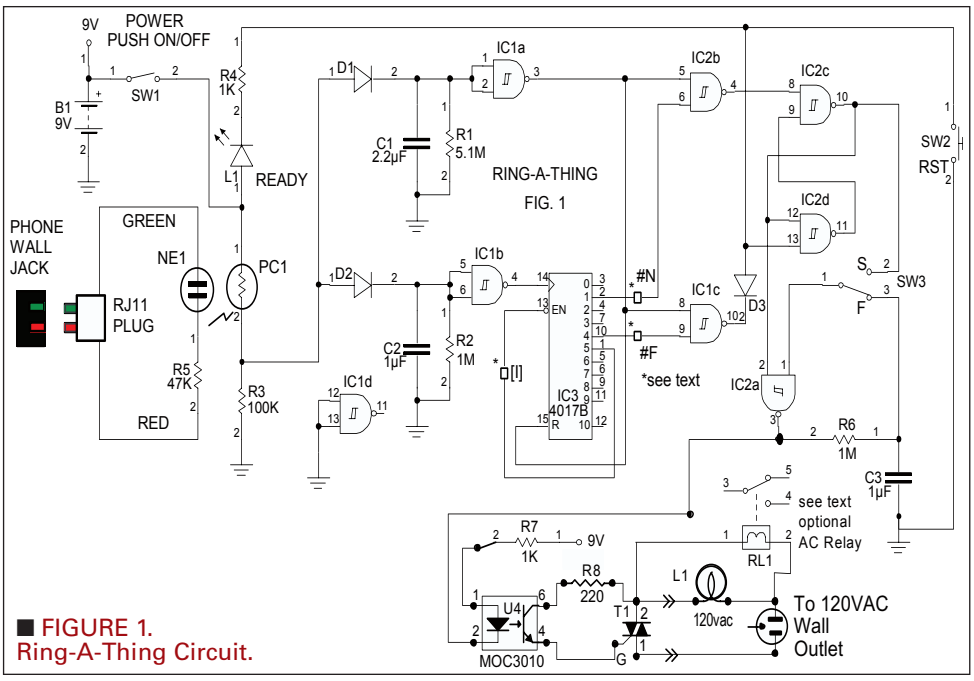
Take a look at the schematic in **Figure 1**. It indicates the jumpered selected numbers as 'one ring on' and 'four rings off.' Basically, you let the phone ring once for the "#N" time, hang up immediately, then approximately 12 seconds later, the light turns on. To turn the light off, let the phone ring for the "#F" number selected (four, then in this case), immediately hang up. Again, approximately 12 seconds later, the light will turn off. All other ring input counts are ignored and will not change the pre-existing condition.

A neon bulb (NE1) provides excellent isolation between the circuitry and the phone line because of its high impedance across the ring and tip (red and green) wires within the phone wall socket. However, it makes no difference which wire is connected to either side of the neon bulb for it to light when the pulsating higher voltage ring signal is present.

The neon bulb is soldered to the circuit board, directly connected to the phone line jack via a phone cord having an RJ-11 phone plug on one end and two stripped wire ends soldered to the board on the other end.

Since this project only needs to monitor ring signals (not requiring any data or audio transmissions for it to function), it presents no problem with line loading, which would otherwise be necessary to contend with by using properly designed impedance-matching transformers or opto input circuit configurations.

The photocell (PC1) is placed close to the neon bulb on the circuit board. Each one is soldered in place and formed to face each other so that the photocell receives proper light reception from the neon bulb when the phone rings. Black tape can be used to wrap the two elements together to ensure the best reception.

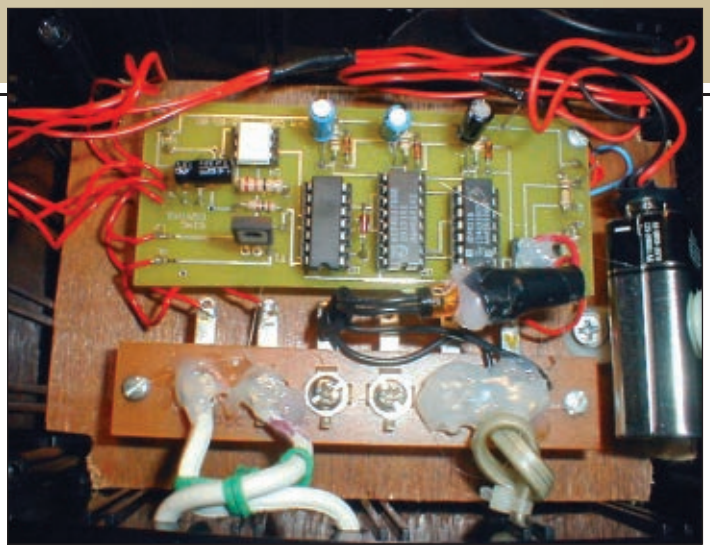


■ FIGURE 1.
Ring-A-Thing Circuit.

How It Works

When the phone rings, a pulsating voltage of approximately 60 to 80 volts is present which is sufficient enough to light the neon bulb. The photocell will respond directly to the bulb output, causing a positive pulsating voltage to pass through the anodes of diodes D1 and D2 into their associated timing circuit networks, which are configured with a resistor,

■ Inside the Ring-A-Thing.



capacitor, and NAND gate segment.

Each network is wired to provide a time delay as per the values of the resistors and capacitors. As the positive voltage pulses pass through the anodes of D1 and D2, they are dampened and a positive voltage is stored by the capacitors. The diodes now prevent the positive voltage charge from discharging back through their cathodes. The input impedance of each NAND gate is so high that voltage leaks in this manner are not considered. The only convenient discharge path for the stored positive voltage in the capacitors is through the resistors to ground. The amount of charge that the capacitors can hold — combined with the resistance values — determines the discharge rate of the positive voltage to ground. Use the formula R x C x .67 = T for your timing requirements.

The component values of R1/C1 will provide approximately 12 seconds and 1.5 seconds for R2/C2 but — depending on the 4093 IC manufacturer and tolerance values of the components used — it could be slightly different. Since there are no critical timing considerations for circuit operation to be concerned with, the values indicated should be sufficient with any phone service provider as long as the timing cycle of IC1a is longer than one ring cycle to the next, or at least eight seconds.

With a positive voltage applied to each NAND gate timing network (IC1a and IC1b), their normal high-state output pins go low, and remain so during the entire input charging time. Immediately following the absence of an input ring pulse, the capacitors will start to discharge and, when sufficiently discharged through their respective resistors to a ground potential, their output pins go high, indicating the completion of their intended time delay cycle.

Timing circuit IC1b has output pin 4 connected directly to clock input pin 14 of IC3 — a 4017 1-of-10 output decoder. With the values shown (approximately 1.5 seconds in duration), ample time is provided to allow one input pulse to IC3 per each complete ring cycle; in this instance, causing #1 output pin 2 to go and remain high. At this exact instance, the timing network of IC1a is being charged and configured to discharge approximately 12 seconds later if no more ring signals were input while discharging.

The IC1a time cycle provides two functions: output pin 3 is directly wired to input pin 5 of IC2b and IC3 output pin 2 (#1) is wired to input pin 6. When both input pins to IC2b are high, then output pin 4 goes low and immediately sets the IC2c/IC2d NAND gate flip-flop at input pin 8. This causes IC2c output pin 10 and input pin 12 of IC2d to go high. Output pin 3 is also wired to input pin 15 of IC3, resetting IC3 to a normal off state immediately after the IC2c/IC2d flip-flop has been set. This turns the light on.

With input pin 2 of IC2a high and switch SW3 in the S position, the light will have a steady glow. If SW3 is in the F position, then the bulb will continually flash since IC2a is wired as a feedback oscillator in this position. Oscillation is determined as per the R6/C3 values. Once the flip-flop is set, the light will remain on until reset. This action can be done in one of two ways. Pressing reset switch SW2 places a low voltage on input pin 13 of IC2d, resetting the flip-flop. Diode D3 prevents the low voltage from appearing at IC1c output pin 10 while lighting the ready indicator, LED L1. Switch SW2 provides another function of indicating if the device is powered on. If power switch SW1 is in the on position, it can be verified by simply pressing switch SW2, which will light LED L1 while pressed. Otherwise, LED L1 does not light with the power off.

The other option of resetting the flip-flop is to allow exactly four rings to be entered into IC3, in which case output pin 10 of IC3 (#4) goes high, is inverted to low by IC1c, is passed through the cathode of D3 to pin 13 of IC2d, which resets the flip-flop and lights the ready indicator LED L1 during the reset time period. (Whew!)

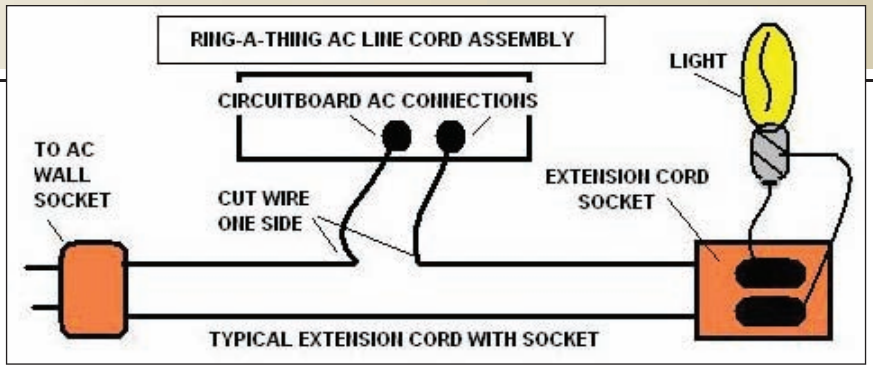
That's about it. The ring input counts used here have worked out pretty well. You can select any number of rings you like (from one to nine for either on/off activation), but using a lower number for on and a higher number for off seems to be more practical. Pin 13 (I) of IC3 should be

PARTS LIST

IC1-IC2	CMOS 4093 Quad two-input NAND Schmitt-Trigger	[13400]
IC3	CMOS 4017 1-of-10 Output Counter	[12749]
IC4	MOC3010 Triac Driver	[26278]
T1	Triac TO-220 400V/2.5A	[1165690]
D1-D2-D3	1N4148	[36038]
L1	Yellow LED Indicator	[34825]
R1	8.2M	[691796]
R2-R	1M	[691585]
R	100K	[691340]
R4-R	1K	[690865]
R	47K	[691260]
R8	220	[661343]
C1-C2	2.2 µf	[93731]
C3	1 µf	[29831]
Battery Snap		[109154]
NE1	Neon Bulb	[210315]
PC1	Cadium Sulfide Photocell	[202403]
RJ11	Phone Line Plug on Wire Lead; Strip Wire Ends	[196227]
SW1	Push On/Push Off Power Switch	[315492]
SW2	SPST PushButton Switch	[174414]
SW3	SPDT two-position Switch	[75969]

All items show Jameco part numbers; **www.jameco.com**.

Misc: Nine-volt Duracell or Lithium battery; circuit board; IC sockets and terminal strip (optional); 120 VAC light bulb/socket; AC cord/plug; AC relay [see text]; wire; assembling hardware; soldering equipment; appropriate sized enclosure. I do have a number of pre-drilled circuit boards on hand for those interested. Email me at jfmcircuits@frontiernet.net for info.



■ AC Cord Assembly.

jumpered to the next highest unused output pin number to prevent excessive and unwanted ring input counts to IC3. If you have a fax or phone answering machine connected to the phone line, make sure the highest ring number you select is lower than the turn-on ring number for either of the latter devices. Please note that the Ring-A-Thing project shown in the **photo** was assembled with an earlier circuit board layout but the circuit and circuit board design described here are identical in operation and dimension, respectfully. It is assumed that the reader has knowledge of working with AC power.

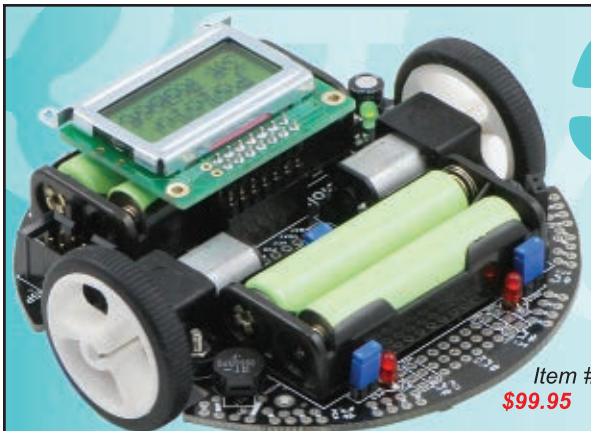
Construction

The enclosure used is 6″ x 4″ x 2″ which provides ample room to house all the components and battery. Although wires to the switches and LED can be soldered directly to the circuit board, I chose to use a terminal strip between the outside world phone line and AC cords to the circuit board. I joined the neon bulb and photocell together with black tape (as mentioned previously), and used a glue gun to seal them and to cover the terminal connections. Wiring is straightforward; and 20 gauge stranded wire throughout will work fine, but solid wire for the three jumper wires is recommended. Recheck all soldering connections — especially to the IC pins — because any cold solder joints can cause irratic circuit behavior.

Follow the **diagram** included here for AC cord assembly and installation. This project is not recommended for use in a busy phone environment. It's better for remote environments, such as camp sites. Using a land-line cordless phone will let you use your Ring-A-Thing locally and remotely. If your phone service allows you to dial your own phone number, hang up immediately and you can receive call back ringing.

By replacing the light bulb with an AC relay, the Ring-A-Thing can be used in higher-wattage devices such as air conditioners, heaters, or even swimming pool equipment, as well as smaller appliances such as a window fan, coffee pot, radio, TV, garage door, etc. Using a nine-volt Duracell or Lithium battery has provided long, dependable operation but a regulated nine-volt DC power supply can also be substituted for permanent installation. **NV**

3pi Robot



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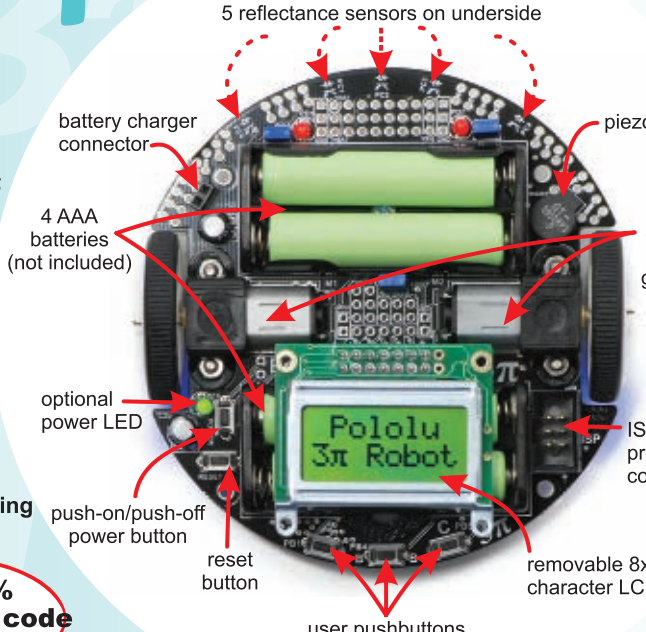

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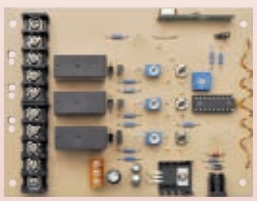

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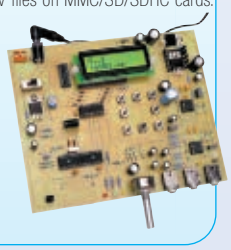

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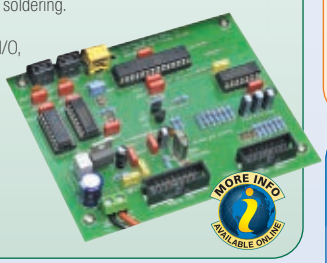

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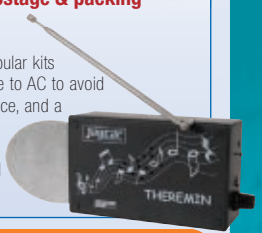

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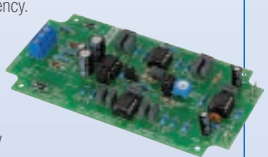
Power supply: dual rail ± 15-60VDC; single rail 12-30VDC or 11-43VAC
Current: 40mA max
S/N ratio: >100dB @ 1V
22Hz-22kHz filter



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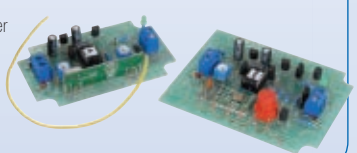

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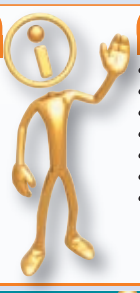

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Experiments with Alternative Energy

Part 4 - Build a "Double Wide" Sun Tracker

By John Gavlik, WA6ZOK

This time, the subject of alternative energy is on Sun Trackers: the mechanical devices that keep solar panels pointed at the sun all day. I'll show you how to build one with one or two solar panels along with a low voltage DC geared motor that is controlled by either the Parallax BS2 or PICAXE 28X2 microcontrollers. You already know from our past articles — and from common sense — that maximum power can only be obtained if the solar panels are constantly pointed at the sun from sunrise to sunset; thus the need for a Sun Tracker. While the concept of mechanical sun tracking is fundamentally simple, there are many factors to be considered in achieving it. This article and the one that follows next month describe how it's done and how you can do some very interesting experiments.

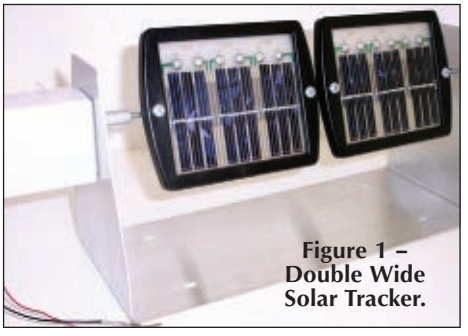


Figure 1 – Double Wide Solar Tracker.

Sun Tracker Design

Our Sun Tracker design can be expressed in the following general categories:

- Mechanical
- Electronics
- Firmware

Mechanical

Mechanically, the Sun Tracker consists of one or two solar panels (your choice) coupled to a 12 inch threaded rod attached to a geared DC motor that's all mounted on a custom mounting bracket (**Figure 1**). The solar panels are attached to the threaded rod using two small angle brackets that are, in turn, secured by #8 screws, washers, and nuts (**Figure 2**). The threaded rod is then coupled to the shaft of a geared DC motor with a standard shaft coupler (**Figure 3**).

To help balance the weight of the cantilevered solar panels, a counter-balance consisting of a straight bracket and some washers is attached to the threaded rod in the center of the back of the solar panel (**Figure 4**). The counter-balance makes it much easier for the small geared motor to rotate the solar panels. The motor and solar panel wires are routed to the BS2 or PICAXE "test bed" boards where they connect into the proper holes on the solderless breadboard.

The mechanical assembly of the Sun Tracker is straightforward. However, there are many detailed steps involved. Due to the limited space for everything else I want to cover here, you can find complete details for assembling everything on my website at **www.learnonline.com** → Experimenter Kits → BS2 or 28X2 → Build a "Double Wide" Sun Tracker. A **Parts List** is included here.

Electronics

Our Sun Tracker is controlled by either a Parallax BS2 or PICAXE 28X2 microcontroller (your choice) mounted on its solderless breadboard alongside the Sun Tracker mounting bracket (**Figure 5**). Also included are the NiMH battery and battery charger circuit from Part 3 and a new H-bridge circuit to control the DC motor which is powered by the rechargeable battery. The H-bridge circuit is the interface between the micro and the motor. It uses a PWM (Pulse Width Modulated) technique created in the firmware to control the motor's rotational travel and, thus, the solar panel's degree of movement. We want to keep the motor's travel fairly short in order to track the [relatively] slow movement of the sun, hence the PWM technique that pulses the motor in short east-west movements. By using the rechargeable battery, we take the load off the solar panel to power the motor directly. You may configure the solar panels in any series-parallel arrangement you desire. Our versatile solar panels are really three solar modules in one housing,

Figure 4 – Counter Balance Weight on Back of Solar Panel.

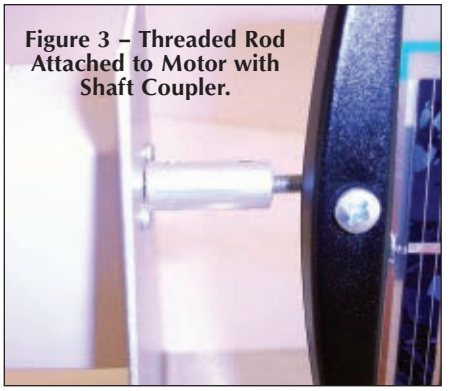


Figure 3 – Threaded Rod Attached to Motor with Shaft Coupler.

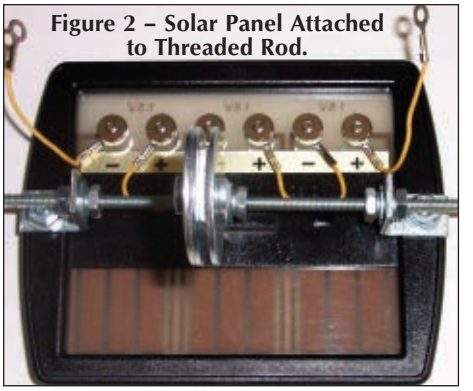


Figure 2 – Solar Panel Attached to Threaded Rod.

so with two panels you have six solar modules that you can arrange in a variety of voltage-current output configurations. Just make sure that the total "open circuit" voltage does not exceed five volts as it will swamp the A/D converter inputs.

Hook up the solar panels, motor wires, battery, and other jumpers as described in the detailed instructions. This includes the H-bridge circuit on the solderless breadboard, as well as the NiMH battery. Refer to **Figure 6** for a combination Block Diagram/ Schematic of the hookup. As you can see, there is a lot going on here, and I'll go into how the firmware handles all of this hardware next.

Firmware

The firmware is subdivided into four basic functions:

- Sun Tracking
- Battery Charging
- Data Logging
- Data Output to Computer

Each major function is serviced by the micro in a round-robin manner that repeats from top to bottom, over and over again. A flow diagram of the firmware functions can be seen in **Figure 7**. Refer to it in order to better understand the following discussion.

Sun Tracking

When first powered up or after you push the reset button (on the Parallax BOE or Homework board), the firmware doesn't know where the sun is yet so it goes into *Search Mode*. In *Search Mode*, a sample of the solar panel's voltage is taken then the firmware causes the motor to move slightly to the east and a new voltage sample is taken. If the new voltage sample is more than the last sample (called *lastVolts* in the code), the firmware moves the solar panels east again. However, if the new voltage sample is less than the last sample, it means that we have overshot the sun's position. When this happens, the firmware enters the Track Mode. **Figure 8** illustrates these actions.

The *Track Mode* is designed to ensure that the solar panels are always facing the sun as it travels in a westerly direction during the day. Each time through the *Track Mode* loop, the firmware takes a sample of the solar panel's voltage and compares that sample to *lastVolts*. If the sample and *lastVolts* are the same, nothing happens and the solar panels are not moved. Otherwise, the solar panels are moved slightly west, then another voltage sample is taken. If the new voltage sample is less than the last voltage sample, that means that we've overshot the sun's position again, so the firmware activates the H-bridge circuit and causes the panels to move back east again. **Figure 9** shows how this works.

After the *Search Mode* has located the sun's position, the *Track Mode* is invoked each time through the Main firmware loop, so the solar panels are constantly moving slightly west to follow the sun if the voltage samples warrant such movement. Most commercial sun trackers do essentially the same thing because the sun is quite predictable.

Battery Charging

As I said earlier, the NiMH battery is used to power the geared motor through the H-bridge circuit, so it stands to reason that since we have solar panels at our disposal we should use them to charge the battery. I've

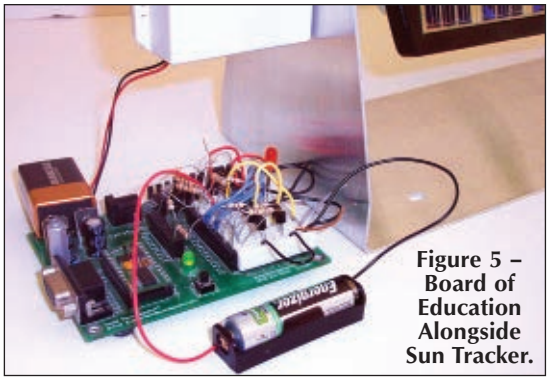


Figure 5 – Board of Education Alongside Sun Tracker.

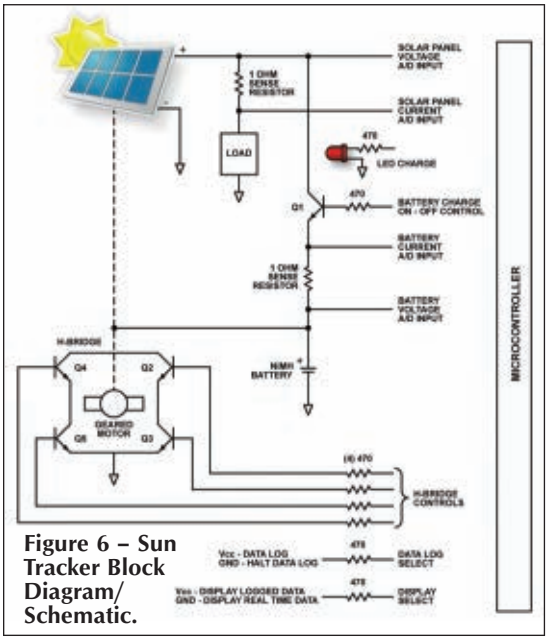


Figure 6 – Sun Tracker Block Diagram/ Schematic.

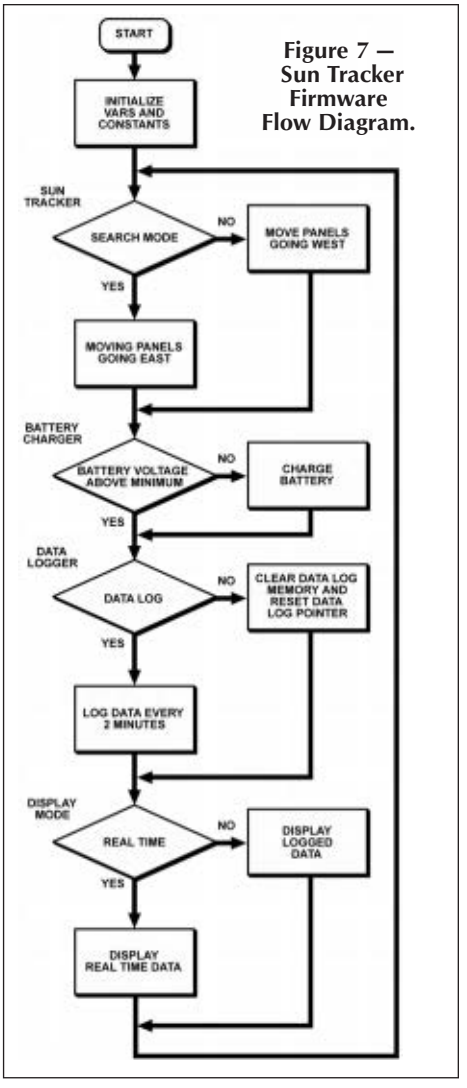


Figure 7 — Sun Tracker Firmware Flow Diagram.

used the same circuitry and basically the same firmware as described in Part 3 with some firmware modifications that allow it to fit into the Main round-robin loop. In the *Test_Battery_Voltage* routine, the rechargeable NiMH battery voltage is sampled. If it is at an acceptable voltage level, the firmware returns to the Main loop. However, if the battery voltage falls below a minimum voltage level which you set as a firmware constant called *fullDischargeVolts*, the battery begins its "energy loop" charging cycle.

In the *Charge_Battery* routine, the energy loop turns transistor Q1 ON which delivers the solar panel's voltage and current into the battery. The LED is also solidly illuminated at this point. The firmware monitors the battery's voltage and current, and keeps Q1 and the LED ON until the accumulated current level called *minEnergy* in the code is achieved. This puts about 1/20 C of charge into the NiMH battery. That should keep it turning the motor for quite a while. Of course, the battery still powers the geared motor even when it is being charged. Again, if you want to know more about the details of how the battery charging algorithm works, refer to Part 3 and/or go to **www.learnonline.com** → Experimenter Kits → BS2 or 28X2 → Build an On Demand Solar Powered Battery Charger.

Data Logging

Most sun trackers do not do data logging of the solar panel voltage, current, and power. However, since our theme is on experimentation, I felt that it would be important to actually measure and save the electrical output of the solar panels as they gathered sunlight during the day. With this data, you can compare the added performance of the Sun Tracker's ability to gather solar energy against a fixed solar panel's output. Data logging of the solar panel's voltage, current, power, and load resistance values are done as follows:

Approximately once every two minutes, the firmware takes a snapshot of the solar panel's voltage and current readings. This consists of two bytes each for voltage and current making the total "data record" four bytes. With this process, we are essentially taking a snapshot of the sun's condition every two minutes as it appears to travel across the sky — including all the voltage and current dips created by interference from clouds, haze, and other natural obstructions. Since a normal day consists of about eight useful hours of sunlight and our sample rate is once every two minutes, this translates to 240 samples per day (8 hrs x 30 samples / hr = 240 samples). Multiplying 240 samples times four bytes per sample gives us 960 bytes required for one day of storage. Both the BS2 and 28X2 have at least this much storage available where the program actually uses 1024 bytes for slightly more data logging time.

Data Logging Pointers

To handle reading, writing, and displaying the logged data the firmware maintains two pointers to the data logged memory area: a Data Log Pointer and a Display Pointer. Refer to **Figure 10** to follow along. The following description involves the EEPROM memory of the Parallax BS2. The PICAXE 28X2 operates the same way with scratchpad RAM, but the actual memory address locations are different. At the beginning of the data log cycle and when the data log memory is cleared (we'll get to this in a moment), the data log pointer is set to the bottom address of the data log memory area. Each time a data log event takes place, the solar panel's voltage and current — both two byte variables — are written into memory. The Data Log Pointer is then incremented by four bytes to the next

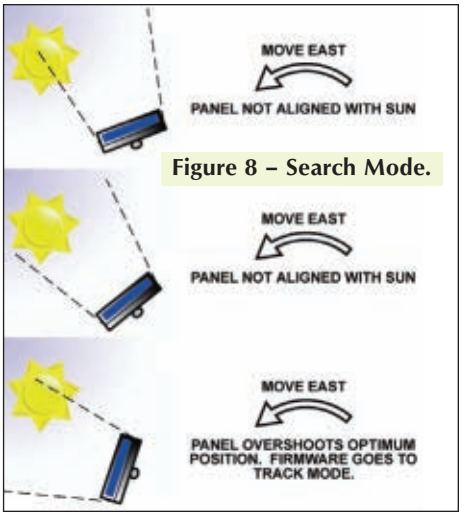


Figure 8 – Search Mode.

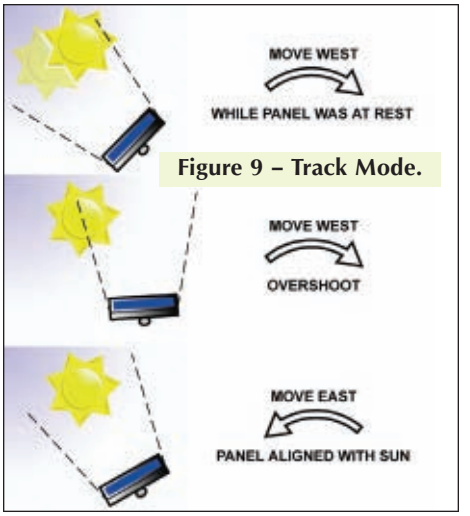


Figure 9 – Track Mode.

"data record" memory location. The process continues until all 256 data records (1024 bytes of data) have been written. At this point, the firmware detects the fact that the Data Log Pointer is at its maximum value and data logging is discontinued. The Data Log Pointer remains fixed at address $0400 until the data log memory is cleared. While this is happening, the Display Pointer is incremented on every pass through the Main loop (about once a second), then cycles back and restarts at the first data logged event again. This permits you to view the logged data as it is being accumulated or after the data log memory is full. The Display Pointer cycles from address $0000 to address $03FC in four-byte increments, and then back to address $0000 on a continuous, once per second round-robin basis. You can reset it to $0000 at power on or when the reset button is pressed to restart the display of logged data.

Data Logging Activity

To help you know what's happening during the data logging sequence, the LED briefly flashes every time through the Main loop to indicate that data logging is taking place. This is like a one-second "heartbeat" that let's you know that all is well with the data logging activity. Approximately once every two minutes, when a data log sample is taken the LED will flash with a longer duration (about one second) to let you know that a snapshot was taken and stored in the data log memory. When the data log memory becomes full, i.e., when all 1024 bytes (256 data records) are stored, the LED flashes four times for each pass through the Main loop. This flashing will let you know that the data log memory is full and that further data logging has ceased.

You are able to enable and disable the data logging feature with the Data Log Select signal — a resistor-jumper on the test bed (**Figure 6**). Based on this jumper setting, the Main routine directs the firmware to either clear the data log memory and cease data logging, or continue with data logging until the data log memory becomes full. For example, if you previously recoded a set of data and now want to record another set, simply move the jumper from Vcc to ground and the logged memory will be erased the next time through the Main loop. The LED ceases to flash when data logging is disabled, which is another state that lets you know what's happening. Move the resistor-jumper back to Vcc when you want to resume data logging. I use a 470 ohm resistor instead of just a wire jumper to limit the current into the micro's input port when it's connected to Vcc. The LED flash sequences for data logging are listed next including those for the battery charging cycle, as well:

LED Flash Sequences

Data Logging

- Once a second — data logging in progress — short flash.
- Once every two minutes — log event — longer one second flash.
- Four rapid flashes — data log memory full.
- No flashing — data logging disabled — data log memory erased.

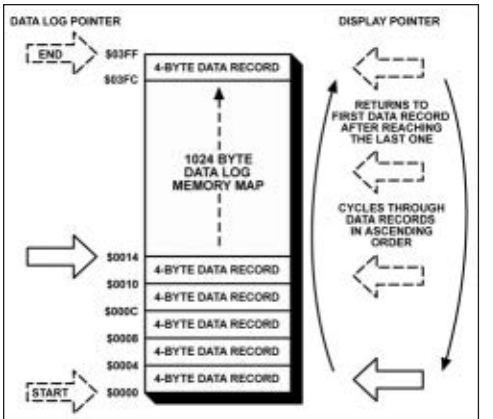


Figure 10 — Data Logging Pointers.

Battery Charging

- Solid on — battery is charging.
- Slow flashing — battery voltage is below minimum while charging.

Data Output

There are two ways to view the solar panel data on the computer: in real time and while data logging is taking place; or when the data log memory is full. This is also handled by a resistor — jumper. Real time data is displayed on the computer when the Display Select jumper (another 470 ohm resistor) is applied to ground. Logged data is displayed when it's attached to Vcc (refer to **Figure 6** again). The ability to switch between real time and logged data display is quite powerful in terms of experimenting with the Sun Tracker.

For example, you can study the effects of the sun's activities in real time while data logging continues in the background. Or, you can witness the display of the logged data as it occurs. Just configure the Display

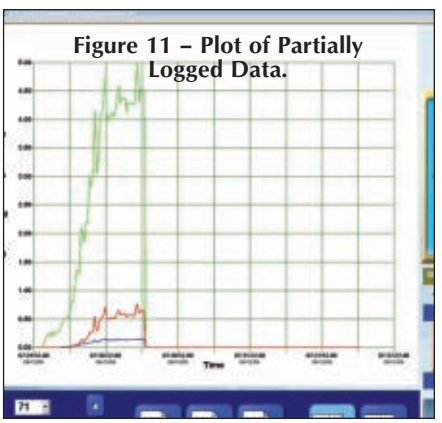


Figure 11 – Plot of Partially Logged Data.

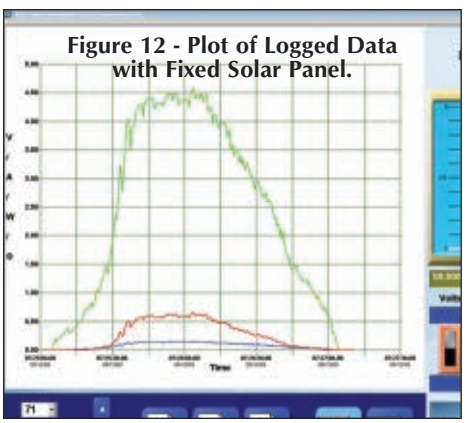


Figure 12 - Plot of Logged Data with Fixed Solar Panel.

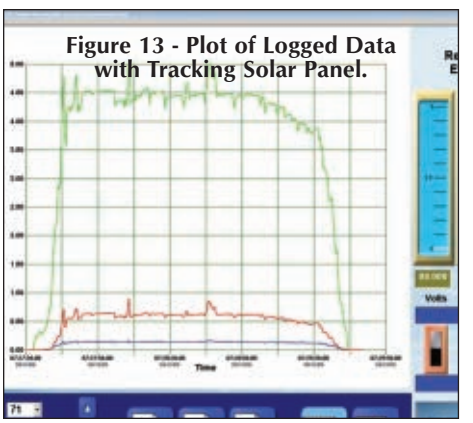


Figure 13 - Plot of Logged Data with Tracking Solar Panel.

Select jumper accordingly. When viewing logged data, the firmware increments the Display Pointer every time through the Main loop. Therefore, the firmware steps through the logged data one data record at a time. If the data logging sequence is in progress and the data log memory is not full, the computer will display all the recorded logged data up to that point followed by "all zero" data for the data log memory that is yet to be recorded (**Figure 11**). Since there is no real indication of where the logged events are relative to the displayed data, you can restart the display process from memory address $0000 by pressing the reset button or cycling power to the micro. This action resets the Display Pointer to address $0000.

Orienting the Tracker for Best Results

The Sun Tracker's east-west motor movements are designed with the geared motor facing due south. This will allow the solar panels to acquire and track the sun as it travels from east to west. Another consideration is ensuring that the solar panels have an unobstructed view of the sun all day long without the possibility of shadows from trees, buildings, or other fixed obstructions. This may not be possible if you're inside and trying to track the sun through a window as would normally be the case in very cold or inclement weather. Nevertheless, proper orientation is key to acquiring the optimum amount of sunlight during the day.

Besides the standard south orientation, you may want to also consider angling the entire mounting mechanism from horizontal to align with the sun's height above the horizon. You learned in Part 2 that the sun's apparent angle is dependent on the time of year and your latitude, so it's best to angle the entire mounting bracket mechanism in a "Polar Mount" fashion for best results (refer to the sidebar on Single Axis Sun Trackers).

Data Log Example

Here's what you can expect from the actions of the Sun Tracker. For **Figure 12**, I used a stationary solar panel without any tracking. I placed it facing due south and recorded its output for one day. Right beside it, I used another panel attached to the Sun Tracker and recorded the same sun data as shown in **Figure 13**. As you can see, the plot of the sun's voltage is much narrower for the stationary panel as compared with the panel on the tracker. The wider plot indicates the increased power and energy captured with the Sun Tracker in operation. This is the real function of the Sun Tracker; that is, to capture the maximum amount of sunlight and resultant electrical power and energy possible. Refer to **Figure 6** in order to set the Data Log Select and Display Select jumpers for data logging.

Summary

As you can see, our Sun Tracker is quite a versatile experimental tool. I felt that just doing a mechanical sun tracker function wasn't enough given the power of our microcontrollers; they should be used to their fullest capability in every way possible to make the project and experiments more interesting. It's always nice to add more firmware functions — mainly because they're free and don't cost any more than the microcontroller hardware that supports them. Always be aware, though, of "feature creep" that can overcomplicate things and destroy the best of designs.

An important point to note about the Sun Tracker is that all of the energy to move the motor comes from the NiMH rechargeable battery, which is trickle-charged during the day as necessary. This frees up the solar panel to power a load without the periodic heavy current drain of turning the motor every second or so. Another equally important design element is the ability to data log and display the sunlight data in real time or logged mode. I didn't have enough space left to go into the details of the H-bridge circuit, more firmware programming details, single axis versus dual axis sun trackers, or more of the data logging experiments that you can do with the double wide Sun Tracker, so that's what we'll do in the next installment. In the meantime, conserve energy and stay green. **NV**

Parts List

Qty	Description
1	Mounting Bracket
1	Geared Motor
1	12" Threaded Rod (#8)
1	Shaft Coupler
2	Solar Panels
4	3/4" Machine Screw (#8)
2	1/2 Machine Screw (#8)
18	Hex Nut (#8)
18	Flat Washer (#8)
18	Lock Washer (#8)
1	Acorn Nut (#8)
4	Small Angle Bracket
2	Straight Bracket
8	Flat Washer (1")

The Double Wide Sun Tracker is available as a *Nuts & Volts* exclusive kit. For kit details, go to **http://store.nutsvolts.com** or page 74 in this issue.

Single Axis Sun Trackers: Horizontal, Vertical, and Polar Mountings

A horizontal sun tracker is like the one we built here. As its name implies, the main axis is aligned parallel to the ground. When the rod that holds the panels is faced due south, the panels will track the sun from east to west. A vertical tracker is like vertical window blinds where the axis is aligned perpendicular to the ground. Here the panels rotate in a vertical plane to follow the sun. A polar tracker is like a vertical tracker that is tilted, generally at the angle the earth turns on its axis. In so doing, it is able to capture more of the sun's energy. If the tilt angle is further "manually" adjusted to account for the additional tilt due to the latitude and seasons of the year, then even more of the sun's energy can be captured. *Photos courtesy of Wikipedia.*

Horizontal Mount Solar Panels

Vertical Mount Solar Panels

Polar Mount Solar Panels

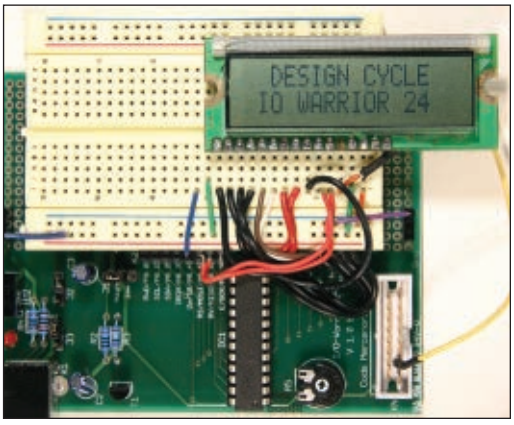
BY FRED EADY

TAKE AN IO-WARRIOR INTO YOUR NEXT EMBEDDED BATTLE

We are all used to stuffing code into a microcontroller to enable our embedded applications. This month, the tables are turned. The microcontroller work has been done for us and we must perform some Bill Gates C++ coding to force bits back and forth across the USB pipe. The folks at Code Mercenaries have assembled a microcontroller package that embeds a fully compliant, low speed USB HID device. All we have to do to access the IO-Warrior's I/O subsystem is plug the IO-Warrior into a USB port and perform the IO-Warrior API calls required to implement our application.

CODE MERCENARIES' IO-WARRIOR

The IO-Warrior family (available through Saelig; see **Resources**) consists of the IO-Warrior 24, the IO-Warrior 40, the IO-Warrior 56, and the IO-Warrior 24 Power Vampire. The numbers in the IO-Warrior monikers represent the number of actual pins that make up the host microcontroller package. The 24-pin IO-Warrior 24 exposes 16 I/O pins to the programmer while the IO-Warrior 40 provides the programmer with 32 I/O pins. Fifty of the IO-Warrior 56's pins are available to the user. The IO-Warrior 24 Power Vampire is a specialized variant that is designed to power source from the USB portal. All of the IO-Warriors are low speed USB devices with the exception of the IO-Warrior 56, which is a full speed device. The IO-Warrior 24 you see in **Photo 1** is the one we'll be working with. The IO-Warrior 24 is coded to include limited I^2C master support, an HD44780 LCD driver, incoming RC5 IR command support, and SPI master mode support. There is also a special function mode that allows the IO-Warrior 24 to drive an 8 x 32 LED matrix with a little help from some external shift registers.



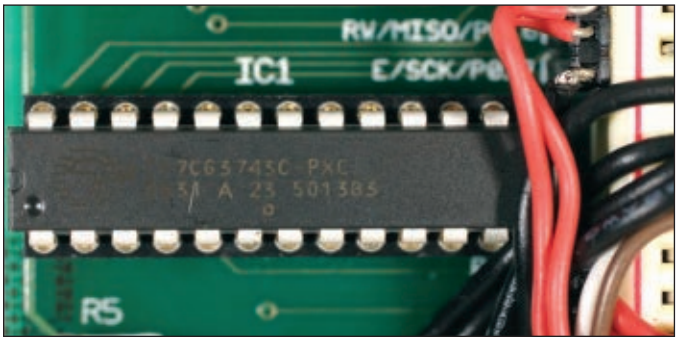
■ PHOTO 1. The IO-Warrior 24 comes as a kit. The Design Cycle version is shown here. I added the solderless breadboard and the 2 x 16 Lumex LCD.

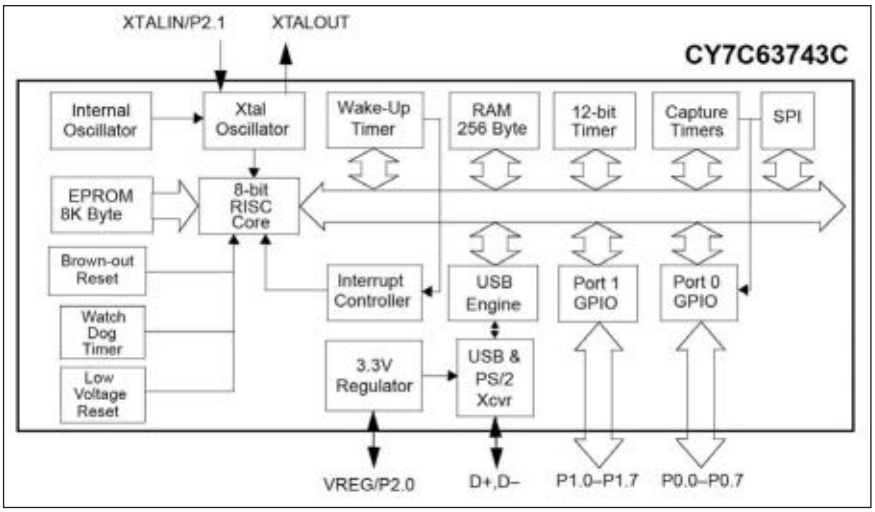
The basis of the IO-Warrior 24 is an OTP (One Time Programmable) Cypress CY7C63743C-PXC enCoRe USB combination low speed USB and PS/2 peripheral controller which you can see sans the IO-Warrior version label in **Photo 2**. The CY7C63743C-PXC's claim to fame is its ability to automatically operate in USB or PS/2 mode with a minimum of external supporting components.

For you young'uns, a PS/2 is (was) an IBM personal computer that replaced the venerable IBM XT and AT personal computers. The PS is short for "Personal System." USB overtook the clocked PC PS/2 interfaces in the 1990s.

To eliminate the more commonly used microcontroller support components, the CY7C63743C-PXC's internal oscillator can be used in lieu of an external ceramic resonator, while a 3.3 volt internal regulator provides voltage for the USB pull-up resistor. The CY7C63743C-PXC isn't very good at sourcing current on its I/O pins (2 mA max). However, it makes up for the weakness by being able to sink up to 50 mA on a single GPIO pin. Otherwise, as you can see in **Figure 1**, the PXC is a typical USB-enabled microcontroller. A pinout diagram of it and

■ PHOTO 2. The veteran Cypress CY7C63743C-PXC enCoRe USB combination low speed USB and PS/2 peripheral controller take on the IO-Warrior 24 USB mission.





■ FIGURE 1. The CY7C63743C-PXC hangs its hat on the reduced component count hook. No external clock source or voltage regulator is needed for this part to operate in USB mode.

its associated IO-Warrior 24 pinout are given to you in **Figure 2**.

Note that the IO-Warrior 24 configuration does not allow the use of an external clock source of any kind. Instead, the XTALIN pin is used as an input to select the power mode. The IO-Warrior 24 power pin is checked at power-up and bus reset only. When the power pin is pulled logically high, the USB power mode is set to high. In high power mode, the IO-Warrior 24 will request 500 mA from the USB power bus. A low on the Power pin will result in the IO-Warrior 24 settling for 100 mA max from the USB portal. The V_{reg} output is intended to power the USB D pull-up resistor and that is all.

The special SPI, I²C, and LCD functions take precedence over the normal GPIO pin logic. The PXC GPIO speeds are too slow to physically implement the I²C clocking via the I/O pins. So, the I²C protocol is handled internally to the IO-Warrior 24 to improve the data throughput. The IO-Warrior 24 can only participate in an I²C network as the one and only master node. Due to the IO-Warrior's lack of a stable hardware I²C clock, it may not be the best I²C master for some I²C slave devices.

SPI and LCD support on the IO-Warrior are mutually exclusive. This is due to the fact that the LCD E signal is multiplexed with the SPI SCK signal and the SPI data I/O pins (*MOSI* and *MISO*) are shared with the remaining LCD control signals *RS* and *R/W*. The IO-Warrior 24 SPI portal is capable of clocking at 2 MHz. However, the USB interface bandwidth is limited and the full bandwidth of the SPI channel cannot be utilized. LCD and LED matrix support are also nonconcurrent as some of the LCD data pins are used to drive the LEDs. A separate IO-Warrior 24 application note describes the implementation of an LED matrix.

THE IO-WARRIOR 24 STARTER KIT

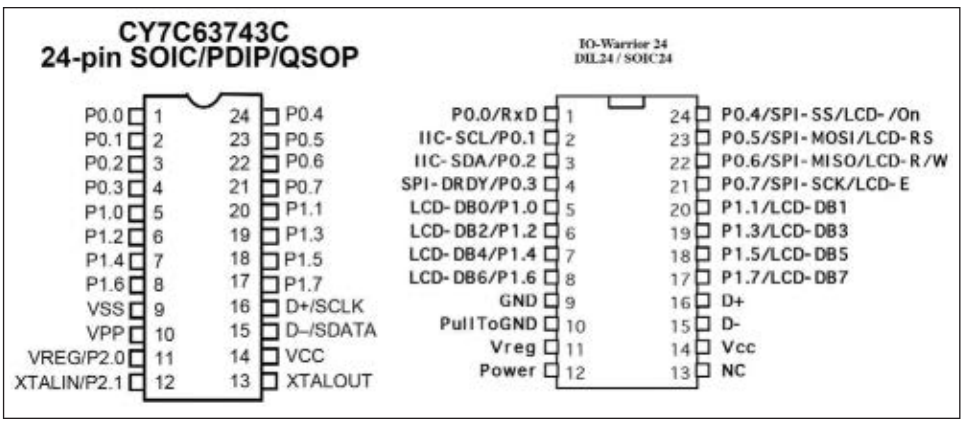
The IO-Warrior 24 Starter Kit comes out of the box in kit form. My assembled IO-Warrior is shown in **Photo 1**. As you can see, putting one of these together is a snap. I took the liberty of adding the solderless breadboard and the LCM-S01602DTR/M LCD. You can get an idea of how the starter kit is laid out by matching up the components you see in **Photo 1** with their graphical counterparts in **Schematic 1**.

The LCM-S01602DTR/M LCD's I/O pinout is compatible with the layout you see in **Schematic 1** with the exception of pins 15 and 16 which do nothing on the LCD as it has no backlight. Note the use of a PNP transistor backlight switch. Recall that the CY7C63743C-PXC doesn't like to source current and grounding (sinking) the BC307's base is right down the PXC's alley.

ARMING THE IO-WARRIOR 24

All of the major PC operating systems support USB. In addition, those operating systems natively support HID (Human Interface Device) class devices such as keyboards, joysticks, and mice. A major advantage to HID class devices is that they can be accessed from the application level. The IO-Warrior 24 is internally coded to act as a USB HID class device.

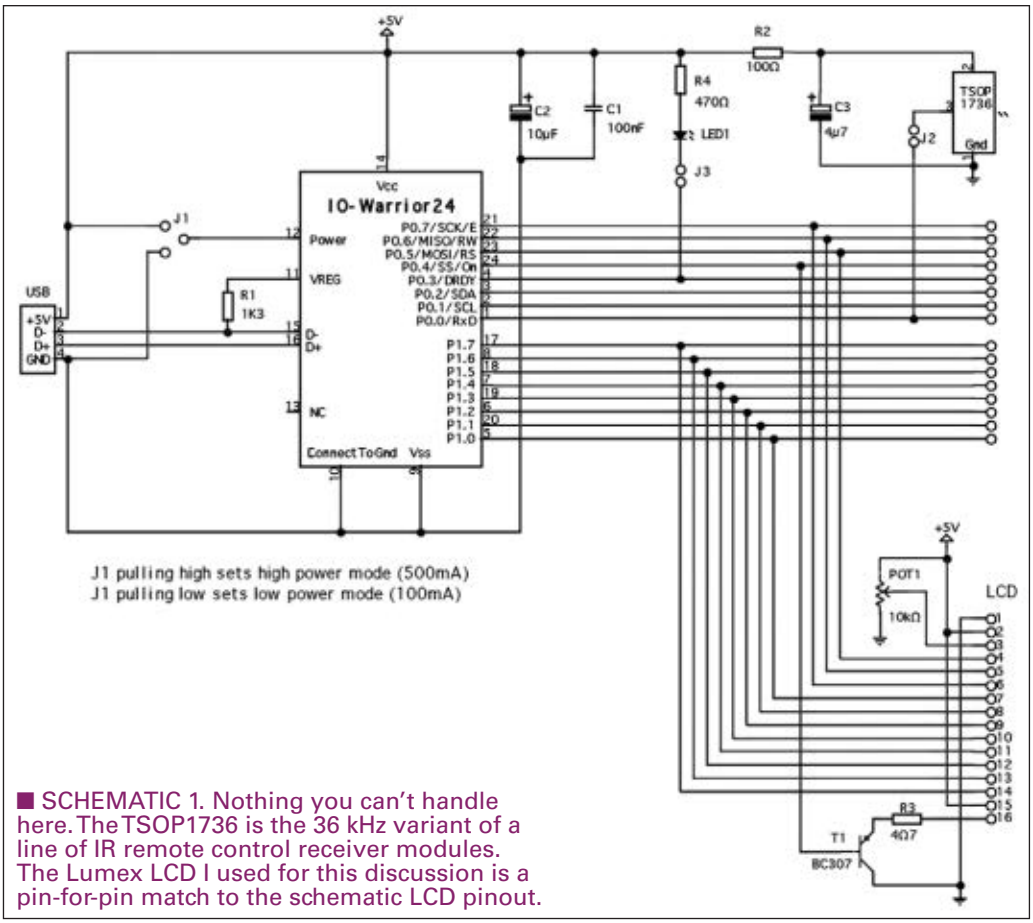
The CY7C63743C-PXC USB subsystem consists of three USB endpoints. Thus, the IO-Warrior 24 inherits that trio of endpoints. To get data to and from device resources, USB endpoints can be assigned to interfaces which provide a path to the device's functions. In the case of the IO-Warrior 24, interface 0 is the direct path to the GPIO pins. The special mode functions available via the IO-Warrior 24 firmware are spoken to via interface 1. If you recall your USB 101 training, endpoint 0 is common to all USB devices.



■ FIGURE 2. You can clearly see the native CY7C63743C-PXC multiplexed GPIO pin functions in this figure. The XTALIN and XTALOUT expect to see a 6 MHz ceramic resonator when the external clock option is selected. P2.0 and P2.1 are alternate inputs. Firmware forces the CY7C63743C-PXC to suit up with the IO-Warrior 24 armor.

Endpoint 0 is used to interrogate and configure a downstream USB device. Also, endpoint 0 can be used to send data to a downstream USB device's functions. The IO-Warrior 24 USB driver firmware employs endpoint 0 for output data (host to IO-Warrior 24) and as a vehicle for the host to send commands to the IO-Warrior's special mode functions. The path used to set the logical state of the IO-Warrior 24 GPIO pins flows through endpoint 0 and interface 0. The commands destined for the special mode functions also enter the IO-Warrior 24 via endpoint 0 but flow through to interface 1.

The IO-Warrior 24 can only report the state of the GPIO pins when it is asked to do so by the host. Endpoint 1 is used for this purpose. When logic states on the IO-Warrior 24's GPIO pins change, the new data is transferred on the next host request. Thus, when the state of the GPIO pins change, a report is generated and flows from the GPIO function through interface 0 and out to the host via endpoint 1. Replies from the special mode functions pass from interface 1 through endpoint 2 to the host. Endpoints 1 and 2 are called interrupt-in endpoints. In this case, interrupt means that data is transferred only when there is new data to pass along. The host determines when the new data is transferred which (due to the USB protocol) is once every 8 to 10 mS.

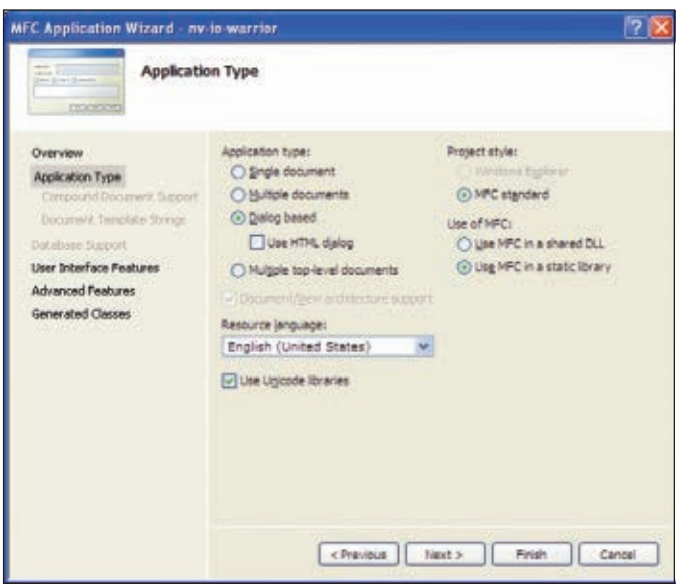


■ SCHEMATIC 1. Nothing you can't handle here. The TSOP1736 is the 36 kHz variant of a line of IR remote control receiver modules. The Lumex LCD I used for this discussion is a pin-for-pin match to the schematic LCD pinout.

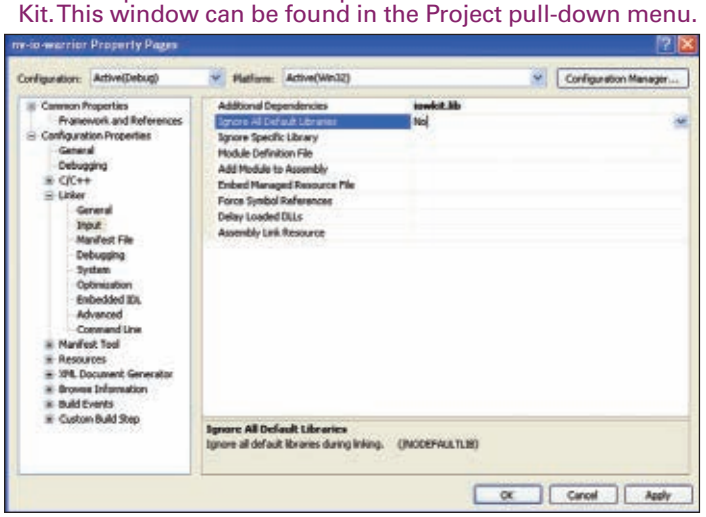
IO-WARRIOR 24 FIRE CONTROL

We've already discussed more USB concepts than

■ SCREENSHOT 1. There's no need to get fancy and complicated. All we want to do is display the results of the IO-Warrior API calls. Visual C++ is easy to learn and allows you to associate the IO-Warrior API calls with buttons and controls.



■ SCREENSHOT 2. Things just don't work well in the compilation and link processes without including this library into the mix. The library is included with the IO-Warrior Software Development Kit which is part of the IO-Warrior 24 Starter Kit. This window can be found in the Project pull-down menu.



■ SCREENSHOT 3. Visual C++ is carrying the work load behind this visual. This message box was generated with a couple of lines of Visual C++ code. If the IO-Warrior 24 is not connected to the host USB portal, this little box will pop up.

you need to know in order to code an IO-Warrior 24 application. The idea behind the IO-Warrior is to allow a programmer with absolutely no USB knowledge to apply USB technology in a microcontroller application. To this end, the Code Mercenaries folks have preloaded a CY7C63743C-PXC with HID firmware and supplied a USB-laden API for the host PC. The Windows API is housed in a DLL called *iowkit* and the Linux library is called *libiowkit.so*. The API encompasses all of the functionality for every IO-Warrior variant and is designed to be used with any Windows or Linux programming language. I've chosen to exercise the IO-Warrior 24 resources using Visual C++ which is one of the Windows programming languages available within Microsoft's Visual Studio 2008. I'll demonstrate the capabilities of the IO-Warrior API with the help of a Visual C++ dialog based MFC application. **Screenshot 1** — which is one of the MFC Application Wizard configuration windows — backs up my previous declaration. The only additional step we need to take outside of the MFC Application Wizard is to include the *iowkit.lib* in the link process. I've done this in **Screenshot 2**.

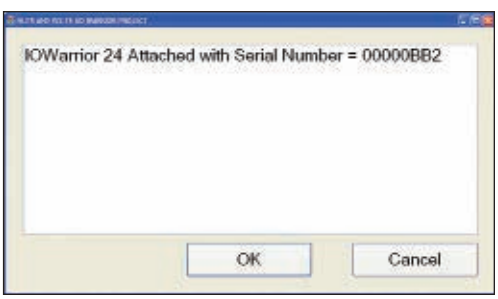
Like Visual Basic, Visual C++ is an event driven programming language. In a normal Visual C++ application, we would place much of the code we're about to write behind a button or control. For simplicity, we'll code everything we can inside of the Visual C++ initialization function which is defined as follows:

```
BOOL CnviowarriorDlg::OnInitDialog()
```

Our initial goal is to discover an IO-Warrior 24 at the other end of the USB cable. This is done with this API call which returns a unique handle for the first IO-Warrior detected:

```
IOWKIT_HANDLE ioHandle_1;
ioHandle_1 = IowKitOpenDevice();
```

The handle is actually a value that we will use to identify the detected IO-Warrior 24 to other API functions. The Visual C++ debug watch window revealed that a value of 0x00B60014 was assigned to the variable *ioHandle_1*. If the *IowKitOpenDevice* API function returns a NULL value, no IO-Warrior 24 was sensed. So, we will need to code an *if-else* segment to handle the possibility of not finding an IO-Warrior waiting in the wings:



■ SCREENSHOT 4. So far, so good. Once again, Visual C++ and the IO-Warrior API are doing most of the work here.

```
CString msgCHECKCONN    = _T("Check IOWarrior
                          Connection");
CString msgNOTDETECTED  = _T("No IOWarrior
                          Detected");

if(ioHandle_1 != NULL)
{
        //Continue on our way..
}
else
{
        IowKitCloseDevice(ioHandle_1);
        MessageBox(msgCHECKCONN,msgNOTDETECTED,0);
        OnOK();
}
```

In the previous code snippet, we assume that the IO-Warrior device open failed as there is only code for the *else* (failure) branch of the *if-else* segment. So, upon receiving a NULL *ioHandle* value, we close all IO-Warrior devices and post a device-not-detected message like the one you see in **Screenshot 3**. Let's code a positive response to the *IowKitOpenDevice* API call that will retrieve the detected IO-Warrior 24's serial number and display it on the LCD and in the application dialog box:

```
CString msgCHECKCONN    = _T("Check IOWarrior
                          Connection");
CString msgNOTDETECTED  = _T("No IOWarrior
                          Detected");
WCHAR SerialNumber[10];
CString SNtext;
UCHAR nextline;
nextline = 0;

if(ioHandle_1 != NULL)
{
        // Get Serialnumber
        IowKitGetSerialNumber(ioHandle_1,
        SerialNumber);
        // Display Serial Number
        SNtext.Format(_T("IOWarrior 24 Attached
        with Serial Number = %s"),
SerialNumber);
        m_DisplayWindow.InsertString(nextline++,
        SNtext);
}
else
{
        IowKitCloseDevice(ioHandle_1);
        MessageBox(msgCHECKCONN,msgNOTDETECTED,0);
        OnOK();
}
```

Note the use of the *ioHandle_1* value in the *IowKitGetSerialNumber* API call, which returns the eight word IO-Warrior 24 serial number in the *SerialNumber* array. Once we have the IO-Warrior's serial number, we can format a message and display it as shown in **Screenshot 4**. Just in case you're wondering, the *_T's* provide Unicode support for the message box strings.

We can also use the IO-Warrior API functionality to send the serial number information to the LCD. However, before we write that bit of code I need to clue you in on the data structure behind the bytes we're about to push towards the LCD's HD44780 controller. I also need to show you the data structure that the IO-Warrior 24 uses to control its GPIO pins. Recall that the IO-Warrior operates in the HID class. That means that the IO-Warrior 24 communicates using reports which are actually data

structures like the one shown here:

```
typedef struct _IOWKIT24_IO_REPORT
 {
  UCHAR ReportID;
  union
   {
    WORD Value;
    BYTE Bytes[2];
   };
 }
  IOWKIT24_IO_REPORT, *PIOWKIT24_IO_REPORT;
```

Each report is prefixed by a *ReportID* byte. The report ID is associated with a pipe. A pipe (in this case) is synonymous to an interface. So, Pipe 0 is used to talk to the IO-Warrior 24's GPIO pins just as Pipe 1 is used to communicate with the special mode functions. The IO-Warrior 24 report data structure contains a report ID and three bytes of payload. Pipe 0 is always used to interface to the GPIO pins. So, the ReportID value for GPIO access is always 0. A ReportID value would not be necessary in any case of GPIO access but Windows requires that a report ID byte be present. With that, here's how we write a 0xAA to the IO-Warrior 24's P0 GPIO pin set and 0x55 to its P1 GPIO pin set:

```
IOWKIT24_IO_REPORT report24;
ULONG rc32;
DWORD BitsRead;
CString BITStext;
CString RCtext;

#define IOW_PIPE_IO_PINS       0
#define IOWKIT24_IO_REPORT_SIZE
sizeof(IOWKIT24_IO_REPORT)

// Write 0x55AA to GPIO
IowKitSetWriteTimeout(ioHandle_1, 2000);
memset(&report24, 0, IOWKIT24_IO_REPORT_SIZE);
report24.ReportID = 0;
report24.Value = 0x55AA; //0x55 to P1-0xAA to P0
rc32=IowKitWrite(ioHandle_1,IOW_PIPE_IO_PINS,(cha
r*)&report24,IOWKIT24_IO_REPORT_SIZE);
// Display number of bytes written (rc32)
RCtext.Format(_T("%X Bytes Written"), rc32);
m_DisplayWindow.InsertString(nextline++, RCtext);
// Read and display states of all 16 IO-Warrior
24 GPIO pins
IowKitReadImmediate(ioHandle_1,&BitsRead);
BITStext.Format(_T("P0 = 0x%X"), (BitsRead &
0x000000FF));
m_DisplayWindow.InsertString(nextline++,
BITStext);
BITStext.Format(_T("P1 = 0x%X"), ((BitsRead &
0x0000FF00)>> 8));
m_DisplayWindow.InsertString(nextline++,
BITStext);
```

The pair of *#define* statements can be found in the *iowkit.h* file, which is part of the IO-Warrior SDK. To be safe, I added the *IowKitSetWriteTimeout* API call to force a timeout of two seconds if the *IowKitWrite* function failed. That's not likely, but the insurance is there to keep the program from locking up on a GPIO write failure. The *memset* function simply clears the *report24* data structure to zero. Adding the GPIO read-write-display code to our existing serial number code results in the display shown in **Screenshot 5**. We've got the hang of putting human readable things into the dialog box display window.

Let's get just as good with the LCD. We must use the eight-byte special report ID data structure to communicate with the LCD's HD44780:

```
typedef struct _IOWKIT_SPECIAL_REPORT
 {
  UCHAR ReportID;
  UCHAR Bytes[7];
 }
  IOWKIT_SPECIAL_REPORT,
*PIOWKIT_SPECIAL_REPORT;
```

You already know how to assemble and transmit a report. So, the language within the enable LCD API special function call should not be foreign:

```
IOWKIT_SPECIAL_REPORT reportLCD;
// These are found in the iowkit.h file
#define IOWKIT_SPECIAL_REPORT_SIZE sizeof
(IOWKIT_SPECIAL_REPORT)
#define IOW_PIPE_SPECIAL_MODE 1

// Enable LCD
memset(&reportLCD, 0,
IOWKIT_SPECIAL_REPORT_SIZE);
reportLCD.ReportID = 0x04;  //ReportID for
                            //LCD-Mode
reportLCD.Bytes[0] = 0x01; // enable LCD Special
                          // Function
IowKitWrite(ioHandle_1, IOW_PIPE_SPECIAL_MODE,
(char *) &reportLCD,
IOWKIT_SPECIAL_REPORT_SIZE);
```

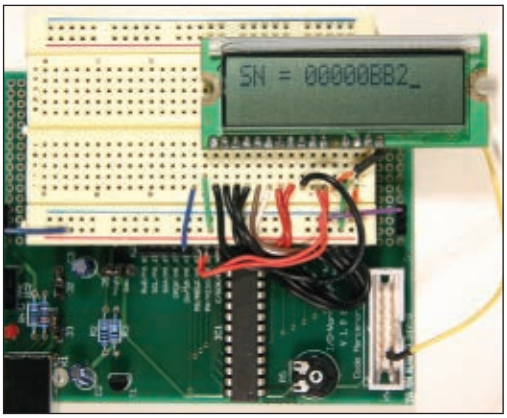
Upon receiving the enable LCD report, the IO-Warrior 24 will initialize the attached LCD and display the cursor at the home position. If the LCD has a backlight, the backlight is illuminated at this time, as well as via the active-low *ON* GPIO pin (P0.4). The LCD is now active and configurable. Notice that we used a *ReportID* value of 0x04 to enable the LCD and we'll use a *ReportID* value of 0x05 to configure the display:

```
// Configure LCD
// Reference page 43 of HD44780 data sheet
memset(&reportLCD, 0,
IOWKIT_SPECIAL_REPORT_SIZE);
reportLCD.ReportID = 0x05; //ReportID for
                           //LCD-Mode "write"
reportLCD.Bytes[0] = 0x04; //R/S mode=0 / Send
                           //bytes
reportLCD.Bytes[1] = 0x38; //function "8-Bit
                           //mode"
reportLCD.Bytes[2] = 0x0E; //function "display
                           //on-no blink"
reportLCD.Bytes[3] = 0x06; //function "entry
                           //mode set"
reportLCD.Bytes[4] = 0x01; // function "CLEAR
                           //DISPLAY"
IowKitWrite(ioHandle_1, IOW_PIPE_SPECIAL_MODE,
(char *) &reportLCD,
IOWKIT_SPECIAL_REPORT_SIZE);
```

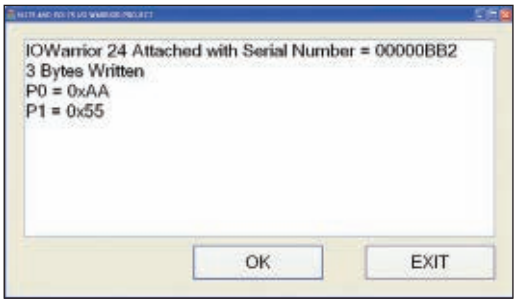
If you go to the HD44780 datasheet page I reference in the code's comments, you'll be able to easily pick out and identify the bit patterns used in the *reportLCD* bytes. With the LCD initialized and configured, we're ready to send it a message to display:

```
WCHAR SerialNumber[10];

// Send Serial Number to LCD
memset(&reportLCD, 0,
IOWKIT_SPECIAL_REPORT_SIZE);
reportLCD.ReportID = 0x05; //ReportID for
                           //LCD-Mode
```



■ PHOTO 3. What we have here is a single-IC USB interface for any HD44780-compatible LCD.



■ SCREENSHOT 5. Note that I changed the CANCEL button to an EXIT button. You can see what I did to support that in the Visual C++ source code. The neat thing about Visual C++ is that in Debug mode you can see the strings and values before they are officially displayed in the dialog box. As you can see here, things worked as designed.

When addressing an LCD, the report ID and LCD command byte must always be sent. So, the maximum number of data bytes we can send to the LCD in a single report is six. That works out well with the "SN = " character string. However, the IO-Warrior 24 serial number is eight bytes long. No problem. Since we have the IO-Warrior 24 serial number coralled in an array, we can send the LCD data one byte at a time. Just as we did in **Photo 3**.

```
reportLCD.Bytes[0] = 0x85; //write 5 bytes to
                           //LCD command register
reportLCD.Bytes[1] = 'S'; //send character to
                          //LCD
reportLCD.Bytes[2] = 'N'; //send character to
                          //LCD
reportLCD.Bytes[3] = ' '; //send character to
                          //LCD
reportLCD.Bytes[4] = '='; //send character to
                          //LCD
reportLCD.Bytes[5] =  ''; //send character to
                          //LCD
IowKitWrite(ioHandle_1, IOW_PIPE_SPECIAL_MODE,
(char *) &reportLCD,
IOWKIT_SPECIAL_REPORT_SIZE);
memset(&reportLCD, 0,
IOWKIT_SPECIAL_REPORT_SIZE);
for(i=0;i<8;++i)
{
 reportLCD.ReportID = 0x05; //ReportID for
                            //LCD-Mode
 reportLCD.Bytes[0] = 0x81; //write 1 byte to
                          //LCD command register
 reportLCD.Bytes[1] = (char) SerialNumber[i];
                           //send character to
                           //LCD
 IowKitWrite(ioHandle_1, IOW_PIPE_SPECIAL_MODE,
(char *) &reportLCD,
IOWKIT_SPECIAL_REPORT_SIZE);
}
```

SOLDIER ON

I've supplied the Visual C++ source code you need to duplicate the IO-Warrior 24 efforts you've just read about in the download package available at **www.nutsvolts.com**. If Visual C++ is not your strength, the IO-Warrior SDK also includes sample code for Java, Delphi, Visual Basic, and C. There's also IO-Warrior support for Linux and MAC. No matter which programming language or operating system platform you choose to use, you can add the IO-Warrior to your Design Cycle. **NV**

SOURCES

IO-Warrior 24 Starter Kit *Saelig* **www.saelig.com**	Visual Studio 2008 *Microsoft* **www.microsoft.com**

■ *Fred Eady can be contacted via email at fred@edtp.com.*

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Output: 12Vdc 1.5A.
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BY CHUCK HELLEBUYCK

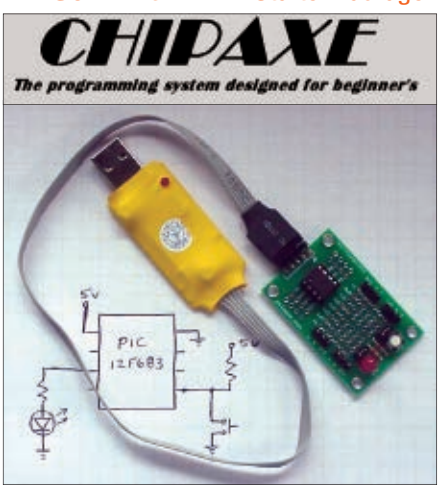
EIGHT-PIN PROJECTS

I often receive great article suggestions and sometimes I receive pre-released products for review. I recently received a development setup that I found quite interesting, as it's targeted at my favorite audience—the beginner market. It is called the CHIPAXE system (see Figure 1) and it is designed to be an open source-style development tool initially based on the PICBASIC PRO™ compiler from microEngineering Labs. However, it can also be used with Assembly or C programming languages. Because the system is open source, you don't need to purchase a pre-programmed chip. It comes with a blank, eight-pin PIC12F683 eight-bit microcontroller from Microchip Technology. You can purchase this part just about anywhere, including from many of the advertisers in this magazine.

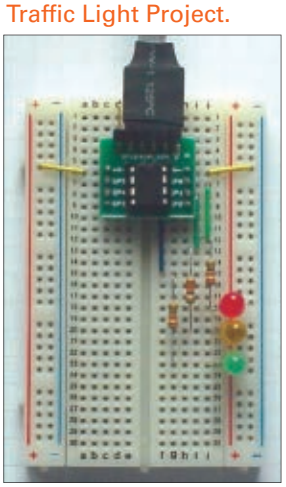
The board is not dependent upon a custom bootloader, as some open source systems require. The package relies on an interesting programmer/cable which is actually a clone of the Microchip PICkit™ 2 programmer; however, this isn't the only option. The board can also be used with an actual PICkit 2 or the latest PICkit 3 programmer, if you prefer. I'll update you on those programmers a little later. A breadboard version of the CHIPAXE development board is also available, and it gave me a great setup to revisit how to program an eight-pin microcontroller. Many beginners find it more comfortable to start with a smaller-sized and less intimidating microcontroller.

The CHIPAXE system uses In-Circuit Serial Programming™ technology to program the chip and the board is powered from the programmer connection, so you don't need an external power connection. **Figure 2** shows the breadboard module wired up to LEDs. I wanted to create a few simple projects for anyone just starting out with the PIC12F683. I initially created a traffic light project using the CHIPAXE board and the sample version of PICBASIC PRO. This is a great project to show a kid since a traffic light is something they immediately understand and it may get them interested in what you can do with a microcontroller. I will show you the traffic light project and then a few other sample projects for this small eight-pin chip.

■ FIGURE 1. CHIPAXE Starter Package.



■ FIGURE 2. Final LED Traffic Light Project.



LED TRAFFIC LIGHT

This project reproduces a traffic light with red, yellow, and green LEDs. The timing of each LED is separately controlled which allows you to control how long each color is lit. The project also shows how to control multiple LEDs from one microcontroller. The completed project is shown in **Figure 2**.

HARDWARE

This breadboard is available from All Electronics (**www.allelectronics.com**). It has letters designating columns and numbers indicating rows. This helps me in explaining the connections for those just getting started with building electronics. The connection table for this project is shown next and the schematic is shown in **Figure 3**.

Connection Table

```
Micro          - Pin 1 at C6
Vdd Jumper     - a6 to +rail
Vss Jumper     - j6 to -rail
Green Jumper   - j7 to j12
330 ohm        - i12 to i18
Red LED        - Anode j18, Cathode -rail
Green Jumper   - i8 to i13
330 ohm        - i13 to i20
Yellow LED     - Anode j20, Cathode -rail
Blue Jumper    - f9 to f15
330 ohm        - g15 to g23
Green LED      - Anode j23, Cathode -rail
```

SOFTWARE

The software is quite simple because it uses some of the commands that make PICBASIC PRO easier to use than many other compilers. The first steps involve making the I/O digital. When the PIC12F683 is first powered up, the I/O defaults to analog mode. The I/O pins share a connection to both analog and digital features. The ANSEL = 0 command line sets all the I/O pins to digital mode.

```
ANSEL = 0   ' Set I/O to digital
```

The PIC12F683 also has an internal comparator which can be shut down with the CMCON0 = 7 line.

```
CMCON0 = 7 ' Comparator off
```

The main program loop begins with the label "main" followed by a colon. We will use this as a marker in a future GOTO command line.

```
main:
```

The I/O pins on the PIC12F683 are referred to as general-purpose I/O pins, or GPIO. The internal register that controls these pins individually is also called the GPIO register. These can be controlled by writing to the GPIO register directly, but we would also need to set up the TRISIO register inside the PIC12F683. The TRISIO determines whether the pins are digital-input or digital-output pins. Both of these are automatically controlled with the HIGH or LOW command.

The GPIO.0 is the nickname for the GP0 pin. The software uses the HIGH command to place a high signal on that pin. This will light the LED. The PICBASIC PRO compiler doesn't care if you use capitals or lower case letters for the commands. The red LED is lit first for two seconds and then shut off to create the stoplight portion of the traffic light. All actions are on the GP0 pin which is connected to the red LED.

```
HIGH GPIO.0     'Light Red LED
PAUSE 2000      'Delay 2 second
LOW GPIO.0      'Red LED off
```

The green LED is next and it is lit for the same amount of time as the red LED. The green LED is connected to the GP2 pin.

```
HIGH GPIO.2     'Green LED on
PAUSE 2000      'Delay 2 second
LOW GPIO.2      'Green LED off
```

Finally, the yellow LED is lit for a short time and then it turns off. The yellow is connected to the GP1 pin.

```
HIGH GPIO.1     'Yellow LED on
PAUSE 1000      'Delay 1 second
LOW GPIO.1      'Yellow LED off
```

The final step is to loop back to the main label to light the red LED and repeat the process.

```
GOTO main       'Loop Back to Red LED
```

NEXT STEPS

The logical next step is to change the delays to make the traffic light fit your application. If you wanted to make a real traffic light from a project like this, then the delays need to be a lot longer. There are three unused I/O pins, so adding three more LEDs for another crossing lane of traffic would be an option. Unfortunately, the GP3 pin is an input-only pin and cannot drive an LED. This is an example of where a larger-pin microcontroller might be a better choice.

SENSING A SWITCH

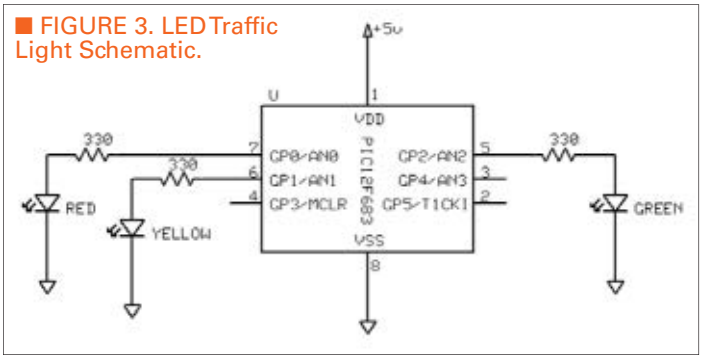
Many projects require some kind of human interface to control the operation. A momentary pushbutton switch is a very common way to do this. It can start and stop the operation, or speed up or slow down what the microcontroller is controlling. In order to do this, however, the software needs to recognize that a switch was pressed. This project shows a simple method of sensing a momentary pushbutton switch.

The software must monitor the switch continuously as part of the main loop of code, and then respond. In this project, the software lights an LED until the switch is pressed, at which point the LED shuts off. As long as the switch is pressed, the LED will stay off. As soon as the switch is released, the LED will once again light up. The completed project is shown in **Figure 4**.

HARDWARE

The hardware uses the same red LED connections as the traffic light project. The addition of the switch is shown in the schematic in **Figure 5**. The switch is wired as a low-side switch which means the circuit has a pull-up

■ FIGURE 3. LED Traffic Light Schematic.



resistor to five volts so the input to the micro is high when the switch is not pressed and low when the switch is pressed. If the parts were reversed where the switch was connected to five volts and the resistor to ground, then it would be a high-side switch.

The software will test the input pin GP4 to see if it changes to low, indicating the switch has been pressed. The GP4 pin will be configured as an input pin in the software, so all we need from the hardware is a known idle state which is determined by the pull-up resistor. The connection table for the breadboard is as follows:

Connection Table

```
Micro          - Pin 1 at C6
Yellow Jumper  - a6 to +rail
Yellow Jumper  - j6 to -rail
Green Jumper   - j7 to j12
330 ohm        - i12 to i18
Red LED        - Anode j18, Cathode -rail
Yellow Jumper  - j22 to -rail
Orange Jumper  - f22 to e22
Orange Jumper  - b22 to b19
White Jumper   - b8 to b17
10k ohm        - a17 to +rail
Switch         - d17 to d19
```

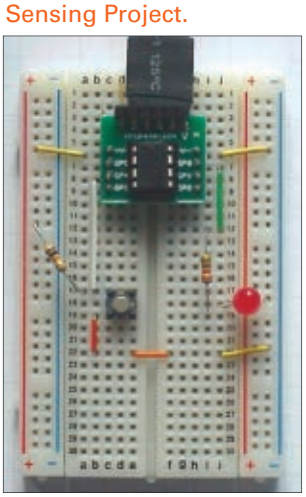
SOFTWARE

The software starts with the same I/O setup, but now adds a new line to make the GP4 pin an input for the switch. This command acts on the internal TRISIO register of the PIC12F683. That register determines whether the I/O pin is an input or output. Each bit of that eight-bit register represents a pin. A 1 in the GP4 slot makes it an input and a 0 makes it an output. The INPUT GPIO 4 command line sets the GP4 pin to a 1 for input mode.

```
ANSEL = 0   ' Set I/O to digital
CMCON0 = 7 ' Comparator off
INPUT GPIO.4
```

The main label starts us off again, followed by an IF-THEN-ELSE command from the PICBASIC PRO compiler. This command will test the equation after the IF, to determine whether it is true or false. If the equation is true, then the command following the IF command line will be executed. If it is not true, then the command following the ELSE line will be executed. In this case, if the GP4 pin is high — meaning the switch is not pressed — then the red LED is lit. If instead the GP4 pin is low — meaning the switch is pressed — then the LED is shut off.

■ FIGURE 4. Final Switch Sensing Project.



```
main:
If GPIO.4 = 1 then
HIGH GPIO.0     'Light Red LED
Else
LOW GPIO.0      'Red LED off
ENDIF
```

A GOTO statement completes the loop and sends control back to the main label, so the switch can be tested again.

```
GOTO main       'Loop Back to Red LED
```

NEXT STEPS

You could add the extra LEDs from the traffic light project and change to red, yellow, or green with the push of a button. You could also create a speech timer where the green indicates time is okay, yellow means time is running out, and red means time is up. The switch starts the process. You could also just reverse the logic and have the LED light when the switch is pressed. This is a very simple change that I'll let you figure out.

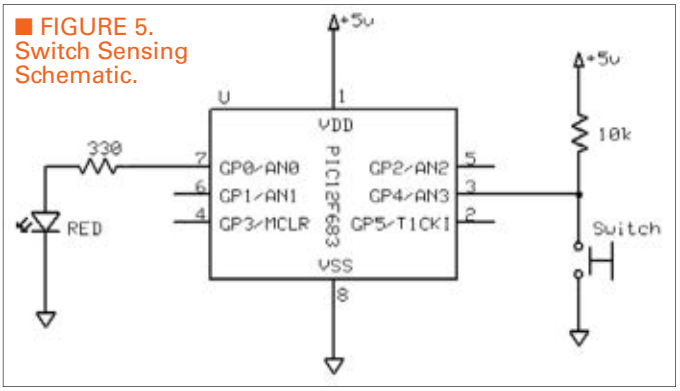
The thing to remember is that the switch represents several different options. A Sharp GP2D15 obstacle-detection sensor can easily replace the switch for robotic applications. A magnetic reed switch could replace the switch to create a simple alarm system. Any device that has a simple open-collector output and a digital on/off output state can replace the switch.

SENSING LIGHT

The PIC12F683 has a built-in analog-to-digital converter (ADC), so I'll use that to read a cadmium sulfide (CdS) cell. A CdS cell or photoresistor is a resistor whose resistance decreases with increased light exposure. It can also be referred to as a light-dependent resistor or photoconductor. You can get a pack of them from RadioShack under part number 276-1657.

The PICBASIC PRO compiler has an ADCIN command to make this another easy task to complete. I used an eight-bit resolution result that worked perfectly. As the light changes, I have the ADC value tested. If the result is a high value (high resistance), then it is dark out and the LED lights up. **Figure 6** shows the final setup.

■ FIGURE 5. Switch Sensing Schematic.



HARDWARE

The schematic is very similar to the switch schematic, except the switch is replaced by the CdS cell. The pull-up resistor is also lower, but it could easily

be replaced by a potentiometer so you have some sensitivity adjustment. The connection table is shown below, along with the schematic.

Connection Table

```
Micro          Pin 1 at C6
Yellow Jumper - a6 to +rail
Yellow Jumper - j6 to -rail
Green Jumper  - j7 to j12
330 ohm       - i12 to i18
Read LED      - Anode j18, Cathode -rail
Yellow Jumper - j22 to -rail
Orange Jumper - f22 to e22
Yellow Jumper - b22 to b18
White Jumper  - b8 to b17
1k ohm        - a17 to +rail
CdS Cell      - d17 to d18
```

SOFTWARE

The start of the software requires a different setup since we will be using the GP4 pin as an analog input. Using the binary designation in the PICBASIC PRO compiler allows me to easily set the AN4 bit of the ANSEL register making it analog, while the rest of the I/O pins are zero or set to digital mode.

```
ANSEL = %00001000   ' Set I/O to digital except
                    ' AN3/GP4 is Analog
```

Once again, the comparators are shut down.

```
CMCON0 = 7 ' Comparator off
```

The state of GP4 has to be set to input mode using the TRISIO register which can also set the remaining I/O pins to outputs. GP3 is always an input.

```
TRISIO = %00011000 ' GP4 input, GP2 thru GP0
                   ' outputs
```

The ADCIN command requires some setup parameters to be established such as ADC resolution, ADC clock source, and sampling time. These are easily done with DEFINE statements.

```
' Define ADCIN parameters
Define ADC_BITS       8       ' Set number of bits
                              ' in result
Define ADC_CLOCK      3       ' Set clock source
                              ' (3=rc)
Define ADC_SAMPLEUS   50      ' Set sampling time
                              ' in uS
```

A variable is established to store the ADCIN result.

```
adval  var    byte       ' Create adval variable
                          ' to store result
```

The main label establishes the main loop, followed by the ADCIN command line where the CdS cell is read.

```
main:
ADCIN 3, adval        ' Read channel AN3 to adval
```

After the value of the CdS cell is stored in the adval variable, it is compared to the value 150. If it is less than 150, then the LED is off. If the value is greater than 150, then it is dark and the LED is lit using the HIGH command.

```
If adval > 150 then  'Light LED if in the dark
High GPIO.0          'Light all LEDs
ELSE
LOW GPIO.0
ENDIF
```

Another GOTO statement completes the main loop.

```
goto main           'Loop Back to test
                    'potentiometer
```

NEXT STEPS

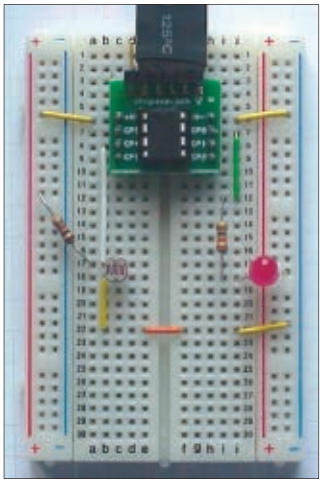
Changing the threshold value from 150 to something higher or lower will determine how dark it has to be to light the LED. The limit is 0 to 255 since we used an eight-bit result. As with the switch project, other sensors can replace the light sensor. For example, a thermistor could replace the light sensor to measure temperature. A potentiometer could be used to create a manual interface. If you remove the pull-up resistor, then a Sharp GP2D12 object-detection sensor that produces a variable output voltage can be directly read by the analog pin for more accurate robotic obstacle detection.

I would like to create more projects using this great eight-pin setup, but I'm running out of time and space, as I wanted to cover some news that has happened since my last article. Give this little eight-pin part a try in your own setup and see what you can come up with.

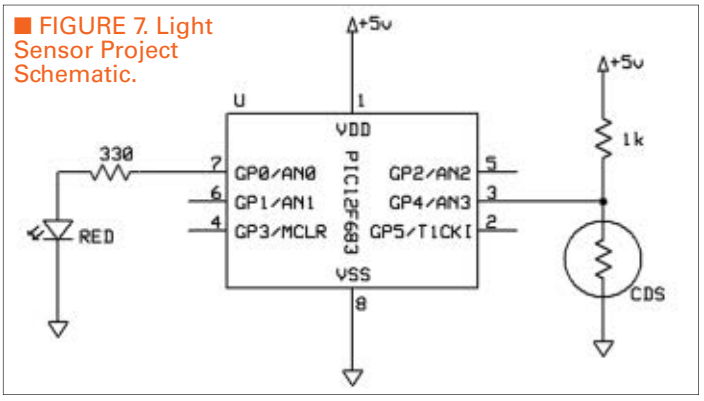
PICBASIC PRO COMPILER

In a previous article, I mentioned that you needed to use Microchip's MPLAB® IDE version 8.15 or earlier with microEngineering Labs PICBASIC PRO compiler. This is no longer the case because microEngineering Labs recently released a new version of the compiler that works with the latest version of the MPLAB IDE. The setup instructions are slightly different from the previous method of getting the PICBASIC PRO compiler to work within the MPLAB IDE. Full details are available at **http://melabs.com/support/mplab.htm**.

Along with this update comes expanded chip support in the sample version of the PICBASIC PRO compiler. What is really great is that microEngineering Labs added the PIC16F88X parts to the supported microcontroller list. This allows you to use eight- to 40-pin parts without the need for external MCLR pull-up or crystals/oscillators in order to test the compiler. After you use this compiler for a while, you'll find the full-priced version of it



■ FIGURE 6. Final Light Sensor Project.



■ FIGURE 7. Light Sensor Project Schematic.

to be well worth the investment.

MICROCHIP'S PIC16F1 MICROCONTROLLER FAMILY

Microchip recently released a new series of PIC16F parts called the PIC16F193X family. Featuring the company's enhanced mid-range eight-bit core, these parts offer many more features than the previous PIC16F family such as higher program memory (up to 32K), a faster internal oscillator (16 MHz), and a lot more RAM (up to 4K). This allows these new microcontrollers to offer more peripherals such as additional timers and PWM channels. More communication channels are expected to be available on future parts. These parts will be easily identified by the four-digit number after the letter F, starting with a 1. More details are available at **www.microchip.com/enhanced**.

MICROCHIP DEVELOPMENT TOOLS

Microchip recently released the PICkit™ 3 Debug Express and MPLAB ICD 3 tools which offer much higher programming speeds and better debugging capabilities than previous versions. There is also a higher-end MPLAB REAL ICE™ tool. As new products are released, you will need the PICkit 3 or MPLAB ICD 3, as the PICkit 2 and MPLAB ICD 2 will not support PIC16F193X parts.

CONCLUSION

I hope you enjoy the topics I've covered, but feel free to let me know your thoughts either way by emailing me at chuck@elproducts.com. I've also started a free newsletter at **www.elproducts.com**, so be sure to sign up for it. As this is my last column before the holidays, be safe and I hope you have a happy one. **NV**

Complete code listings are available at **www.nutsvolts.com**.

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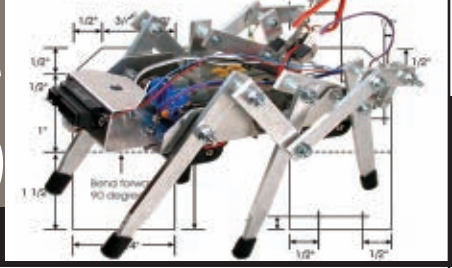


■ BY VERN GRANER

TRY, TRY AGAIN

"I have not failed. I've just found 10,000 ways that won't work."
— Thomas Alva Edison

IF AT FIRST YOU DON'T SUCCEED ... DON'T TAKE UP SKYDIVING! Yes, I know "try again" has to be one of the oldest work-related clichés. However, many times if you turn over a dusty old cliché, you find a kernel of truth nestled under it. In this particular case, that kernel is persistence pays. My direct experience has taught me that nothing is ever as easy as it looks. Experience has also taught me that when things get complicated, a methodical and consistent approach is typically the best course of action. Problems seem to be a natural part of development, so encountering them should come as no surprise and you certainly shouldn't let possible (or actual) problems stop you from building. If you've started building, it means you have something to work on, something to improve.

YOU MAY ASK YOURSELF HOW DID THIS GET HERE?

Sometimes, when we see a finished project, we can only picture it in its finished form. It seems as if it sprung fully-formed from the mind of the creator directly into being. In my career, this has never been the case. I have to design, then prototype, then test (lather, rinse, repeat!). I evaluate what works in the prototype and what doesn't. I then revisit the design and make changes. Sometimes the creation and testing of a prototype reveals better ways that the idea might be implemented. Other times, things just don't work no matter how the diagrams, datasheets, and experts insist it should!

In this month's article, I'm going to give you a behind the scenes tour of the more notable projects I've been involved with and the hidden problems we encountered along the way. I hope to document how these projects would never have come to fruition if not for many people's tenacity in overcoming problems and improvising solutions. I'll begin with one of the single biggest projects upon which I've worked, The Ponginator.

THE PONGINATOR MK-I

Back in the December '07 issue of *Nuts & Volts*, I introduced The Ponginator MK-I, a 20 foot tall smoke-spewing, light-flashing, music-playing, siren-wailing robot with quad-barrel pneumatic ping pong ball cannons. It was the centerpiece of The Robot Group's presentation for the very first Maker Faire in Austin, TX. In the days leading up to that event, we had struggled with various issues including multiple prototype ping pong ball propulsion systems, leaky air lines, and a stripped cannon pan motor.

In spite of those challenges, the Ponginator was assembled on-site the day before Maker Faire opened and performed much more smoothly than anyone could have imagined. The Ponginator was an unmitigated success. It operated amazingly well for something that, in only 30 days, went from a pencil sketch to towering over the arena floor. This was just the beginning of the Ponginator's career, and more problems would present themselves as we tried to adapt it to changing requirements.

THE PONGINATOR MK-II

When it came time for the next event, we figured it would be easy to just bring out the Ponginator and set him right back up. Unfortunately, when we visited the proposed site, we discovered that we would be in an outdoor area. In the original design, we hadn't considered the challenges an outdoor venue would pose. For starters, the MK-I used a two-story construction scaffolding as a frame and was wrapped with a tarp. There was concern over how we would keep the whole thing from toppling over if the wind picked up. To be safe, we needed to redesign the frame and find something fairly substantial to use as an anchor. Time to put on the thinking caps!

■ FIGURE 1. The Ponginator MK-II frame test-fit on the van.

■ FIGURE 2. Testing the pneumatic cannons on the new frame.

■ FIGURE 3. Test-fitting the Ponginator MK-III on the new bucket lift.

As we would need transportation to and from the event anyway, we decided my full-sized Ford van could act as both the frame and the anchor. We fabricated a new PVC-pipe frame from scratch that mounted to the top of the van (**Figure 1**). We then mounted the crossbar and hung the pneumatic cannons to make sure they could still move properly (**Figure 2**). Though we still had the original Ponginator "skin," we discovered we would need to make a new one as the old one had both a hole cut for a video display (not practical in the MK-II design) and was also about five feet too big for the new frame.

In spite of having to do a thorough retrofit, on the day of the show we managed to assemble the Ponginator for the first time in downtown Austin without any major issues. The MK-II was a smash hit, thrilling crowds with his siren wail and catchy dance tunes. This event also saw the unveiling of the Ping Pong Printer, which didn't exactly go as planned either (are you seeing a trend here?), but we'll touch on that in a bit.

THE PONGINATOR MK-III

After this last show was done, the Ponginator again went into a storage shed until the next big event: Maker Faire Austin 2008. By the time this event rolled around, I had sold the van so we no longer had our "base." However, as luck would have it, my brother Walt had recently purchased a 30 foot hydraulic bucket-lift for his construction company and was happy to let us use it.

We brought all the parts out of storage and mounted them on the lift bucket (**Figure 3**). After fabricating new brackets, adding shelves for the speakers, and mounting the air compressor, we towed the lift out from under the trees and extended it to its full height of 30 feet (**Figure 4**). It looked AMAZING!

When it was time for the event, we trucked the lift out to the Maker Faire show but on the way, one of the gear motors that positions the cannons stripped due to stresses on the mounts created by the movement of the trailer while being towed. We had to quickly swap motors out on the show floor when we arrived. As before, we put all the new electronics and pneumatics together for the first time right there at the show. Once again, the Ponginator lived up to its reputation, not only earning us another Maker Faire "Editors Choice" Blue Ribbon, but also being immortalized on a MAKE poster, and then to headlining on the **GeeksAreSexy.com** website, among others.

This is a perfect example of how a project can still enjoy continuous success in spite of changing circumstances if the people involved persist. Which brings us to the Ping Pong Printer — a rather problem-plagued device that grew out of the Ponginator project.

■ FIGURE 4. The Ponginator MK-III towering 30 feet up in the air.

■ FIGURE 5. The Ping Pong Printer with plastic water jug hopper.

PING PONG PRINTER PROBLEMS

The Ping Pong Printer was featured in my February '08 column and was basically a solution to an economic problem. Turns out the Ponginator uses up lots of ping pong balls when it's in operation. As we wanted the ping pong balls to be souvenirs (and not just trash), we had some custom-printed ping pong balls created for the MK-I. Though these worked fine, they turned out to be very expensive (on the order of about .60 cents each!).

The Ping Pong Printer was designed to allow us to create our own "ordnance" for the Ponginator. It was built by a team of folks from The Robot Group including myself (programming), Rick Abbott (metal/plastic fabrication), and Marvin Niebuhr (carpentry).

THAT JAMMED JUG!

When I first designed the Ping Pong Printer, a five

DER MAGNETFELDER DETEKTOR: DAS BLINKENBOARD!

by Nyssa Hughes and James Delaney

As promised, we continue our series on new uses for Das BlinkenBoard. This month, we feature an amazing and simple mod from the "UnfocusedBrains" of James Delaney and Nyssa Hughes. By adding a Hall-effect sensor and a 2K resistor, they have turned the mild mannered Das BlinkenBoard into a magnetic field detector! It uses the LEDs as a bar-graph to display both relative field strength and magnetic pole polarity of magnets held near the sensor. In their own words, here's how James and Nyssa did it:

Because our home laboratory was without a way to measure relative magnetic field strength, we figured it was time to build a simple Gauss meter. Turns out it was really easy! We started by reading a few datasheets, then settling on a Honeywell SS49 analog position sensor (which is a type of Hall-effect sensor). By connecting the part to a voltmeter, we were able to detect magnetic fields from various magnets and read voltage levels from the SS49 to determine the field's relative strength.

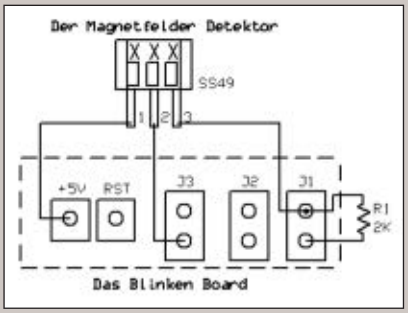


FIGURE A. Schematic showing how to connect the SS49 to the Das BlinkenBoard.

Not wanting to stop there, we decided to build a steam-punk inspired "prop" version of a magnet detector. Fortunately, we had a Das BlinkenBoard on hand, so James built a cable to connect the SS49 to the BlinkenBoard (**FIGURE A**). When it came time to program the microprocessor on the BlinkenBoard, James ran into some challenges when he discovered that the datasheet for the SS49 sensor was very confusing. Our friend Paul Atkinson came to the rescue (he always seems to be helping us out!). He read the datasheet and told James that a 2K ohm "load" resistor would be needed to make the SS49 work according to specifications. We simply added the resistor and Der Magnetfelder Detektor (DMD) was born.

Now that we had the unit working, the final step was to build a snazzy case in which to place the electronics. Since this is a prop version of a magnet detector, we decided to build it as a piece of foam covered in an ink jet color-printed "skin." Nyssa cut two pieces of foam into a 3" x 5" rectangle to make the case deep enough. She then cut a BlinkenBoard-sized hole in both pieces. As James designed the custom graphics for the skin, Nyssa glued the two pieces of foam together. The graphic was printed, sprayed with a layer of protective acrylic, and cut out (**FIGURE B**). The SS49 sensor was taped to the back of the paper, with the sensor facing up (**FIGURE C**).

FIGURE B. The printed cover for "Der Magnetfelder Detektor."

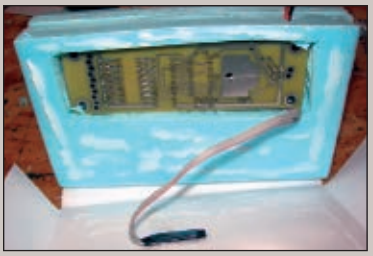


FIGURE C. The Das BlinkenBoard mounted in the foam enclosure.

Next, Nyssa stuffed the BlinkenBoard into the foam frame with the circuit. This allowed room to run all the cables for the LEDs in the space beneath the circuit board. She pushed the SS49 sensor cable into a gap between the circuit board and the foam, and plugged it into the circuit board.

Then, it was time to glue the graphic to the foam and drill the holes. The graphic was glued only to the face of the DMD. Using a drill press made quick work of the eight holes. With the holes drilled, Nyssa was about to stuff the LEDs through, but first needed to figure out which LED was "South." The first LED in the series is the one that goes into the South hole. The eighth LED is the one that goes into the North hole.

The LEDs were poked through the holes in sequential order. After some adjustments, the LED cables got organized, plugged in, and taped down. Nyssa poked a hole into the side of the paper-covered foam through which to run the power. She glued the sides of the DMD and added some foam feet (**FIGURE D**).

FIGURE D. The Cables and foam feet on the bottom of the foam case.

Now it was time to play with magnets! By holding a magnet to the DMD's printed button, you can determine the general strength (i.e., one LED versus eight LEDs) and the alignment of the magnet. If the bar graph starts on the North side, you are holding the North pole of the magnet to the sensor and vice-versa.

Please let us know if you configure your Das BlinkenBoard as Der Magnetfelder Detektor. Also, please let us know if you do something fun and interesting with your own Das BlinkenBoard. You can send your emails to vern@txis.com.

DER MAGNETFELDER DETEKTOR RESOURCES

Honeywell SS49 Sensor from Mouser
www.mouser.com/ProductDetail/Honeywell/SS49/?qs=sGAEpiMZZMvhQj7WZhFIALYB7HV1zJHHKzTnhQJMM%252bM%3d

James Delaney's Blog
www.unfocusedbrain.com/

Nyssa Hughes' Blog
www.nyssa.com/

http://en.wikipedia.org/wiki/Hall_effect

Das BlinkenBoard Web Page
www.DasBlinkenBoard.com

Source Code
www.nutsvolts.com/index.php?/magazine/downloads/

gallon water jug was sitting on a cooler by the kitchen table where I was sketching. I envisioned the jug filled with ping pong balls (like a gumball machine) and a motor "stirring" the balls to make sure they flowed down the bottle neck to the printer. I figured that would make a simple and easy "hopper" to feed blank ping pong balls into the printer. It looked good on paper and once built, it worked fine with a handful of ping pong balls. However, once we filled up the entire water jug, the first problem appeared.

At the beginning of the print cycle, the stirring rod system would activate as designed but, instead of the balls mixing around, they would "stack up" and stick to each other. This would cause the stirring rods to bind and resulted in the motor attempting to back spin, twisting and eventually tearing up the motor wires.

Upon closer inspection, we discovered that – unlike

the smooth-surfaced gumballs I used for inspiration — ping pong balls are created with an abrasive surface so they can get traction on the ping pong paddle and table. Unfortunately, this extra friction caused the balls to stick together in the jug, jamming the stirring rods. The only way to un-jam the system was to fill the jug to less than 10% of its capacity (**Figure 5**) which really defeated the purpose of the jug itself. This was about the time we noticed a second problem with the design (insert deep sigh here).

It seems that rotating the ping pong balls inside the plastic jug caused them to build up a static electric charge! This would cause the ping pong balls to cling tenaciously to the sides of the jug making the stacking/jamming problem worse and, of course, stopping them from dropping down through the indexer to the print pedestal (insert second deep sigh here).

DOES SIZE REALLY MATTER?

As we were pondering what to do about the sticking, stacking, and static problems, our bulk-order of blank white ping pong balls arrived. We were excited by this good news and dumped a bunch of these new balls right into the jug in the hopes they would be smoother and might alleviate the jamming. No such luck. These new balls jammed the exact same way. We weren't getting off that easy! We then dumped out the jug and put just a handful of these new balls back in for testing. We activated the printer and the first ball dropped right onto the pedestal for printing as expected (**Figure 6**). When the printing was done, the "indexer" (**Figure 7**) started to cycle, then jammed without releasing the second ball. We removed the jammed ball and tried again. Same thing, the indexer was stuck and would not release the second ball. A lot of head scratching later, we discovered the root cause of the indexer jams.

It turns out that there are two "types" of ping pong balls. The first type is "professional" 40 mm balls and the second type are "hobby" ping pong balls that are 38 mm. We had started buying the test balls from local sporting goods stores and they were of the 40 mm variety. Subsequently, when Rick had machined the parts, he had used 40 mm as his reference size. When the indexer would try to cycle, it would bump into the bottom edge of the next ball in line to be printed and stall without completing the cycle. Rick took the printer back to his shop and reworked the indexer push-bars to accommodate the 38 mm balls. Once this was done, the bulk purchased balls worked fine but we still had the existing multiple water jug issues to contend with.

CHANGE TO CHAIN DRIVE

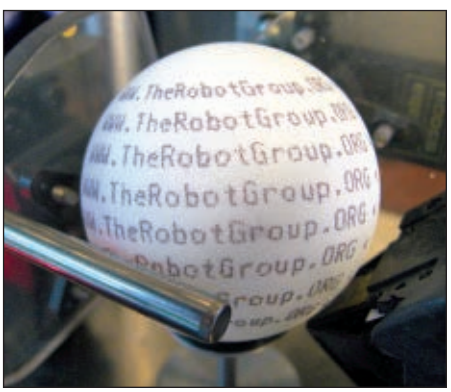
When Rick had the Ping Pong Printer at his shop to re-engineer it for the 38 mm balls, he also took time to look at the plastic jug and try to come up with a new way to serve ping pong balls to the printer. After a few different designs were tossed around, he settled on an ingenious chain drive belt-scoop feed system which he then fabricated from aluminum, polycarbonate plastic, and steel (**Figure 8**). This new system would ferry the balls up to the top of the Ping Pong Printer, then let them roll down a ramp and drop into the indexer. This new design solved both the static problem as well as the stacking/sticking problem, but at the cost of a bit more software complexity. I had to figure out how to sense when to run the motor and — more importantly — when to stop it. To deal with this, I added an IR beam-break detector to determine when a ball was rolling down the ramp. A bit of coding had the software turning on the belt drive motor, waiting for a ball to occlude the sensor, then switching the motor off. With these modifications, the new and improved Ping Pong Printer was all ready to go.

Since then, we've used the Ping Pong Printer not just to make "ammo" for the Ponginator, but to create souvenirs for many events such as movie premieres (**Figure 9**), South By South West Austin, and multiple Dorkbot events. Around this time, the video of the Ping Pong Printer in action (with its original water jug) was picked up by a number of tech-blogs and ended up with over 30,000 views (and counting)!

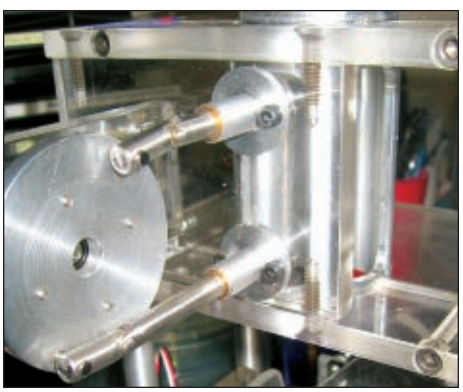
NOTHING EVER GOES AS PLANNED

The point I'm trying to make with all this detail on what went wrong and how it was overcome is that we have yet to encounter a problem that could not be bested with the proper amount of perseverance. As the above examples show, given the right motivation and the right people, you can overcome just about any engineering challenge. Just expect that Murphy is alive and well and living in your

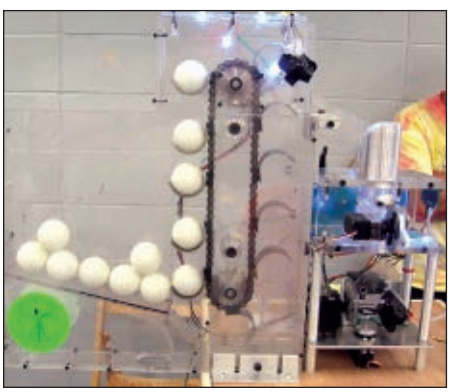
■ FIGURE 6. A ping pong ball on the print pedestal after printing.



■ FIGURE 7. The indexer stage that controls the fall of balls into the printer.



■ FIGURE 8. The new chain-drive ping pong ball hopper.



■ FIGURE 9. The Ping Pong Printer at a movie premier in Austin, TX.

projects, but with the right team, and/or the right attitude, he can be evicted. You just have to learn to manage the stress.

HOW DO YOU SPELL "SUCCESS?"

For many of us (me included!), success is spelled "S-T-R-E-S-S." When a deadline is looming, you're staring down the throat of a killer problem, and you have no idea of how to solve it, it's time to try and regain perspective. Take a deep breath and a step back. Look at what you're doing, what you've accomplished, and envision how you would like things to come out. Remember the bottom line: Making things is supposed to be fun! Unfortunately, the price of this type of fun is sometimes a bit of stress (okay, sometimes more than a bit!). Being nervous, feeling pressure, getting headaches, lack of sleep, worrying, and then worrying some more, then worrying about worrying ... The point is to "keep your eye on the prize."

Bear with me as I wax a bit philosophical here; projects like these are supposed to be the events that — when you look back on your life — clearly stand out as landmarks along the twisted path of this mortal coil (hmm ... I wonder how many uH a mortal coil has ... but I digress ...). I don't know about you, but when I turn around and examine my life there are long gray blurs of continuous, monotonous, "work." Swaths of the regular "nine to five" stuff that consumes much of my life. Honestly, I can't tell you what I was doing at this time and date exactly 10 years ago, or even 10 months ago! However, I *can* tell you all about my first Maker Faire in San Mateo, CA and going out to San Francisco to attend RoboGames. I can tell you about the first First Night Austin, and the second First Night Austin, and I can also tell you all about the first Robot Group meeting I attended. I can tell you all about the first article I had published in this magazine (yes, writing can be a project!).

For me, these projects really stand out when I look back on my life. I can also tell you that each and every one of these memorable events was surrounded by stress. It was the price of admission. The interesting part is that each of us gets to set that ticket price. If we choose to relax, take the long view, and realize this isn't rocket science (well ... maybe in some cases it is), it might help to reduce that price.

Remember: ELECTRONICS IS SUPPOSED TO BE FUN! Treat it accordingly. Build a project, draw a drawing, create a monster, find a team, form a team, do something that challenges you. Take some chances. But for cryin' out loud, HAVE FUN with it! And please, PLEASE take care of yourself so you can be healthy and ready to PLAY! If you have questions, comments, or would like to share your project experiences, feel free to drop me an email. As always, I can be reached at vern@txis.com. **NV**

RESOURCES

Maker Faire Austin
http://makerfaire.com/pub/e/2097

Ponginator in *Nuts & Volts*:
http://nutsvolts.texterity.com/nutsvolts/200712#pg84

The Robot Group
www.TheRobotGroup.org

The Ping Pong Printer in *Nuts & Volts*
http://nutsvolts.texterity.com/nutsvolts/200802#pg14

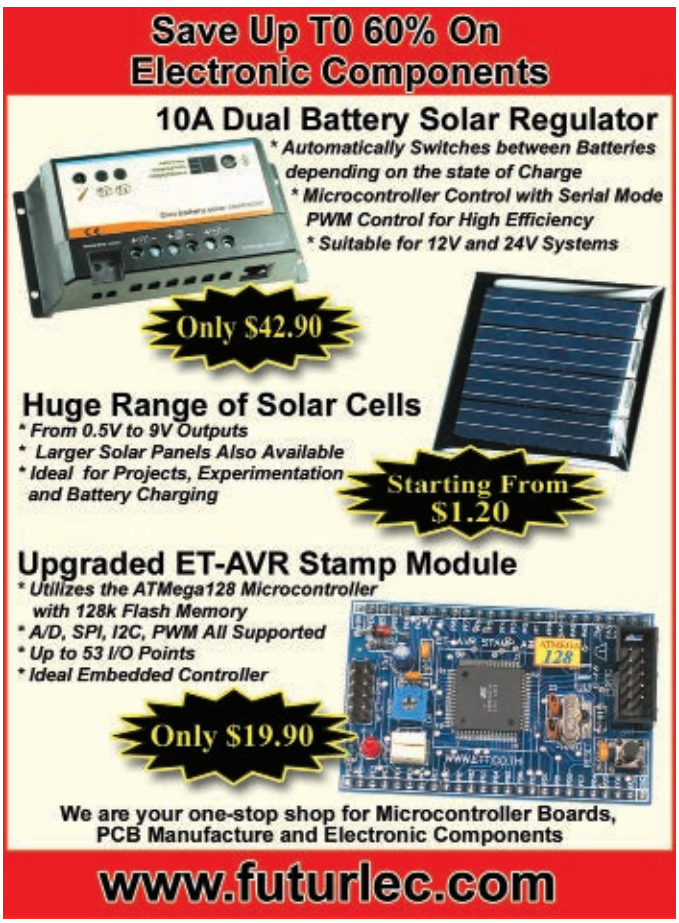
The Original Ponginator Video:
www.youtube.com/watch?v=iPSoFYHywJw

The Ponginator featured on GeeksAreSexy.com:
www.geeksaresexy.com/2009/02/10/feature-the-ponginator-a-robotic-combination-of-king-kong-and-ping-pong/

The Original Ping Pong Printer Video:
www.youtube.com/watch?v=8Ep5OC3E02I

The Ping Pong Printer on the net:
http://tinyurl.com/161

The Creation of the Thereping
http://nutsvolts.texterity.com/nutsvolts/200604#pg50



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#16 SMILEY'S WORKSHOP

AVR MICROCONTROLLER: C PROGRAMMING - HARDWARE - PROJECTS

Follow along with this series! Joe's book & kits are available in our webstore at www.nutsvolts.com

Arduino, Some Loose Ends

by Joe Pardue

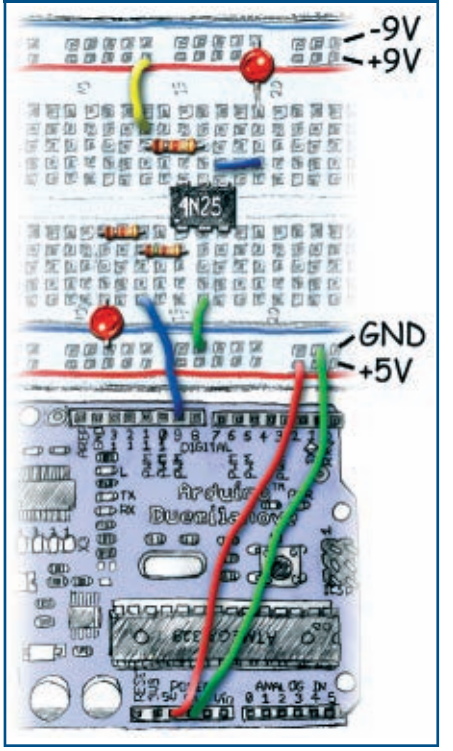
We are nearing the end of our Workshops that introduce the Arduino Projects Kit (available from *Nuts & Volts* and Smiley Micros). This month, we will look at several seemingly unrelated topics that we will need to understand before next month's article on simple motor speed control. We will learn about external interrupts, using the Arduino IDE Serial Monitor to get real data from the PC serial port to the Arduino board, and optical isolation of voltages.

Using External Interrupts To Detect Edges

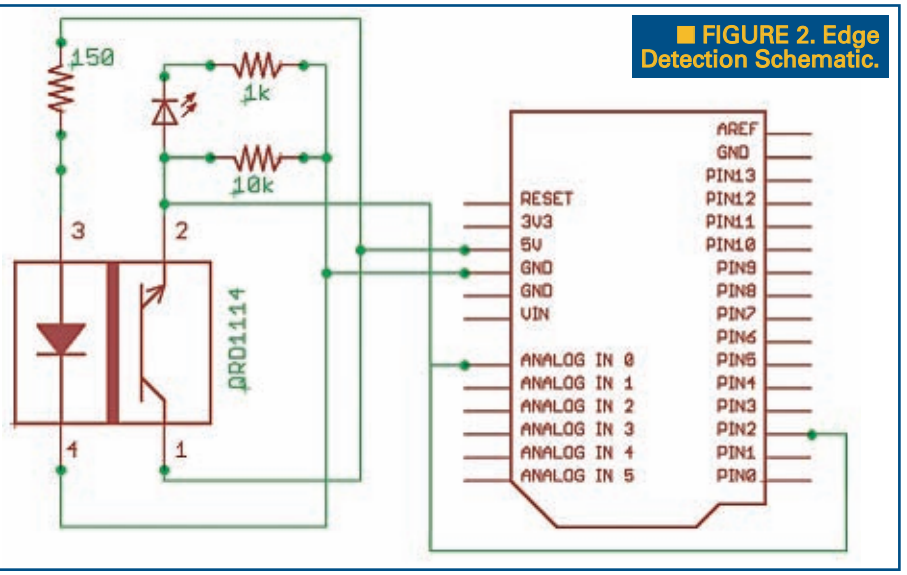
One of the things you might want a microcontroller to do is perform a service only when a certain external event occurs. For instance, you could put an IR laser beam across a door and have the microcontroller monitor the beam so that when someone passes through the door breaking the beam, the microcontroller turns on the lights (or drops a bucket of water on the intruder's head or some such action). If this is the only thing the microcontroller has to do, then it can be dedicated to polling the sensor full time in the loop() function where it would repeatedly run an isItTrippedYet() function that checks the sensor. Polling would drive a person nuts (think of driving kids who are yelling: 'are we there yet,' 'are we there yet,' 'are we there yet'...) but fortunately microcontrollers don't (yet) care what they are doing, so don't feel sorry for them if you give them a really boring task. Anyway, it's not like they can retaliate (yet).

Consider the case where a system has lots of other tasks to perform (maybe it's monitoring dozens of doors and the water levels in all the drop buckets). If it is polling each sensor, then someone could enter the room and be beyond the drop zone before the system even knows they are there. It is very common to conceptually divide up a microcontroller's work into two groups: one group of routine tasks that can be done any old time and another group of special tasks that

■ FIGURE 1. Optoisolation Test Layout.



■ FIGURE 2. Edge Detection Schematic.



must be done immediately when an external event occurs. It is so common, in fact, that most microcontrollers have built-in interrupt peripheral circuitry to accomplish the task.

This circuitry monitors a pin voltage and when a certain condition happens such as 'was high, now low,' it generates an interrupt that causes the main program flow to halt, store what it was doing in memory, and then the system runs the function that was assigned to the interrupt. When that function finishes, the system state is restored and the main program runs again.

You mainly deal with interrupts in one of two ways. If a simple task is all that is required and the rest of the program doesn't need to know about it, then the interrupt service routine can sneak in, handle it, then sneak back out without the main code ever knowing. If, however, a complex task that takes a lot of time away from the main program (yes, it is all relative) needs to be performed, then the interrupt routine should set a flag (change the value of a variable that both it and the main program can see) so that the main program can check that flag as part of the loop() and deal with the consequences of the interrupt when it gets time.

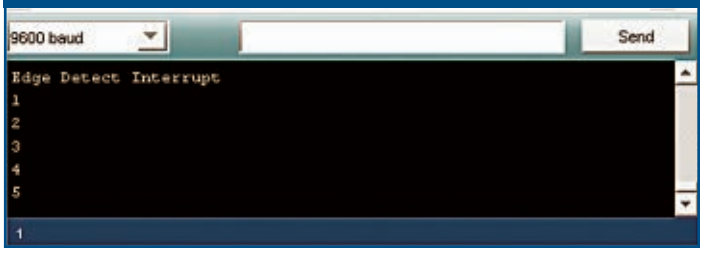
The Arduino library function attachInterrupt(interrupt, function, mode) simplifies the chore of setting up and using an external interrupt. The 'interrupt' parameter is either 0 or 1 (for the Arduino digital pin 2 and 3, respectively). The 'function' parameter is the name of the function you want to call when the interrupt occurs (the interrupt service routine). The 'mode' parameter is one of four constants to tell the interrupt when it should be triggered:

`LOW`: Trigger when the pin is low.
`CHANGE`: Trigger when the pin changes value.
`RISING`: Trigger when the pin rises from low to high.
`FALLING`: Trigger when the pin falls from high to low.

Hopefully, you still have your IR detector set up on the breadboard from before (see Workshop 15; Figures 7, 8, and 9). All you need to do in the hardware is move the signal wire from the Arduino Analog pin 0 to the Digital pin 2 as shown in **Figure 2**, then run the Edge_Detect_Interrupt software. In the former setup, we used the ADC to measure an analog voltage, but this time all we will sense is that the voltage is high enough to represent a digital ON or low enough to represent a digital OFF.

Run the Edge_Detect_Interrupt software and waggle your finger in front of the sensor to get a count like shown in **Figure 3**. Next month, we will use this concept to detect the passing of black and white stripes on a motor encoder wheel to control the speed of that motor.

■ FIGURE 3. Edge Detect Interrupt Counter.




```
Edge Detect Interrupt Software

// Edge_Detect_Interrupt
// Joe Pardue 6/28/09

volatile int count = 0;

void setup()
{
  // setup the serial port
  Serial.begin(9600);

  // say hello
  Serial.println("Edge Detect Interrupt");

  // attach interrupt 0 (pin 2) to the
  // edgeDetect function
  // run function on falling edge interrupt
  attachInterrupt(0,edgeDetect, FALLING);
}

void loop()
{
// do nothing
}

// on each interrupt
// increment and show the count
void edgeDetect()
{
  count++;
  Serial.print(count);
  Serial.println();
}
```

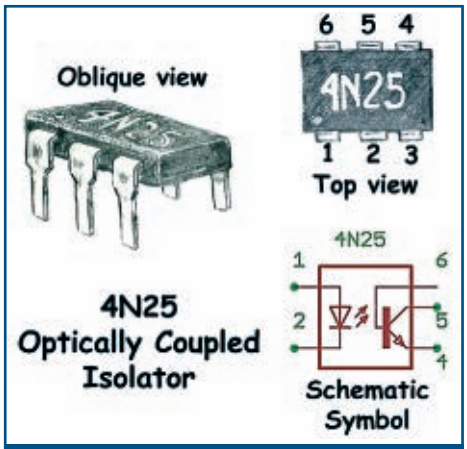
Getting Real With Serial Input

The Arduino IDE provides a simple Serial Monitor (PC side serial terminal program) and some serial communications functions that allow you communicate with the Arduino board. These functions do a good job in sending serial text from the Arduino to the PC, but (IMHO) not such a hot job of receiving data from the PC. The Serial.available() function tells you when there is a character available on the serial port, and the Serial.read() function will fetch that character for you. However, the Arduino does not provide (that I know of) any Arduino-like simplified way to deal with those characters once you've got them.

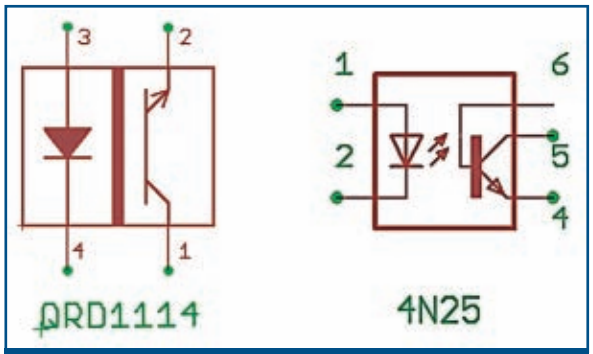
I contrast this weakness of sorts to a real strength of the C programming language: The C Standard Libraries contain a wealth of functions for dealing with data input over a serial port. I want to emphasize that you can use those C libraries with the Arduino IDE, but that kind-of defeats the purpose of Arduino. I touched on this a bit in an earlier article where I differentiated between TAW (The Arduino Way) and ACW (A C Way), so my approach will be to show what you can do with TAW and save the C libraries for later discussion of ACW. I will present an Arduino program that uses logic that mimics one of those C library functions — atoi() (ascii to integer) — that will allow us to input a sequence of numeric characters using the Arduino Serial Monitor and then convert those characters to an integer data value from 0 to 65535. This will be used next month to set the motor speed.

In Workshop 13, we built a Number_Commander that allowed us to pick a tune to play by entering a numeric

character in the Arduino IDE Serial Monitor. While that was cool, it limited us to 10 choices based on input of the characters from 0 to 9. We weren't actually looking at the numbers 0 to 9, but the ASCII character code that represents those numbers. This is an important distinction because the numeric characters are coded with values that are not the same as what we would normally think of as the value of that character. The character '0' is not coded with a value of 0, but with an ASCII code value of 48. Each subsequent numeric character (1 to 9) is coded as 49 to 57. The ASCII values of 0 to 9 are codes for the communication device (for instance, the ASCII code 7 was used to ring a bell; other low numbered codes were used to do things like advance printer paper or return the print head to the left). There are historic reasons for this coding scheme, but for now just look at an ASCII chart (**www.asciitable.com**) and accept that when doing serial communications, sending numbers from 0 to 127 actually represents the characters or actions shown in the chart.



■ FIGURE 4. 4N25 Optically Coupled Isolator.



■ FIGURE 5. QRD1114 and 4N25 schematic symbols.

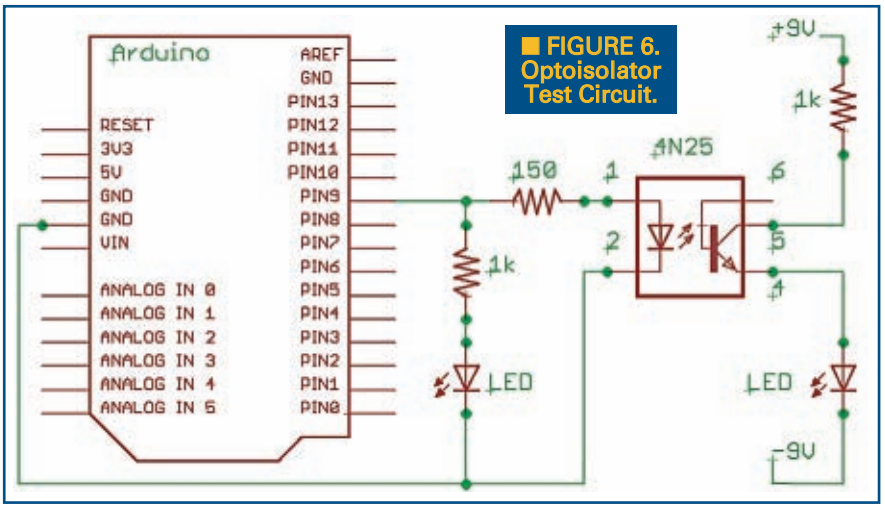
The Arduino IDE Serial Monitor allows you to send characters from your PC keyboard, but if you want to send a real number, say 127, then we have to have some way of receiving the characters '1', '2,' and '7,' and some end-of-number character such as '!' so that the software can know that number sequence has ended. We write a program on the Arduino that stores numeric characters until it sees a '!', then converts those characters to the number they represent. For instance, we could send six characters (42356!) and then convert those characters to an integer with a numeric value of 42,356.

Rather than spend a lot of space with further explanations, we'll just look at the program ASCII_To_Integer. Please be aware that this program can be easily spoofed with bad input, but for learning purposes it will suffice.

If you want a real 'computer programming' moment, first think about how you would collect a sequence of numeric characters and convert them to a number. Then, walk through this code with a pencil and piece of paper — especially the ATOI algorithm that extracts the number from the character string. The guys that came up with stuff like this were not only clever, they wrote some amazingly efficient code.

```
// ASCII_To_Integer 8/1/09 Joe Pardue
// Duplicates (somewhat) the C Standard Library
// function atoi() algorithm using Arduino.
// Note that there is no filtering of the input
// so if you enter something other than an integer
// value from 0! to 65535!, well, good luck.

int myInput = 0;
int myNum[6];
int myCount = 0;
int i = 0;
int n = 0;

void setup()
{
    Serial.begin(9600);
    Serial.println("ASCII_To_Integer");
}

void loop()
{
  // get characters until receiving '!'
  while( myInput != '!' ) getNum();

  // convert end-of-number character '!' to 0
  myInput = 0;
  myNum[--myCount] = 0;

  // convert ASCII string to integer
  ATOI();

  // clean up and do it all again
  clearAll();
}

// Put serial characters in a character array
void getNum()
{
  if(Serial.available())
  {
     myInput = Serial.read();
     // put the character in the array
     myNum[myCount++] = myInput;
  }
}

void ATOI()
{
  // algorithm from atoi() in C standard library
  n = 0;
  for(i = 0; myNum[i] >= '0' && myNum[i] <= '9';
++i)
    n = 10 * n + (myNum[i] - '0');

  // show the number
  Serial.print("You sent: ");
  Serial.println((unsigned int)n,DEC);
}

void clearAll()
{
  myCount = 0;
  for(i = 0; i < 6; i++)
  {
    myNum[i] = 0;
  }
  Serial.flush();
}
```

You can find the source code and supplements for this article in Workshop16.zip at www.nutsvolts.com.



■ FIGURE 6. Optoisolator Test Circuit.

Optical Isolation of Voltage

Have you ever had an EKG and noticed that those wires patched to your chest on either side of your heart go to a machine that is plugged directly into a wall socket capable of providing mains voltage? You might even have gotten so excited about the prospect of being electrocuted in the doctor's office that you were able to make the EKG go wild with all kinds of crazy beeps.

There are many ways to assure that voltages stay separated. The two main ones are electromagnetic isolation with transformers and optical isolation with LED/phototransistor pairs. We will look at the latter as a way to connect a signal between a microcontroller at five volts to a motor at nine volts so that we can prevent the digital equivalent of a coronary in our microcontroller.

Figure 4 provides a drawing and schematic symbol for our optical isolator. You can see that the QRD1114 IR Reflective Object Sensor we looked at in Workshop 15 and the 4N25 Optically Coupled Isolator that we are about to look at have similar schematic symbols (see **Figure 5**). Note that the main difference is that the QRD1114 shows a dark bar between the LED (emitter) and the phototransistor (detector) subcomponents. These parts are nearly identical from an electronic perspective. The primary difference is the packaging.

The QRD1114 detector is shielded from the emitter and can only 'see' the IR if it is reflected back to the device. The 4N25 emitter 'shines' directly onto the detector. The QRD1114 detector will pass a current proportional to the reflected IR, thus the signal level is dependent on the external reflective object, while the 4N25 directly responds to the amount of IR coming from the emitter — it can produce a current through pins 5 and 6 directly proportional to a current through pins 1 and 2. If you did something really dumb like connect a wire from a wall socket to pin 1 on the 4N25, you'd fry the LED. However, none of that voltage would pass through to the device connected to pins 4 or 5. This gives us a way to transfer the information in a signal from one circuit to another using light and without having any electrical connection between those circuits.

In next month's Workshop, we will use this device to isolate a PWM signal at one voltage level, five volts from our Arduino, and scale it to another voltage level (nine volts) for our motor driver.

The Arduino Projects Kit

Smiley Micros and *Nuts & Volts* are selling a special kit: The Arduino Projects Kit. Beginning with Workshop 9, we started learning simple ways to use these components, and in later Workshops we will use them to drill down into the deeper concepts of C programming, AVR microcontroller architecture, and embedded systems principles.

With the components in this kit you can:
- Blink eight LEDs (Cylon Eyes)
- Read a pushbutton and eight-bit DIP switch
- Sense voltage, light, and temperature
- Make music on a piezo element
- Detect objects, edges and gray levels
- Optically isolate voltages
- Fade LED with PWM
- Control motor speed

And more ...

A final note: The USB serial port on the Arduino uses the FTDI FT232R chip that was discussed in detail in the article "The Serial Port is Dead, Long Live the Serial Port' by yours truly in the June 2008 issue of *Nuts & Volts*. You can also get the book "Virtual Serial Programming Cookbook" (also by yours truly) and associated projects kit from either *Nuts & Volts* or Smiley Micros.

Optical Isolation Component, Schematic, and Layout

Our hardware demonstration of these concepts uses a five volt signal from the Arduino pin 9 on the emitter side that is converted by the 4N25 to a nine volt signal on the detector side. Wire this up as shown in the schematic in **Figure 6**, and the drawing in **Figure 1**.

Optical Isolation Source Code

To test this with software, use the ASCII_To_Integer program shown earlier and add just three lines of code. The first two you should add at the top of the file in the variables list are:

```
int value = 0;   // variable to keep the actual
                 // value
int ledpin = 9; // light connected to digital
                 // pin 9
```

Add the third line shown below between the ATOI() and clearAll() functions in the loop() function. The full code is in PWM_Test in this month's source code download on the *Nuts & Volts* website.

```
// convert ASCII string to integer
ATOI();

// control the brightness of an LED
analogWrite(ledpin, n);

// clean up and do
// it all again
clearAll();
```

The integer received from the PC ('n') is convertedto a PWM signal on the Arduino pin 9. The PWM will cause the LED brightness to be proportional to the input value (within limits). We will discuss PWM in moredetail next month when we use it to control the speed of a DC motor.

The LED on the left is directly driven by the Arduino pin 9 through a 1K ohm resistor and that pin also drives the IR LED in the 4N25 through a 150 ohm resistor. The isolated LED is driven by +9 volts through a 1K ohm resistor to pin 5 of the 4N25, through the phototransistor, out pin 4 to the LED.

And that's it for loose ends. Next month, we tie this all together and control the speed of a DC motor. **NV**

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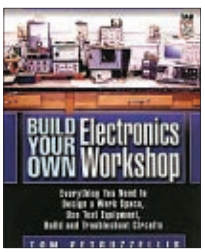

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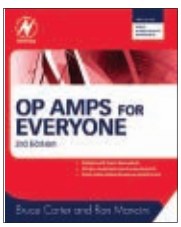

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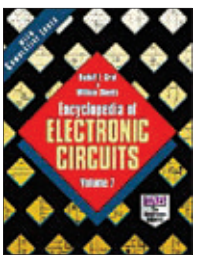

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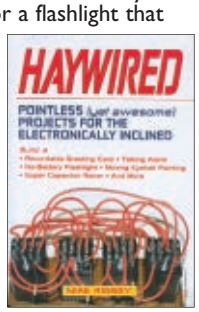

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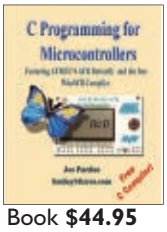

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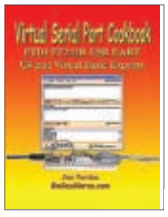

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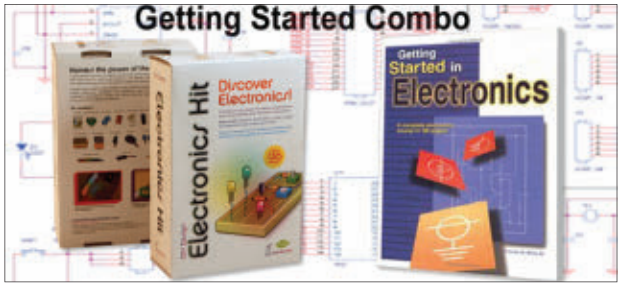

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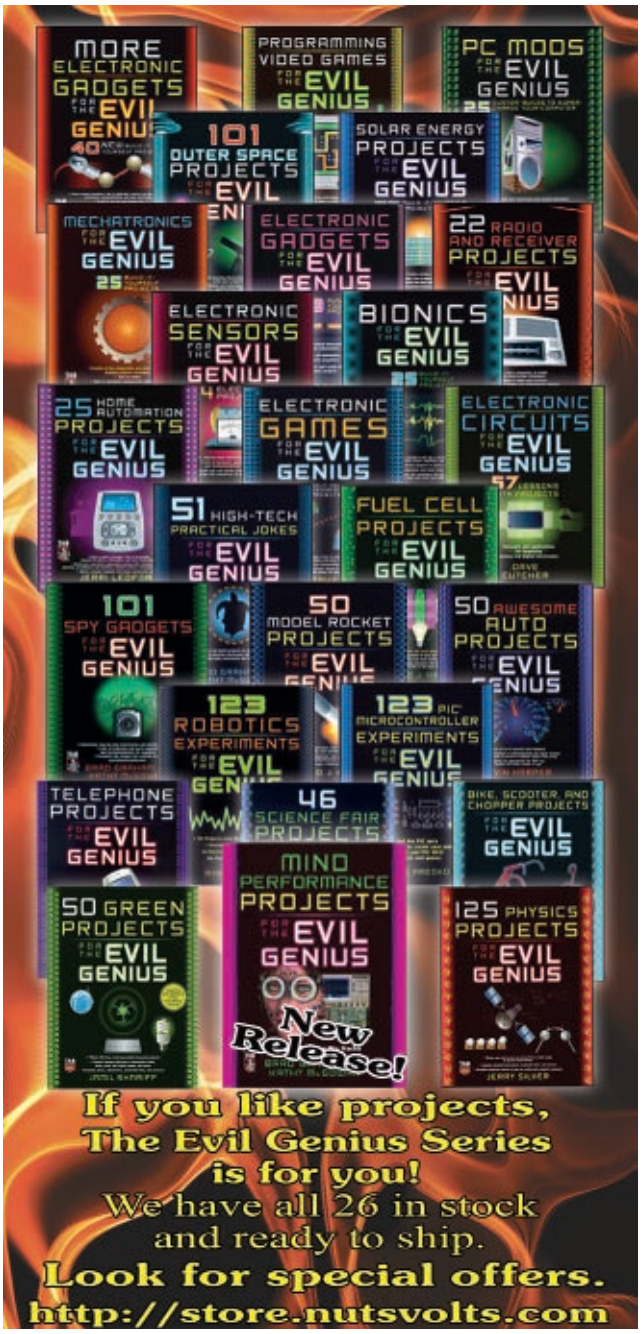

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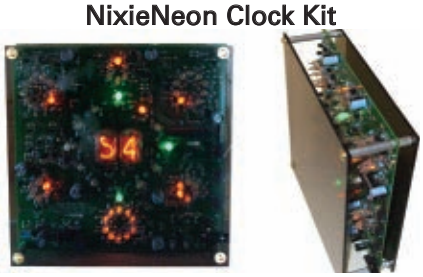

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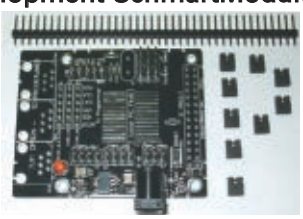

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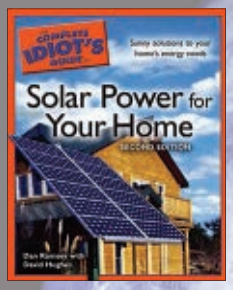

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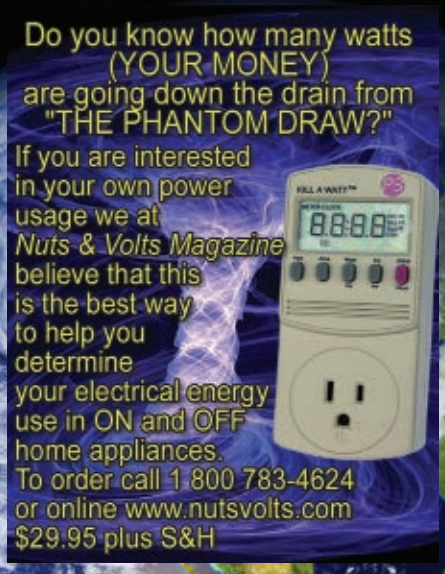

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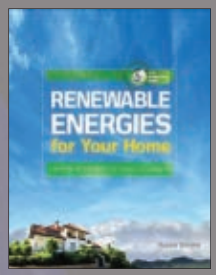

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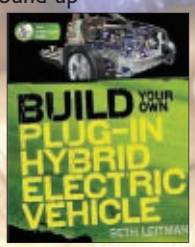

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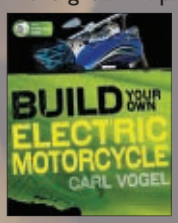

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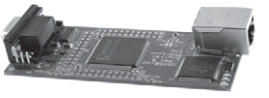

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TECH FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. 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!

All questions and answers should be sent by email to forum@nutsvolts.com All *diagrams should be computer generated and sent with your submission as an attachment.*

QUESTIONS

To be considered, all questions should relate to one or more of the following:

❶ Circuit Design
❷ Electronic Theory
❸ Problem Solving
❹ Other Similar Topics

■ 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).
■ 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.
■ No questions will be accepted that offer equipment for sale or equipment wanted to buy.
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■ Questions are subject to editing.

ANSWERS

■ Include in the subject line of your email, the question number that appears directly below the question you are responding to.
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■ Only your Name, City, and State, will be printed, unless you say otherwise. If you want your email address included, indicate to that effect.
■ Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

Power Supply

I am designing a project where weight is at a premium. I need some help designing a transformerless power supply that can deliver 12-14 volts at three amps. It needs to be auto switching 110/220 VAC. I designed a few projects in the past but they always had a transformer. I see things like laptop power supplies that don't have transformers. They put out three or four amps. How do they do it?

#11091 **Patrick**
Ogden, UT

FM Receiver

I'm looking for an FM circuit with these features:

Fixed digital 95.5 MHz
Mono
Earbud output
Battery powered
Small as possible

#11092 **Don Bartelson**
Merritt Island, FL

Bridge Rectifier Voltage Readings

Why, when I read the open circuit DC voltage with both sides of the output disconnected from the rectifier, I read the input voltage ± 10%? However, if I reconnect the load — a 90 VDC brake — and have the output switching device open, the measured DC output voltage at the rectifier is approximately 30% greater than the disconnected output voltage.

#11093 **John Coonis**
Los Angeles, CA

Vehicle ECU Programming

I would like to know what kind of programming is used in a car ECU. Is it C, C++, Visual Basic, or something else?

#11094 **Mohahamd**
Kuwait

DC-to-DC Step-Up Transformer

I need to locate a DC-to-DC step-up transformer that goes from 120 to around 330 volts. It is for a DC-to-DC converter that will drive a laser diode and can be low wattage.

#11095 **Thomas Wagner**
Coldwater, MI

Wireless HVAC Fan Controller

I want to install a duct fan in my HVAC system to help regulate the temperature of a specific room. But the duct where the fan will go is in the attic and the main airhandler is in the basement. The fan runs on 120 VAC and pulls 2A. I need an affordable wireless system that would turn the duct fan on and off when the main airhandler turns on and off.

#11096 **Eric Peters**
Martinsburg, WV

Power Outage Monitor

From time to time, I experience

power outages when I am not at home. I would like to either build or purchase a device which connects to the AC power line and begins timing when the AC power drops and stops timing when the AC power is restored. The readout must indicate the time elapsed during the outage.

#11097 **Corby Grubb**
Alpha Audio Associates

Labeling Items

Can someone recommend the best way to put professional-looking text labels on a project enclosure, at a hobbyist price point? I've been using Brother P-Touch labels; while cheap, they don't have the visual impact that I'd like to have and don't work well in constrained spaces.

#11098 **W. Walker**
Swansea, Il

Performance of Battery and Super Capacitor

I'm working on an electric go-kart and need help predicting the performance of a combined battery and super capacitor. I need a formula that would show the current output of a small battery and a large capacitor. I'd want two battery types (lead acid, LiFePo4, etc.), so the formula needs to have variables for different battery characteristics. The new supercaps are in the range of 35-100 Farads.

There is one manufacturer that makes a 50 AH lead acid combined in parallel with a large (maybe) 35 Farad capacitor.

Ultimately, I want to know what will happen if I put this in my kart and accelerate for six or even 10 seconds.

#11099 **Cary Z**
Indianapolis, IN

>>> ANSWERS

[#6095 - June 2009]
Triac Controlled Light Switch

I'm looking for a circuit to run a low wattage 120 volt incandescent light. The source will be a Parallax BASIC Stamp II microcontroller (5V @ 30 mA per I/O) and the circuit needs to be opti isolated. I'd like to use a triac if possible. The light will be off for short periods of time (two to five seconds) and on for about a minute at a time.

#1 *Nuts & Volts* advertiser All Electronics (**www.allelectronics.com**) has two suitable solid-state relays (SSR) for less than $5: SRLY-19 and SRLY-31. These parts have a 5 VDC compatible input, and an optically isolated triac output for switching the AC load.

The SRLY-19 input is 3-8 VDC and the output 24-140 VAC @ 1A. Wire the pins as follows: pin 4(-) to Stamp gnd; pin 3(+) to Stamp output; pin 2 (~) to AC; and pin 1(~) to lamp. The other side of the lamp goes to the other AC line. See the online catalog for a picture of the SSR. The SRLY-31 input is 4-10 VDC and the output 24-280 VAC @ 1.5A. Wire the pins as follows: (-) to Stamp gnd; (+) to Stamp output; (~) to AC; and (~) to lamp.

For controlling a heavier load, consider the three amp SRLY-20.

Dennis Crunkilton
Abilene, TX

#2 **Figure 1** is a fairly straightforward solution taken right from the MOC3010 datasheet. The MOC3010 will keep your microcontroller optically isolated from mains. R1 will limit the current through the MOC3010 input diode and what your microcontroller sinks to approximately 13 mA. R2 limits the current through the output triac of the MOC3010 per the datasheet. The T801-600G is an eight amp triac capable of about a 900 watt load provided it is heatsunk properly. Exercise caution when working with mains voltages and consider installing a fuse between the AC line and your incandescent lamp for safety. Both parts can be found at Mouser where you can also get the datasheets; **www.mouser.com**.

Mike Bernath
Denver, NC

[#6096 - June 2009]
24 Hour Counter

I need to build a 24 hour, battery-operated counter with a 2" readout that will have the capability to be manually adjusted up/down and reset to 0.

I have a small kitchen timer that will do what you ask. It can be set up to 99 hours, 59 minutes, and 59 seconds. It will count up and down, has four timer settings for program timing, a clock, and alarm. The manufacturer is Component Design Northwest, Inc., in Portland, OR. You can search for the above on the Internet. Click for Retailer, then click Timers. Click for Digital Hour/Minute /Second. Click for model PT1A.

I have had it for about 10 years, and other than changing the LR44 battery about every three years, it has not failed me yet.

John Lippert
Menomonee Falls, WI

[#7091 - July 2009]
Wind Speed Controller

I need a circuit for several applications that need to be switched on/off (open/closed) by relay, depending on wind speed.

The circuit needs to be able to set a minimum wind speed to activate and

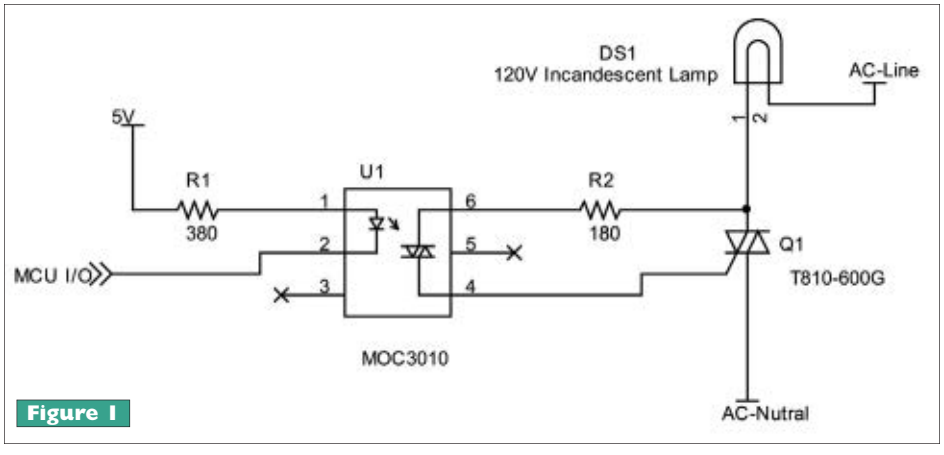

Figure 1

a maximum wind speed to deactivate. Also, it needs variable activate and deactivate timers (about 30 seconds to five minutes) so that wind gusts will not activate/deactivate the circuit too rapidly.

There are several stand-alone wind speed devices on the market, as well as included in complete weather stations. They all seem to be wireless in nature and talk to some type of receiver monitor or computer. A stand-alone "wired" wind speed device to controller circuit would be preferred.

#1 A stand-alone wired wind speed alarm can be found at **inspeed.com** under "windswitch." You can add an external time delay relay like Ramsey Electronics #K2579 (**www.ramseykits.com**) if the built-in delay is not enough.

Bob Lindstrom
Broomfield, CO

#2 The easiest way to solve this is probably with a hot-wire anemometer. A mass flow sensor in a modern vehicle uses the same principle. Linear Technology (**www.linear.com**) has an application circuit for the LT1014 using a #328 bulb with the glass envelope removed as a wind speed sensor. A couple of comparators connected to this circuit should give you the desired result (look for window comparator circuits and timer circuits in the LM339 datasheet). You can use Linear Technologies LTspice IV to model the circuit.

Walter Heissenberger
Hancock, NH

[#7092 - July 2009] Inventory Tracking

We have been trying to find a better way to keep track of thousands of inventory items we have on campus. We would like to do this the cheapest and most effective way. Our budget right now is not that large. We have looked at a few applications from iTunes App store, but most of them are web based — "Info already on the web." I was wondering if RFID chips could do this sort of thing? We want to put the serial number, item name, and model number into either a barcode or chip that can be stuck to the item. Is the RFID system able to do this or very inexpensive barcode software?

#1 RFID is practical and cost-effective. For the campus inventory system, tags — which are about the size of a postage stamp and about as thick (there's a little bump where the chip is located) — are available that could store a few bytes up to 3,000 bytes for less than $1 each.

These tags can be written, read, and re-written over the life of the asset. The tags are "passive" meaning that they have no internal power supply. Portable reader/writers are available. Tag data can be security protected. I am personally working on a prototype, portable reader which should cost less than $100.

John Higgins
via email

#2 A cheap and effective way to keep track of your inventory would be to label the inventory with barcodes. You can do this for free by downloading a barcode font from the several offered on the web. A search for "barcode font free" will locate these. Use any word processor with a label printing function to generate the inventory labels with your data, using the special barcode font for the barcodes. You can read the barcodes with a laser barcode scanner and "keyboard wedge," which you can find online by searching for "keyboard wedge barcode scanner." A "keyboard wedge" allows you to connect a barcode scanner inline with your keyboard. When a barcode is read, the wedge inserts the characters read into your inventory software, as if you had manually typed the characters on your keyboard. To use a keyboard wedge with a portable computer, use a "USB keyboard wedge scanner." You may use any inventory software that you wish, including free or shareware programs offered online, as no modifications need be made to the inventory software to use a wedge scanner. I looked at a few that might work for you that are freeware on **ZDNet** and **download.com**, simply searching for "inventory software." The website at **www.taltech.com/products/interface.htm** has a good overview of complete barcode reading systems.

Howard Krausse
Willow Creek, CA

[#7093 - July 2009] Simple Low Frequency Transmitter

How would I build a low frequency (say 512 Hz), battery operated sine wave transmitter that was small enough to fit inside 1" PVC pipe? I'm not sure if a resistor, capacitor, or crystal is the best; how do you wind a coil antenna to match the frequency?

I sell a programmable Quad DDS chip that is very accurate in the audio range (512.00 Hz) and four outputs. It has a square wave output, but can be converted to triangle, then filtered to sine.

A 555 timer chip and a few other parts would be cheaper, but the freq will drift with temp change.

As far as the antenna goes, at that freq, just about any coil will work.

If you need a strong field, you can drive the coil with a cheap audio amp chip, like the LM386.

I can email you plans for most of this stuff; **SteveMerrell@Gmail.com**

Steve
Tucson, AZ

[#8097 - August 2009] Need LCD Datasheets

I'm looking for datasheets or advice on how to use an LCD unit salvaged from a mid 1980's medical device. The PCB is labeled "PWB641C-CEM, OPTREX." There are 19 pins, two of which are "A" and "K" which I believe to be power for the backlight. The chips are "HD44105H" and two "HD44102CH."

Anyone can type ANY CHIP ID directly into any search engine and get information from many sources.

The 'link' below will give you the 'HD44102CH' chip.

http://pdf1.alldatasheet.co.kr/datasheet-pdf/view/169419/HITACHI/HD44102CH.html

John Mastromoro
Saint Johnsville, NY

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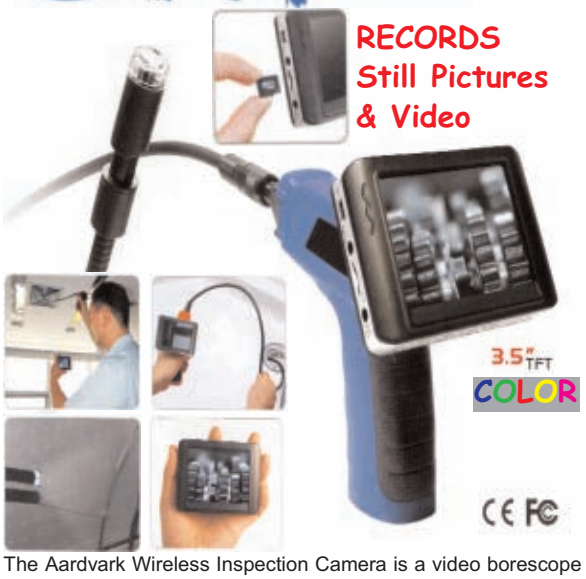

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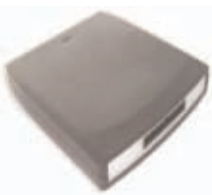
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # **DSO1060** NEW ITEM **$549.00**

34 Channel USB Logic Analyzer



The CSI5034 is a sophisticated, portable, and easy-to-use 500MHz, 34-channel logic analyzer equipped with features found only in more expensive bench type instruments. Using advanced large-scale integrated circuits, integrated USB 2.0, CPLD, FPGA, high-frequency digital circuitry, embedded systems, and other advanced technology, make the CSI5034 your best choice in pc-based logic analyzers The CSI5034 is suitable for electronic measurement engineers, college students in scientific research and development and teaching assistants.

- 34 input channels capable of simultaneously monitoring data and control information, and is capable of capturing narrow pulses and glitches that may be missed by other test equipment.
- Delay feature provides the ability to capture data around the waveform, both before and after the desired trigger signal. This allows the operator to view the data at multiple points in the data stream
- Memory feature stores multiple data points for error analysis of the unit under test and to aid in locating defective components.
- Intuitive and flexible viewing screens to facilitate analysis of the system under test. Data can de displayed as binary, decimal, or hexadecimal values.
- Can be triggered in a variety of ways (rising edge, falling, edge or both) , and also has an advanced trigger function that allows logic operations to be performed on the data before a trigger is generated. This provides the ability to trigger on a specific data byte or word from any of the monitored channels.

NEW ITEM Item # **CSI5034** **$329.00**

Premium All-In-One Repairing Solder System

The BlackJack SolderWerks BK6000 Repairing System is a digital multipurpose reworking system that incorporates a Hot-Air Gun, Soldering Iron, (compatible with leaded solder or lead free solder), with integrated smoke absorber and a desoldering Gun.

Item# **BK6000** **$199.00**

Hot Air System w Soldering Iron & Mechanical Arm

The BK5000 from BlackJack SolderWerks provides a very convenient combination of hot air & soldering in one compact package. The hot air gun is equipped with a hot air protection system providing system cool down & overheat protection.

Item# **BK5000** **$119.00**

Hot Air with Vacuum I.C. handler & Mechanical Arm

The BlackJack SolderWerks BK4050 is designed to easily repair surface mount devices. Its digital display & tactile buttons allows easy operation & adjustments. The BK4050 includes a hot air gun and a vacuum style I.C. handler.

Item# **BK4050** **$119.00**

Thermostatically controlled desoldering station

The BlackJack SolderWerks BK4000 is a thermostatically controlled desoldering station that provides low cost and solid performance to fit the needs of the hobbyist and light duty user. Comes with a lightweight desoldering gun.

Item# **BK4000** **$119.00**

Digital Display Solder Station for Lead Free Solder

The BK3000LF is a compact unit designed to be used with lead free solder that provides reliable performance featuring microprocessor control and digital LED temperature display. A wide range of replacement tips are available.

Item# **BK3000LF** **$74.95**

Compact Digital Display Solder Station

The BK2000+ is a compact unit that provides reliable soldering performance featuring microprocessor control and digital LED temperature display. A wide range of replacement tips are available.

Item# **BK2000+** **$56.95**

Compact Soldering Station

The BlackJack SolderWerks BK2000 is a compact unit that provides reliable soldering performance with a very low price. Similar units from other manufacturers can cost twice as much. A wide range of replacement tips are available.

Item# **BK2000** **$36.95**

Featuring spot-on, dual-laser aiming, the TN01U close-focus, non-contact IR thermometer measures the temperature of electronic components as small as 0.1-in. with pin-point accuracy. Compact and lightweight, the instrument provides a large LCD and a bright dual-laser aiming system that allows for accurate aiming. Features include a measurement spot size of 2.5-mm in diameter at distances up to 18 mm, measurement range from -55ºC to +220ºC,(-67-428 deg F) an accuracy of ±2% of reading or ±2ºC whichever is greater, a repeatability of ± 0.2ºC, display resolution of 0.1ºC, and a response time of 1s. Operating with two AAA batteries providing 18 hours of continuous use, the instrument measures. This is the most advanced infrared thermometer manufactured today providing fast, accurate, non-contact component temperature measurements for hardware designers, Test, QA and Service professionals.

Item # **TN01U**

$129.00

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Dual Output DC Bench Power Supplies

High stability digital read-out bench power supplies featuring constant voltage & current outputs. Short-circuit & current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance & long life. All 3 Models have a **1A/5VDC Fixed Output** on the rear panel.

Item #:	Price 1-4	Price 5+
CSI3003X-5 0-30V/0-3A	$119.00	$112.00
CSI5003X5 0-50V/0-3A	$127.00	$119.00
CSI3005X5 0-30V/0-5A	$129.00	$122.00

Temprature Controlled Reflow Oven

The HHL3000 Reflow Oven is a highly versatile tool used for reflowing and preheating different surface Mount technology (SMT) components and printed circuit boards (PCB's). The system utilizes a microcontroller to effectively amd efficently manage the working temperature while facilitating the duration of the heating process. A bright LED display clearly displays the time and temperature along with a fully digital control panel for ease of use and monitoring.

The HHL3000 makes use of infrared (IR) heat wave technology to distribute heat evenly on the component and PCB. Included is an integrated temperature sensor that allows positioning in such a way that the measurement of the actual temperature of PCB and components can be obtained. This minimizes damage to the PCB and its components due to thermal shock or low level temperature conditions.

FUNCTIONS and FEATURES

* Microprocessor-controlled equipment.
* Direct PCB temperature measurement, improves accuracy and lessens damage or distortion.
* Five (5) temperature and time control points with automatic slope adjustment. Configurable to suit different solder paste and circuit boards.
* Two (2) default profiles suitable with most common solder paste specifications.
* Quick and easy resetting of control points for precise tuning of reflow profiles.
* Built-in safety feature of industry standard 0.01°C/s to 3°C/s rising slope.
* Fully digital panel controls and read-out of time and temperature for monitoring and ease of use.
* Highly compatible with lead-free applications.

Item# **HHL3000** **$949.00**

3 in 1 FOCUSED Infrared Soldering/Repair System

The CSI720 Three in One Focused Infrared Welding System generates heat through a concentrated infrared heat wave, providing precise soldering without movement of surrounding components.

ESD Safe, Focused Infrared Welding Station For reworking BGAs, micro BGAs, QFPs, PLCCs, SOICs, small SMD and other circuit board components. Unit produces a concentrated infrared heat wave, for precision soldering. Infrared soldering eliminates movement of surrounding components, and marks on reworked PCB's, both associated with standard hot air gun reworking.
3 in 1 Repairing System Combines the function of an Infrared Welding Tool, Soldering Iron and Pre-heater.
Full Digital Control with LED Displays Allows precision setting of welding temperature & time, soldering iron and pre-heating temperatures.
Closed loop temperature control For instant and precise process adjustments.
Adjustable Infrared Tool Post Stable and adjustable Infrared welding tool holder for increased precision soldering and hands free operation.
Adjustable Eye shield & Welding Goggles To protect users from harmful light rays.

Uses infrared heat wave technology instead of the conventional hot air, effectively solves the major problem being encountered when using the hot air gun, which is the movement of surrounding components while reworking.

Item # **CSI720** **$1,399.99**

Triple Output DC Bench Power Supplies

- Output: 0-30VDC x 2 @ 3 or 5 Amps & 1fixed output @ 5VDC@3A
- Stepped Current: 30mA +/- 1mA

Item #:	Price 1-4	Price 5+
CSI3003X3 0-30Vx2@3A	$198.00	$193.00
CSI3005XIII 0-30Vx2@5A	$259.00	$244.00

New Products!

Say It Module (#30080; $79.99) Provides voice recognition for built-in pre-programmed commands or up to 32 user defined commands. Good for robots, home automation, etc. GUI software for the BASIC Stamp®2 microcontroller and example code for the Boe-Bot® is available.

Propeller Servo Controller USB (#28830; $39.99) Control up to 16 servos (32 servos with 2 controllers) with this network-ready module. Propeller-based and open-source.

P8X32A-Q44 Schmartboard Kit (#27150; $39.99) Learn surface-mount soldering and then program on this convenient development platform for the multicore Propeller chip. Kit includes surface-mount and through-hole package options for select components.

7.2 V Motor, Bracket and Wheel Kit (#570-00070; $99.99) Lightweight and sturdy aluminum brackets specifically designed to make mounting the included all-metal 7.2 VDC motors a breeze. Giving your robot rugged mobility has never been easier!

433 MHz RF Transceiver (#27982; $39.99) Send serial data wirelessly between microcontrollers or to a PC. The low power consumption makes this module ideal for use in battery powered applications. Line of sight range up to 2500 feet (depending on operating conditions).

MMA7455 3-Axis Accelerometer Module (#28526; $34.99) This low-power sensor measures acceleration along its X, Y, and Z axes. Module has wide supply voltage compatibility range (2.2 - 5.5 V), selectable sensitivity (±2g, ±4g, ±8g), user-configurable interrupts, and user-settable registers to calibrate each axis.

To see all the new products visit www.parallax.com
Order online or call our Sales Department toll-free at 888-512-1024 (Monday-Friday, 7 a.m. - 5 p.m., PT).

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