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Meet Vanessa Carpenter and Dzl Møbius, SparkFun customers and developers of the Critical Corset. Using a heart rate monitor, an Arduino, and a cleverly hidden air pump system, Vanessa and Dzl designed a corset that explores the rules of attraction. As the user's heart rate increases, the corset gently tightens, creating a more confident posture.

Whether you need a heart rate monitor or just a handful of LEDs, the tools are out there. Create a project you'll love, and let your geek shine too.

©2009 SparkFun Electronics, Inc. All rights reserved. All other trademarks contained herein are the property of their respective owners. Arduino is released under the Creative Commons Attribution Share-Alike 3.0 License. For more info on Vanessa and Dzl's project visit www.illutron.dk.
Industry guru Forrest M. Mims III has created a stumper. Video game designer Bob Wheels needed an inexpensive, counter-clockwise rotation detector for a radio-controlled car that could withstand the busy hands of a teenaged game player and endure lots of punishment. Can you figure out what's missing? Go to www.jameco.com/untangle to see if you are correct and while you are there, sign-up for our free full color catalog.
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Designing with Efficiency In Mind

It’s difficult to ignore the ‘go green’ mantra that’s sweeping through the media and permeating virtually every industry. The way I see it, most of the activity is focused on marketing and printing consumer-friendly green stickers that proclaim enhanced efficiency of sorts for the same old products. Even so, it is time for us to take responsibility for our carbon footprint by using what we have more intelligently, by buying more efficient products in the first place, and — for electronics enthusiasts — by designing with efficiency in mind.

Changing behavior requires data — what better excuse for me to buy one of those energy monitors I’ve been eyeing for months (see photo). Prior to this purchase, I used a short extension chord with the outer insulating jacket removed and a clamp-on current meter around the hot lead to determine current flow. However, the new energy use meters are much easier. Not only do they perform the power factor corrections, they can even calculate operating cost in dollars and cents. I’ve been a long-time user of CF lighting, but never achieved the activation energy required to test all the electrical devices in my home or workshop. With my new meter, moving from appliance to appliance and from device to device was an education in energy use. Some of the older equipment in my shop has a better energy profile than the new equipment — especially older 120 VAC test equipment with an on-off switch. The low voltage wall transformers that power my new instruments consume energy just sitting there.

One of the biggest hits to my wallet turned out to be a large, rack mounted UPS. Before testing the power consumption at idle, I never considered the operating cost. However, at 200W, 24x7, the UPS turns out to be one of the most expensive pieces of equipment in my workshop.
Another surprise was my desktop computer. Turning on my screen saver adds an additional 40W load to my PC’s power supply. Leaving the self-powered speakers on while the computer is off — a 20W hit. Laser printer on standby — another 20W. A power strip full of wall transformers idling away — 25W. Copy machine on standby — 20W. As you can see, energy use adds up quickly.

However, unless you’re energy conscious when you purchase new video card or rack-mounted power supply, you might be leaving out an important variable in your purchase decision: operating cost. Wouldn’t it be great for manufacturers to list, for example, relative energy consumption for hard drives? Just how much extra does it cost to run one of those 9,600 RPM drives versus a 10,000 RPM model?

Another area highlighted by my time with the energy use meter is how little forethought I’ve given to the operating cost of the various devices that I’ve designed and built. For example, in deciding between an inefficient single-chip linear supply and a more efficient switched supply, my thoughts have been on heat production, space requirements, noise generation, ancillary component needs, and — of course — initial cost. I’ve never considered long-term energy consumption to determine which power supply design makes the most economic sense.

Here are some examples of energy design questions that you might consider in your next project:

- If your project includes a fan, do you plan to run it constantly or only when needed?
- Does the design for your new device have an auto shutdown feature so that it shuts down after a preset time has passed without activity?
- Do you really need a string of super jumbo LEDs on the front panel of your new project, or will a small, energy-efficient LED do the job?
- If your circuit includes a communications transmitter, is the power output the minimum needed for reliable communications?
- If your design includes mechanical linkages and motors (think robot), and it’s intended for constant use, are the materials as light as possible? Are the motors high efficiency or simply the least expensive to purchase?

Although it’s a good idea to consider energy efficiency in the design stage of all of your electronics projects, I’m not suggesting you double the cost of your next project that’s going to spend most of its time sitting unused on the shelf. I’m talking about devices that you plan to use frequently. As an aside, if you’re thinking of purchasing an energy meter, go in with a friend or two. Once you know the energy needs of your equipment and appliances, there isn’t much need for constant monitoring. And you can always go with the split power cable if you have a clamp probe for your ammeter. The point is to get into the habit of using energy consumption as a factor in your component selection and electronics design decision-making process. 

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TACHful FEEDBACK

I’ve been reading NV occasionally for some time now. I finally got around to subscribing to your fine mag in the last week or two. The first time I bought it you had an article about making a digital tachometer from 7490 counters, etc. That caught my eye because about 20 years ago I designed and built a tach very much like it. There were differences in how we did the math, but the units were very similar. Mine just had one or two wraps of wire around the coil wire and a small amplifier feeding a 556 timer (for clean pulses) instead of the diskette drive pickup the author used. The other timer in the 556 was how I did the math part, counting the pulses on the tens counter first for two seconds gave me the avg rpm's for a six cylinder; 1.5 seconds for a V8; and three seconds for a four cylinder. This count was entered into an array or flip-flops as a memory just before the counters were reset. I think your author used a multiplexer, but I'm not sure what that is.

Now you guys have me interested in PICs. I wish we had them back then ... I could have saved a lot of work. Maybe I'll make another tach when I get the time, but it will be PIC based. I can't believe how easy those little chips are to use. You've got me tinkering again.

Fred McNeil

TUNED INTO ANTENNAS

I noticed Russ’ answer to the "Antenna Question" in the Sept 09 Q & A regarding AM antennas and thought I might add something. If you take an example of an AM station broadcasting at 1,000 kHz about in the middle of the band, the wave length is about 980 ft. A quarter wave length is about 245 ft. A dipole antenna would have two elements about 245 ft long. (The "about" comes from small correction factors which are probably not greater than 10%.) Now an AM transmitting tower is one of the dipole elements. It is insulated from the ground and driven by the power generated by the final amplifier of the transmitter. The other element is the image created by the ground plane. I would not be surprised if they lay conductors out on the ground to insure a really good ground plane. With this kind of setup, you know the radiated signal will have vertical polarization; that is the radiated electric field oscillates up and down and the accompanying magnetic field will oscillate horizontally and perpendicular to a line going back to the transmitting antenna.

The best receiving antenna would be a vertical wire 245 ft long. That's clearly not possible. But the longer the vertical antenna, the better.

The other way is to utilize the magnetic field. I used to have an AM antenna that had a horizontal ferrite bar about an inch in diameter and was about six inches long. It had a lot of turns of wire that not only picked up a signal but was part of a capacitor tuned circuit. You not only had to swivel the ferrite bar so it was perpendicular to a line back to the transmitting antenna, but you had to tune the capacitor to achieve resonance for the station frequency.

FM stations have a wavelength about a 100 times smaller, so a transmitting antenna is much smaller. The towers for FM just serve to hold the transmitting antenna up high for line-of-sight transmission. A 90 degree phase shift feeds horizontal and vertical elements in such a way that circular polarization ensues for the transmitted wave. Consequently, it doesn't matter if you pick up the signal with a vertical or a horizontal conductor as long as in the case of a horizontal conductor it is perpendicular to a line going back to the transmitting antenna.

There was a company (C. Crane Company) that specialized in AM radios. If they are still in business, they might be a source of sensitive AM receivers. Well I hope I haven't bored you to death.

Dean Kaul

Thanks for writing, Dean; I knew most of that except about C Crane Company. I didn’t want to use up column inches to expound on that question.

Russ Kincaid

Continued on page 77
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REPU S L I G H T
F O R C E D I S C O V E R E D

Back in July, a team of Yale University (www.yale.edu) researchers announced the discovery of a curious “repulsive light force.” No, we’re not talking about emanations from the Lifetime Channel. It’s actually a physical phenomenon that can be used to push things like tiny mechanical switches on micro- and nano-scale electrical systems. As it happens, this is the team’s yang discovery, having previously discovered the yin of its attractive complement.

The forces are different from light’s radiation pressure, which pushes in the direction the light travels. Instead, these push or pull in perpendicular directions. The team had already used the pull force to open a nanoscale switch but couldn’t close it again by pushing in the opposite direction. But by using both forces, they now can manipulate components in both directions.

To create the repulsive force on a silicon chip, the team split an infrared beam into two separate beams and forced each one to travel a different length of silicon nanowire (i.e., a waveguide). As a result, the two light beams became out of phase, creating a repulsive force whose intensity can be controlled: the more out of phase the beams are, the stronger the force.

“These light forces may one day control telecommunications devices that would require far less power but would be much faster than today’s conventional counterparts,” according to Prof. Hong Tang. “An added benefit of using light rather than electricity is that it can be routed through a circuit with almost no interference in signal, and it eliminates the need to lay down large numbers of electrical wires.”

MICROCHIP HANDLES 1,000 CHEMICAL REACTIONS SIMULTANEOUSLY

Another recent discovery with perhaps more imminent practical application is a microchip technology that UCLA (www.ucla.edu) researchers claim could replace flasks, beakers, and hot plates in chemistry labs. A collaboration of chemists, biologists, and engineers has produced a chip technology – based on microfluidics – which is defined as “the utilization of miniaturized devices to automatically handle and channel tiny amounts of liquids and chemicals invisible to the eye.”

In a demonstration, the team performed chemical reactions using “in situ click chemistry,” in which reactive molecular building blocks are designed to “click” together selectively and covalently. The technique is often used to identify potential drug molecules that bind tightly to protein enzymes to either activate or inhibit an effect in a cell. According to the group’s report, “While, traditionally, only a few chemical reactions could be produced on a chip, the research team pioneered a way to instigate multiple reactions, thus offering a new method to quickly screen which drug molecules may work most effectively with a targeted protein enzyme. In this study, scientists produced a chip capable of conducting 1,024 reactions simultaneously, which, in a test system, ably identified potent inhibitors to the enzyme bovine carbonic anhydrase.”

The next step for the team is to look into applying the technology to other screening reactions in which there are limited amounts of chemicals and material samples, e.g., with protein enzymes called kinases which are involved in the malignant transformation of cancer. In time, the concept may open up many new areas for biological and medicinal studies.

COMPUTERS AND NETWORKING
$300 NETBOOK INTRODUCED

The latest entry in the netbook market from Acer, Inc. (www.acer.com), is the Aspire One D250 which sneaks in under the $300 wire on most Internet stores. Its main claims to fame include a 10.1-inch CrystalBrite™ backlit LED display with 1024 x 600 pixel resolution, integrated webcam and microphone, and a fighting weight of only 1.11 kg (2.4 lb). It also includes a multigesture touchpad, an 802.11b/g WiFi connection, and Fast Ethernet (Bluetooth and 3G...
When you talk to someone on the phone, the conversation generally is not recorded and therefore disappears when you hang up, unlike email and other files sent over the Internet. As many of us have learned the hard way, these things can last forever and come back to haunt us at any time. As noted by University of Washington (www.washington.edu) doctoral student Roxana Geambasu, “When you send out a sensitive email to a few friends, you have no idea where that email is going to end up. For instance, your friend could lose her laptop or cell phone, her data could be exposed by malware or a hacker, or a subpoena could require your email service to reveal your messages.”

But Geambasu and some other students at UW’s department of computer science and engineering have created a prototype system called “Vanish” that can place a time limit on text uploaded to any Web service through a browser — essentially making it self-destruct over time. The process is a little complex to cover here, but it basically “washes away” data using the natural turnover (called “churn”) on peer-to-peer networks.

It’s still in the prototype stage, but you can read the documentation and even download it from vanish.cs.washington.edu. You just need to have Java 5 or higher and Firefox on your machine. Vanish has been successfully tested on Fedora Core 7, Ubuntu Jaunty, Mac OS X 10.4+, Windows XP, and Windows 7, and it will probably work on other platforms, as well.

**MULTI-TERABYTE TAPE**

For most of us, tape drives seem about as modern as wringer washing machines, but tape backup — at less than $0.04 per gigabyte — still offers a significant cost advantage over other storage systems. The present standard is the Ultrium LTO-4 format, defined and licensed by the Linear Open Tape consortium of drive manufacturers HP, IBM, and Quantum (www.trustlto.com). LTO-4 tapes have a raw (native) capacity of 800 GB, but a new version — appropriately dubbed LTO-5 — will offer 1.6 TB native and 3.2 TB compressed.

Media manufacturer Ilation (www.imation.com) recently announced that it will be introducing the next-generation LTO-5 cartridges early next year. The tape uses metal particulate media and employs Imation’s proprietary TeraAngstrom™ technology which produces a significantly smoother surface and a high signal-to-noise ratio (SNR) to deliver reduced errors and faster transfer rates. Compressed data transfer rates run up to 360 MB/second — a significant improvement over previous tape generations.

At present, Imation is the only company licensed to manufacture the new tape format, although Fujifilm has at least tentative plans to join in. The interesting thing is that we couldn’t locate anyone who can sell you a LTO-5 drive or has announced a specific product. But presumably at least one of the big three (or competitor Tandberg) will come up with something. Notably, there is already a roadmap to LTO-6.
— a 3.2 TB format — on the drawing boards, but with the future of the tape drive market being somewhat questionable, no one is sure it will ever appear.

ARE YOU AN IDIOT OR WHAT?

One would think that all Internet users — having been pummeled for years by spam and viruses — would have learned something. But according to a report by the Messaging Anti-Abuse Working Group (MAAWG), almost a third of surveyed consumers admitted to responding to a message they believed to be spam, and 80 percent doubted that their PCs were at risk of ever being infected by a “bot.” The report is based on 800 interviews with users in the United States and Canada who are not security experts and whose email addresses are not managed by a professional IT department.

To download the depressing report, visit www.maawg.org and click on the “MAAWG Consumer Survey...” links. The MAAWG general meeting, by the way, will take place Oct. 26-28 in Philadelphia, so if you are interested and don’t mind the $400 registration fee, you might want to check it out.

CIRCUITS AND DEVICES

CAMERA FEATURES ULTRA-WIDE-ANGLE LENS

There is no shortage of choices if you’re looking for a digital camera, but you might want to consider the new LUMIX DMC-ZR1 from Panasonic, especially if you like wide-angle shots but also want a long-range zoom. This 12.1 MP unit features “the world’s first 0.3 mm thin aspherical lens” which allows the body to remain compact while providing an optical zoom range of 25-200 mm.

Other features include high-speed autofocus, a 2.7 inch LCD screen, an optical image stabilizer, and the other usual niceties. And, yes, you can choose among black, red, blue, and silver. Suggested retail price is $279.95.

iPOD RECORDING DEVICE

There is also no shortage of iPod accessories, but a pretty neat one is Mikey from Blue Microphones (www.bluemic.com). Mikey essentially turns the iPod into a recording device so you can capture lectures, live music, and pretty much any form of audio presentation. It is built around Blue’s stereo condenser capsules and features three-position user-selectable gain settings, a speaker for playback, and a 180° pivoting mike head that can be set in a variety of positions for optimal recording. You can also choose from three sensitivity levels, so whether you use it to capture a Metallica concert or a poetry reading at Barnes & Noble, you’re covered.

According to Blue Mic, it requires no software installation and will record continuously for up to four hours. Musicians may want to note that Mikey can record and store up to four tracks, which can then be mixed down to allow even more tracks.

As of this writing, detailed technical specs were essentially nonexistent, with neither the company’s website nor the Mikey manual providing even rudimentary data such as frequency range. But for $79.99, you can’t go far wrong. NV
Companies have been trying to produce a suitable e-book reader for years. None have been practical or affordable, and worst still people didn’t really enjoy the reading experience. However, the latest technology now makes it possible to create a truly desirable e-book reader. Probably the best example is Amazon’s Kindle (see Figure 1). The first generation unit came out in 2007 and was a big hit. Amazon’s second generation device called the Kindle2 is an even bigger hit. I bought one recently and for the first time I see that such a device is highly usable. It is also innovative.

The Kindle2 is about the size of a large paperback book at 5.5 x 8 inches. The six inch (diagonal) screen is a high contrast black on white LCD. The device is one of the thinnest electronic products I have ever seen and it is very light — lighter than most of the books you might read. The Kindle2 also has a huge 2 GB Flash memory to store books, magazines, and newspapers. Amazon claims you can store up to 1,500 books. (That ought to be enough for a long time!) I regularly read about 60 books per year, so in about 25 years the memory will be full.

The controls are pretty easy to use. There are pushbuttons for next page, previous page, menu, home, back, and a navigation scroll button. A full keyboard is also provided with a search function. You can even change the font size to fit your eyeballs. If you are not a good reader, the Kindle has a text to voice output. Just plug in your headset and let the device read to you (like an audio book if you like those).

The coolest feature of the Kindle2 is the built-in cell phone. You don’t use it to make calls and there is no monthly phone bill to worry about. It is a dedicated Sprint connection back to Amazon, so the phone lets you review and buy books directly. I have already bought five books this way. They download in under a minute. (Talk about convenient!) The good news is that e-books are much cheaper than print books simply because there is no paper or printing involved. Most current best-seller books cost approx. $9.95 vs. the $20 to $27 of a printed version and many books are free. The price of the Kindle2 is about the only downside of this innovative product. At $359, you need to read a lot of books, but I suspect my unit will pay for itself in less than a year.

As for the actual reading experience, it is fine. I thought I would have to go through an adaptive process to get used to reading from a screen, but I didn’t. I actually hate reading from a computer screen but the Kindle2 is as close to a printed book as you will probably get electronically. There are hundreds of thousands of book choices to choose already,
Incidentally, Amazon has a newer model called the DX that has all the same features of the Kindle2 but with a much larger 9.7 inch screen. This model is designed to better display newspapers, magazines, and college textbooks. The DX model will also display PDF documents so it has potential as a business tool. It also has a larger memory that can hold up to 4,000 books, but at a cost of $489. Personally, I have never felt constrained by the six inch screen, but no doubt some content is better displayed all on one page without scrolling.

**OTHER E-BOOKS**

There are other e-book readers on the market from Sony, Plastic Logic, and iRex. However, none have been as successful as the Kindle. The Sony models definitely deserve consideration. Sony has an extensive line of e-book readers with prices from less than $200 to near $400. Their Reader Digital Book called the PRS-700 sells for $349 and has a six inch E-Ink screen like the Kindle. It has a 512 MB Flash memory to hold up to 350 average size books.

Sony’s latest models are the Reader Pocket Edition (Figure 2) and the Reader Touch Edition. Both feature an E-Ink display and come in a variety of colors. The pocket edition has a five inch screen and sells for $199. It can store up to 350 books. The Touch version has a six inch touch screen that also lets you write on it with a stylus to annotate pages or highlight text. Its price is $299. Both products come with a protective sleeve and the USB cable for connecting to your PC so you can download books from Sony’ eBook Store (which has hundreds of thousands of titles).

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The iRex device called the iLiad is a high-end device with a 10.2 inch display. It is a touch screen with a 768 x 1,024 pixel resolution. The price is a whopping $859. This device lets you write on the screen to make notes or highlight text. It runs the Intel XScale processor and has a 256 MB Flash memory.

Another feature is built-in stereo audio speakers or headphones. Instead of a cell phone inside, it uses Wi-Fi for wireless connection to a hot spot with 802.11b/g technology to download books. A 10/100 MHz Ethernet port is built in, as well.

Plastic Logic has a forthcoming reader called the eReader. It is not available yet but should be soon. It has a full 8.5 by 11 inch (14 inch diagonal) screen with touch screen manipulation. It will have wired and wireless communications capability. Look for it in early 2010.

Samsung also recently released an e-book reader for their Korean customers. The unit is not available in the US, but my guess is you can expect one in the near future. Even Apple is said to be working on some kind of e-book reader.

**WHERE YOU GET BOOKS**

For E-book readers to be successful, there has to be a huge base of books to draw from. Publishers and the e-book reader companies are spending big bucks to make sure you never run out of things to read.

Amazon claims they have 270,000 books available for the Kindles and new ones become available daily. They are categorized well and you can search for what you want. Sony also has a massive collection of over 500,000 books thanks to a deal with Google who has digitized a jillion books over the past several years.

Some publishers are rushing to get textbooks out for e-book readers.
For example, CourseSmart is a joint venture of McGraw-Hill, Pearson Education, and four other publishers who are offering students a rental or subscription to their books. You can rent for 30, 60, or 180 days after which access expires. Many colleges (and publishers) are currently testing the electronic textbook idea with somewhat mixed results from students. With high textbook prices and publishers losing money thanks to used book resales, I suspect the e-book will happen sooner rather than later.

Another source of e-books is Scribd — a website that lets you read documents online. It will have 5,000 plus titles available from Simon & Schuster. And don’t forget Barnes & Noble. Google (now making their books available via Sony) is expected to announce a separate e-book store itself in the future. My guess is that there is roughly a million books available now with many more to come. I haven’t seen any technical books yet, but hopefully we will see that in the future.

You can also get subscriptions to most of the major newspapers (Wall Street Journal, USA Today, etc.) and many magazines. Prices are a bit lower than the print version. The larger screen readers are probably better for these, but smaller readers do okay.

Basically, there is no shortage of stuff to read on an e-reader and the real tidal wave of material is yet to come.

An important thing to keep in mind is to be sure that the book you are downloading is compatible with your reader. There are several e-book file formats too numerous to discuss here. Some are proprietary and others open. Most online sources will clue you in about this to ensure a match with your reader.

**FUTURE OR FAD?**

If you are skeptical about electronic books, think of this. We communicate with photographs as much (if not more) as we do with text. Look what has happened to the photography and film business over the past 10 to 15 years. Film cameras have almost disappeared and finding film for that 35 mm SLR you spent a fortune on a while back is a nightmare. Now, you can now get a 10 or 12 megapixel camera for $100 or so. Plus, a high percentage of cell phones now contain a two or three megapixel camera.

My guess is that the same thing will happen with electronic books. Once the copyright, royalty, and distribution issues are resolved, we’ll be able to get virtually any book in electronic form. You’ll be able to carry your whole library around in an e-reader that’s the size of a standard book. I like that scenario but I am a bit saddened at the thought of the loss of all those hard copy books.

I have a huge library now that won’t just go away, but it looks like I won’t be adding to it much in the future. **NV**
In the Workshop, we’ve been using a new development board and components kit: the Arduino Duemilanove and the Arduino Projects Kit (available from Nuts & Volts and Smiley Micros). We recognized that The Arduino Way (TAW) is a very simple and easy way to begin using microcontrollers. And we learned that while TAW uses a C-like language, it does not (IMHO) provide a clear path to learning the C or AVR architecture — both of which are our long-term goals for this Workshop series. So, we were introduced to A C Way (ACW) that uses more standard (again IMHO) AVR tools. We decided to discuss projects using the kit with TAW, but also provide the software ACW in the Workshop zip file for those ready to move on. After we’ve introduced all the kit parts, we will then move exclusively to ACW since we will be looking at issues that are more difficult to accomplish with TAW (such as using timer interrupts).

Last month, we learned to measure light and temperature, and faked showing decimal numbers from data stored as integers. This month, we are going to learn about IR (infrared) object detection.

**But Is It Light?**

In Figure 1, we see Cute L’il Bunny in the dark having her very last thought. What she doesn’t know is that bad ol’ Mr. Snake is a pit viper and has a couple of IR Object Detectors located in pits on either side of his head between his eyes and his nose. These sensors allow him to triangulate on objects that are hotter than the surrounding environment, such as bunnies that think they are well hidden in the dark but are actually glowing brightly to the snake. Yum.

William Herschel accidentally discovered infrared radiation in 1800. He used a prism to split sunlight into colors and placed thermometers along the spectrum to measure the temperatures of the colors. He was shocked to note that the hottest part occurred in the unlit area just below the visible red zone, which he named infrared (infra means below). [Incidentally, in 1781 he discovered Uranus, but I don’t know if thermometers were involved.]

We cannot see IR with our eyes, but if the source is intense we can ‘see’ it with our skin as the perception of warmth. You can close your eyes tightly and find a nearby heater by holding your palms out and turning around until you feel the heat — this isn’t exactly high resolution ‘seeing’ but it is ‘perceiving’ IR light.

You might think it would be cool if we could see IR with our eyes. Well, think about that for a moment. Since we operate at 98.6°F, we — like that poor bunny — are beacons of IR light and if we could see it we would be blinded by the emissions in our own eyeballs. Snakes can use IR because they are cold blooded. Figure 2 shows a NASA thermoscan of a dog that — in addition to looking really creepy — provides a false color view at how the dog might appear to something that can see IR.

Even though you can’t see IR with your own eyes, you can detect it with a digital camera. Just hold a TV remote...
pointed at your camera (even a cellphone camera will show this) and press the power button. With your eyes you see nothing but as shown in Figure 3, the camera shows a light.

**Some Common Uses For IR Sensors**

One of our most common electronic IR emitters is, of course, on that blessing to couch potatoes everywhere: the TV remote control. It broadcasts a coded IR signal to the IR detector on the TV console that decodes the signal and saves you the excruciating drudgery of waddling over to the TV to change the channel.

And where would the military be without IR for target acquisition? Fire a Sidewinder missile (named after a pit viper) at the exhaust pipe of your enemy’s jet and say good-bye to your little friend. Another cool way to improve your kill skill is with night vision goggles. This way you can be like Mr. Snake.

There are many other uses, such as on a factory production line that senses tomato soup cans passing on a conveyer belt. This is much more boring than blasting enemies (or eating bunnies), but that’s the practical example we will construct by the end of this Workshop.

**IR Reflective Object Sensor: The QRD1114**

The Arduino Projects Kit has an IR Reflective Object Sensor (the QRD1114) that we will use for several projects. The QRD1114 is made from an IR LED emitter, an IR phototransistor detector, and an IR opaque shield that holds them together. You can remove the emitter and detector by holding the legs and pushing toward the front of the device. If you do this, remember which way the legs were so that you can get it reassembled properly. Also remember to watch for protruding beyond the shield, as this will radically affect the way the device works. The functional concept is simple: The shielded emitter radiates IR from the open end which can only be seen by the shielded detector if the IR bounces off something. This is shown in a cut-away view in Figure 4.

**Making IR Visible**

The QRD1114 must be calibrated to a specific application to be used to its greatest effect. Calibration is necessary for two main reasons: 1. The sensor detects IR not just from the reflections of the associated emitter, but from ambient (environmental) IR; and 2. The amount of IR reflected back from the emitter varies with the IR reflectivity of the reflecting object and the distance to that object.

**IR Doesn’t Know Black From White**

White reflects all visible light and black absorbs it. You might think that a white area would reflect more IR back to the sensor than a black area. I did, but it turns out that the operative part of the definition of black and white is ‘visible.’ Some things that appear black and white to me reflect the same amount of IR and look identical to the IR sensor. I printed my first motor wheel encoder on photographic paper and my detector couldn’t tell the difference in the white and black bars.

Naturally, I assumed that the problem was something in the software or hardware and spent a lot of time looking for a bug. It turns out that printing the same image on plain paper works pretty well. Apparently, the shiny surface of the photo paper is transparent to the human eye but reflects the incidental IR. I found that I got an even better sensor reading if I went over the plain paper printed black areas with a black Sharpie© ink pen. Again, I couldn’t see much difference but the detector sure could.

**Breadboard: Show Invisible IR Intensity With Visible Red LED**

You can see a drawing of the QRD1114 along with its schematic symbol in Figure 5.
We are going to carefully bend the legs on the QRD1114, as shown in Figure 6, so that we can mount it on the end of the breadboard with it ‘looking’ to the horizontal. Be very careful when you bend these legs and even more careful when you trim them to fit in the breadboard. The legs will break if bent more than a couple of times so make sure you get it right the first time. It is very easy to lose track of which leg goes where and since you only get one of these in the kit, you don’t want to screw this up. Bend the legs that go to the phototransistor straight down to the side and then bend the IR LED legs in the same direction, but make the bend a little over 0.1 inch from the bottom. Next, trim them so that they will fit in the breadboard with the face of the sensor at the edge of the breadboard (but not overlapping the foamcore base since that edge slides into the ALP box). The breadboard schematic is shown in Figure 7 and the layout in Figure 8. Figure 9 is a photo of the IR object detector.

As you can see from the schematic, a red LED has been inserted into the circuit that has its brightness controlled by the detector, providing us with a visible cue for the amount of IR being detected. The IR light falling on the phototransistor base provides the bias current that controls the collector emitter current that flows through the LED. You can move your finger back and forth in front of the sensor and the red LED will brighten or dim in response. This is a purely analog response and could — with proper amplification — be used to drive some other analog device such as a motor.

We can get a digital measure of this response by putting a 10 KW resistor from ground to the phototransistor and running a wire from that point to the Arduino ADC in analog input pin 0 as shown in the schematic. Let’s apply this to a real-world experiment (and by ‘real’ I mean ‘contrived’).

**Tomato Soup Can Counter**

I went a little overboard when I did this experiment. I made a foamcore board ‘conveyer belt’ where I placed six Tomato soup cans (reduced sodium for a healthier experiment) and dragged them past the sensor to get calibration values. Figure 10 shows the device in the starting position and after the cans have been conveyed past the sensor.

As for the construction details, I used foamcore board and masking tape, and eyeballed everything. So should you — it’s a
prototype, so expect imperfections. The ‘belt’ should be a little wider than a soup can and long enough to hold six cans (which is the number I had in my pantry), while the ‘base’ should be just slightly wider than the belt so you can slide the cans past the QRD1114 as shown in the pictures. The IR detector should almost touch the soup cans as they pass by to get a good reflection.

**Tomato Soup Can Counter Software**

You have no way to predict the ADC values for the IR returned from a particular object other than it will be between 0 and 1,023. I did preliminary tests using the ReadPot TAW source code in the Arduino IDE (from Smiley’s Workshop 12) and substituting the detector for the potentiometer. The data shown in Figure 11 varied from a low of 145 to a high of 799 for my finger (your finger will probably be different).

When I set up the soup can conveyer and slowly moved a can past the sensor while observing the results from the ReadPot TAW software on the Arduino Serial Monitor (slow since the code is only measuring once per second), I saw a range of values above (>600) which I could be certain that a can is present and another range below which I could be sure there was no can present (<300). There is also a sloppy mid range where I couldn’t be sure (301 to 599). Remember your values won’t be the same as mine. You must make your own measurements to determine the certain ranges: YES_CAN and NO_CAN, then use a true/false variable ‘yes’ to decide if a can has passed the sensor. There really are many ways to do this kind of thing, but I selected the easy (for me) to understand logic of:

If the analogInput is greater than YES_CAN and yes is equal to 0, then set yes to 1. 
Else if analogInput is less than NO_CAN and yes is equal to 1, then set yes equal to 0 and increment the can count.

Think about this for a moment from the perspective of a can moving by the sensor. Before the can gets there, ‘yes’ is equal to 0 for false and the analogInput value is less than the YES_CAN constant we have predetermined that indicates a can is present. As the can moves into view of the sensor, at some point analogValue becomes greater than YES_CAN so we know there is a can and we set ‘yes’ equal to 1 for true (yup, there is definitely a can present). Then, we keep measuring as the can slides past and the analogInput drops to a value less than NO_CAN. We check and see that ‘yes’ is true, so there was a can, but now our analogInput reading says there is no can, so it must have passed by. We set ‘yes’ to 0 and increment the can count. Whew! This will probably
be clearer from reading the source code.

I put YES_CAN and NO_CAN in the Tomato_Soup _Can_Counter source code as hard-coded constants (this is not a good programming practice, but it is useful here for keeping things simple).

```c
// Tomato_Soup_Can_Counter
// Joe Pardue June 27, 2009

// Sensor level constants
#define NO_CAN 300
#define YES_CAN 600

// 0 if NO_CAN, 1 if YES_CAN
int yes = 0;
// Can count
int count = 0;
// variable for analog input value
int analogValue = 0;

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

void loop()
{
    // read the analog input on pin 0
    analogValue = analogRead(0);

    // print prolog to value
    Serial.print("ADC Reading: ");
    Serial.print(analogValue, DEC);

    // If the analogInput is greater than YES_CAN
    // and yes is equal 0 set yes to 1.
    // If analogInput is less than NO_CAN
    // and yes is equal 1, set yes equal 0
    // and increment count.
    if ((analogValue > YES_CAN) & (yes == 0)){
        yes = 1;
        Serial.print(" - YES_CAN");
    }
    else if ((analogValue < NO_CAN) & (yes == 1)){
        yes = 0;
        Serial.print(" - NO_CAN");
        count++;
    }

    // show the count
    Serial.print(" count = ");
    Serial.print(count, DEC);

    // print a newline
    Serial.println();

    // delay 1 second before the next reading:
    delay(1000);
}
```

For this demonstration, I kept the time between ADC readings at one second to avoid being overwhelmed with serial data. When I first tried counting the cans, I got some weird can counts and found that I had to make my conveyer belt narrower so that the cans were all pretty close to the sensor when they passed. The serial output is shown in Figure 12.

Once you get the system calibrated, you should be able to remove the serial output and the one second delay, and set a flag so that you only output the count when it changes.

Please note that you should leave the detector circuit in place on the breadboard for next month’s article. NV

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**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.
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**Ramsey Spooktacular Halloween Treats!**

**Blinky-Eyes Animated Display**
- Animated display of 66 super bright LED's!
- Microcontroller controlled!
- Changes brightness automatically!
- Animated with constant motion!

The ultimate animated LED kit that will dazzle you and delight your friends! Uses a microcontroller to randomly select from many different animations such as a long pause before a wink, or a twinkle of the eye to startle passers-by!

Four modes to satisfy any enthusiast's desires: 1. Off for long random periods, then blinks or winks. Designed to scare! 2. On for long periods before performing an animation, perfect for costumes and displays! 3. Animates all the time for constant motion, perfect display attention-getter. 4. Random fire! When placed in a pumpkin it will light up like you wouldn't believe! As if this weren't enough, the BE66 can also control a small hobby motor to shake bushes at random intervals or signal an external player to make a scary sound! Also has a CDS cell to sense light. In one mode, the display will dim as it gets dark for battery operation, and in the other it will turn off when it's too bright, so it plays only in the dark!

**BE66 Blinky-Eyes Animated Display Kit $59.95**

**Laser Light Show**
- Audio input modulates pattern!
- Adjustable pattern rate!
- Projects neat motorized patterns!
- Uses safe plastic mirrors!

You've probably seen a laser show at concerts or on TV. They're pretty impressive to say the least! Knowing that you can't afford a professional laser display we challenged our engineers to design one that's neat and easy to build, yet inexpensive.

Well, the result is the LLS1 Laser Light Show! This thing is sweet and perfect for your haunted house or halloween parties! It utilizes two small motors and a small standard laser pointer as the basics. Then, we gave it variable pattern and speed controls to customize the pattern!

Not enough, you say? How about a line level audio input to modulate the pattern with your CD's, music, or spooky sound effects? You bet! Everything is included, even the small laser pointer. Runs on 6-12 VDC or our standard AC adapter.

**LLS1 Laser Light Show Kit $49.95**

**BE66 110VAC Power Supply $9.95**

**Tri-Field Meter & “Ghost Detector”**
- See electric, magnetic, and RF fields!
- Watch the magnetic fields of the earth!
- Sense different magnetic poles!
- Detect RF transmitter fields!
- Graphical LED display allows you to “see” the invisible fields!
- Great learning tool for EMF, RF, and magnetic field theory.

Call it a Tri-Field Meter, an Electrical, Magnetic, and RF Detector, a Ghost Detector, or a Tricorder, but walking around with this on Halloween will seriously impress even the most doubting!

The TFM3C has three separate field sensors that are user selectable to provide a really cool readout on two highly graphical LED bargraphs! Utilizing the latest technology, including Hall Effect sensors, you can walk around your house and actually “SEE” these fields around you! You will be amazed at what you see. How sensitive is it? Well, you can see the magnetic field of the earth... THAT'S sensitive!

The technical applications are endless. Use it to detect radiation from monitors and TV’s, electrical discharges from appliances, RF emissions from unknown or hidden transmitters and RF sources, and a whole lot more! If you're wondering whether your wireless project or even your cell phone is working, you can easily check for RF. A 4-position switch in the center allows you to select electric, magnetic, or RF fields. A front panel “zero adjust” allows you to set the sensors and displays to a known clean “starting point.”

If the TFM3C looks familiar, it’s probably because you saw it in use on the CBS show Ghost Whisperer! It was used throughout one episode (#78, 02-27-2009) to detect the presence of ghosts!

The concept is simple, it is believed (by the believers!) that ghosts give off an electric field that can be detected with the appropriate equipment. In the electric mode, the TFM3C’s displays will wander away from zero even though there isn’t a clear reason for it (not scientifically explainable, aka paranormal!). This would mean something has begun to give off an electric field. What it was in the Ghost Whisperer was a friendly ghost. What it will be in your house... who knows! Makes a GREAT learning project besides! Requires 4 AA batteries.

**TFM3C Tri-Field Meter Kit With Case $74.95**

**Automatic Animated Ghost**
- Automatically greets your visitors!
- Responds to sudden noises!
- Built-in microphone!
- Adjustable sensitivity

Who says ghosts are make believe? Once your friends come upon this one they'll think differently! The unique circuit board design includes two ominous blinking eyes that change with various conditions, including sudden changes in ambient noise. A highly sensitive built-in microphone picks up anything from noises to talking and makes the ghost dance with its built-in motor, make eerie sounds with the built-in speaker, and randomly blink. A white cloth and a hanger are included as shown to make it look like the real thing. Runs on 2 AAA batteries (Not included).

**MK166 Automatic Animated Ghost Kit $21.95**

**Halloween Pumpkin**
- 25 bright LED’s!
- Random flash simulates flickering candle!
- Super bright LED illuminates entire pumpkin!
- Simple & safe 9V battery operation

The perfect “starter” kit with a terrific Halloween theme! You won't be scraping and cutting and getting your hands all messy! A simple transistor circuit provides a neat random flash pattern that looks just like a flickering candle. Then a super bright LED illuminates the entire pumpkin with a spooky glow!

The pumpkin face is the actual PC board, and assembly is easy through-hole soldering of all components and LED's. Your pumpkin is powered by a standard 9V battery (not included) which snaps to the back of the pumpkin. An on/off switch is also included. Create a new kind of pumpkin this year, and learn about LED's and electronics at the same time!

**MK145 Electronic Halloween Pumpkin Kit $10.95**

**Portable EL Electroluminescence**
- 3.3 feet long!
- Low power consumption!
- Highly visible brilliant colors

Electroluminescence illuminated flexible wire sets can be used for a lot of things but when they’re battery powered they’re perfect for Halloween and Trick or Treat safety concerns! Each thin, flexible EL wire set is 3.3' long and runs on two standard AA batteries (not included). Current consumption is less than 100mA for long life.

Mode settings include steady glow and slow or fast flash! Make it part of a brilliantly lit, custom designed costume or simply add it for illuminated safety while Trick or Treating in the dark.

**NWR15 EL Illumination Wire Set, Red $19.95**

**NWR15 EL Illumination Wire Set, Green $19.95**

**NWR15 EL Illumination Wire Set, Blue $19.95**

**Spark Generating MY Plasma Generator**
- Generate 2” sparks to a handheld screwdriver!
- Light fluorescent tubes without wires!
- Build your own Plasma Balls!
- Generates up to 25kV @ 20 kHz from a solid state circuit!

This popular kit was conceived by one of our engineers who likes to play with things that can generate large, loud sparks, and other frightening devices! And at Halloween there’s no better effect than high voltage sparks flying through the air! The PG13 Plasma Generator creates a very impressive 25,000 volts at 20 kHz, to provide a stunning display of high voltage! It will draw a cool looking 2” spark to hand held screwdriver, or light fluorescent tubes without any connection!

It produces stunning lighting displays, drawing big sparks, to perform lots of high voltage experiments. In the picture, we took a regular clear “Decora” style light bulb and connected it to the PG13 - WOW! A storm of sparks, light traces and plasma filled the room! Holding your hand on the bulb doesn’t hurt a bit and you can control the discharge! It can also be used for powering other experiments; let your imagination be your guide! Operates on 16VAC/VDC for maximum output. Can also be run from 5-16VAC/VDC to reduce the output voltage.

**PG13 Plasma Generator Kit $64.95**

**PS21 110VAC Input, 16VAC Output, Power Supply $19.95**
Practice Guitar Amp & DI

Practice your guitar without driving your family or neighbors nuts! Works with any electric, acoustic-electric, or bass guitar. Plug your MP3 player into the aux input and practice to your favorite music! Drives standard head-phones and also works as a great DI! $64.95

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Exactly duplicates the upward and downward wail of a police siren. Switch closure produces upward wail, releasing it makes it return downward. Produces a loud 5W output, and will drive any speaker! Horn speakers sound the best! Runs on 6-12VDC.

$7.95

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tuneable with a precision 20 turn pot. Great for sub-audible “CTS” tone squelch enoders. DRives any low voltage load up to 100mA. Runs on 5-12V DC.

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Walking Electronic Bug

Built around a pair of subminiature cell phone microphones, this bug wanders around looking for a sound into! Sensors below his LED eyes sense proximity and make him turn away! Steer him with Flashlight too! Runs on two “N” batteries.

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Learn all about SMT parts and how to solder them! Surface mount parts are tiny and require a special skill to solder. This lab and course covers it all, and you end up with a great “Decision Maker” kit when done!

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We’ve discussed tweezers and magnifiers while working with SMT components. Working with highly sensitive components, ESD safe tweezers can be a life saver! This set of 4 non-conductive tweezers are perfect for any static sensitive devices, and are priced right!

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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

GAME SHOW LOCKOUT

Q I saw a comment in a forum about a game show lock-out and was wondering if you had a schematic or description of the circuit I could use. I only need a two person buzzer system.

— Michael Hickmon

A I answered a similar question in my very first column, May 2007, page 29, but that was more complex than what you need. This solution is adapted from a Pinewood Derby design I did many years ago. In Figure 1, the flip-flops are initially reset by the game master so the NOT-Q outputs are high. When contestant A or B presses his switch, the Q output goes high and the NOT_Q output goes low, lighting the LED and sounding the buzzer. I thought it would be annoying for the buzzer to be sounding until reset, so I put in an R-C which will allow the buzzer to sound for about one second, until the capacitor charges up. IC4 is an inverted OR gate; when any input goes low, the output goes high. I used 74AC logic because it has high output current capability and paralleled the outputs of IC4 for up to 100 mA drive.

The parts list is Figure 2; those are all Mouser part numbers.

MICROCONTROLLERS

Q I wish to step up from the 555s, etc., to micro-controllers for projects as found in Smiley’s Workshop, PICAXE Primer, Getting Started with PICs, and others found in N & V. My questions are: 1. Would you share your pros and cons on microcontrollers by AVR vs. PICAXE vs. Microchip’s PIC line? 2. What devices do I need to program with a computer? 3. What devices do I need to program without a computer? 4. Now that I have the car, where can I get driving instructions?

— Weldon Thorp

A I will answer your questions in reverse: 4. Not knowing where you are, I can’t answer that. 3. I don’t want to think about how you would program without a computer. 2. You could program in assembly code which is converted to hex code that the micro understands or, more likely, you would program in a higher level language such as C or
Basic which is converted into assembly code which, in turn, is converted into hex code. In any case, you will need a cable to connect the computer to the micro, and a suitable platform for the micro. I am a novice when it comes to microcontrollers and know nothing about AVR. I have looked into PICAXE and I have worked with PICs. It is my observation that PICAXE is aimed toward the novice and some flexibility is sacrificed for simplicity. PICAXE uses the Microchip devices and loads a bootstrap program that allows the novice to download the program to the chip without a “programmer.” The big advantage of the PICAXE system is that the Basic software is free. Microchip has a free version of its software with limited lines of code but the pro version is expensive.

If you start with PICAXE, you will soon want to upgrade to PICs, so I think you will be wise to start with PICs.

**MICROPROCESSORS**

A microprocessor is completely foreign territory to me. I appreciate the simplicity and low parts count of your circuits, but what do you need in order to get the program you supplied into the PIC? In looking up the part and its datasheet, I find reference to a compiler and perhaps other equipment. While the chip itself is in the order of $1.20, the referenced compiler looks to run in the order of $100+. Assuming I have nothing other than a computer on hand to begin with — which I don’t — can you give me a list of what I would have to get in addition to the PIC in order to make it work? About how much might it all cost and could it be used with any subsequent microprocessor, or do you need to get new equipment for each different microprocessor?

I have shied away from micros for many years but would like to get my feet wet now. Any help you can offer would be greatly appreciated.

— Clark Kuhl

Microchip does have a free version of their software, but it has limited application and program size. I initially used a programmer from [www.elproducts.com](http://www.elproducts.com) which cost $24.95. I now use a different one with a zero force socket and USB interface which costs $129.90. The Basic software from Microchip is expensive but they have a free demo version with a limit of 31 lines of code. Crownhill also has a compiler which I evaluated and did not like the syntax. However, others may like it and there is a free version which supports many PIC devices; look for Proton Lite in Figure 3.

The PICAXE system may be best for “getting your feet wet” with micros. The cost is comparable to PIC programming with demo versions but you can write large programs with the free software. See the Mailbag for more on this system. Figure 3 is a catalog of available software and hardware that I know about.

**RADIO DISTANCE MEASUREMENT**

I would like to build a system for measuring distances from one to 50 meters. I envision two electronic units: A and B. Each unit contains a transmitter and receiver. Transmitter A sends a signal to receiver B. Receipt of the signal by B causes B to transmit a signal back to receiver A. Receipt of the signal by A causes A to transmit another signal to B. This relay process continues until inhibited by a microcontroller in unit A. At a distance of one meter, the time for radio wave transmission...

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### AVAILABLE PIC PRODUCTS

**WEBSITE**

- [www.beginnerelectronics.com/beginner/Products.php](http://www.beginnerelectronics.com/beginner/Products.php)
- [www.melabs.com/pbpdemo.htm](http://www.melabs.com/pbpdemo.htm)
- [www.melabs.com/products/pbc.htm](http://www.melabs.com/products/pbc.htm)
- [www.melabs.com/products/usbprog.htm](http://www.melabs.com/products/usbprog.htm)
- [www.melabs.com/products/adapters/dlapadpt.htm#Adapters](http://www.melabs.com/products/adapters/dlapadpt.htm#Adapters)
- [www.picbasic.org/proton_development_suite.php](http://www.picbasic.org/proton_development_suite.php)
- [www.picbasic.org/proton_lite.php](http://www.picbasic.org/proton_lite.php)
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**DESCRIPTION**

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- SERIAL CABLE
- PICBASIC PRO COMPILER DEMO
- PICBASIC COMPILER
- U2 USB PROGRAMMER
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- $39.95
- $168.92
- FREE
- $23.64
- $23.64

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**QUESTIONS & ANSWERS**

**Q**

Nothing other than a computer on the order of $100+. Assuming I have itself is in the order of $1.20, the reference to a compiler and perhaps you supplied into the PIC? In looking count of your circuits, but what do...
The first problem I see is that the difference between one meter and two meters is 3.3 nS. You are not able to change that. If you add 20 nS to each receiver, the loop time for one meter is 36.6 nS; the loop time for two meters is 43.2 nS. The corresponding frequencies are 27.3 MHz and 23.15 MHz. You can easily purchase a counter for those frequencies and, with a lookup table, convert to distance. You would want about a 10 nS pulse at 3 or more GHz for the signal. Nanosecond pulses and GHz frequencies are out of my comfort zone, so I can’t help you there. I am too much of a neophyte to attempt the counter/micro interface but it does not seem complicated for a knowledgeable person.

The circuit is powered by the t-stat signal but it could just as well have been powered by the 24 VAC source. The time delay is about 16 seconds with C3 = 15 µF. The parts list is Figure 5.

I initially planned to send the t-stat signal to the gate of the triac with just capacitor coupling similar to the 555 trigger (except positive rectified), but I breadboarded it and found that the triac turns on easily for the positive alternations of AC but requires nearly 5 mA drive to turn on the negative alternation. Not knowing how the relay would react to half wave rectified current, I decided to use the 555 to give a clean 5 mA turn-on signal.

A 12 VOLT FLUORESCENT BALLAST

A while back, you mentioned that you preferred fluorescent to LEDs for high efficiency lighting. Could you design a small, lightweight, efficient, and inexpensive ballast circuit to power fluorescent lamps of different wattages? It would need to be able to work with input voltages of 12.5-14.5 VDC. Please use currently available parts; most examples of this sort of thing tend to use stuff from the designer’s scrap box and are not available to the average guy.
### MAILBAG

**Dear Russell:**

Re: generator voltage regulator; July 2009 issue, page 35.

There is an error with the generator voltage regulator circuit. It needs a diode between the output of the generator and the battery, or the battery will discharge into the generator when it is stopped. I did this on an old outboard boat motor which had a generator. If you look at the original regulator, it has a cutout relay to disconnect the generator from the battery when it is stopped.

— **Daniel Seraphoff**

Response: You are absolutely right. My 1959 Lancia design had the diode but I couldn’t find it, so I forgot. Mea culpa. I have corrected the schematic; see Figure A.

**Dear Russell:**

Re: July 2009 issue, page 32; Timer. What compiler did you use for the Figure 2 code?

— **Mike Selbel**

Response: I use PICBASIC PRO compiler from microEngineering Labs (www.melabs.com) and Micro Code Studio which is a program editor and an interface that makes programming simpler. MicroCode Studio is bundled with PICBASIC PRO. There is a free version with limited lines of code.

**Dear Russell:**

Re: July 2009 issue, page 32; Timer. I was reading the request from a reader named John S. Mitterer who was requesting some help with a circuit for his train set. Although I really liked the answer — and I learned from it — if John does not have the $200 PIC programmer, wouldn’t a 555 timer (as an off delay) be the easiest and least costly option for the simple thing he is attempting to do?

I think that the reason you may have picked the PIC is the problem of seeing through the gap between cars, and part of the solution was to have two photo eyes. I would direct the beam at a 45 (or so) degree angle across the track so it would not see through the space between cars. Then the circuit becomes extremely simple and cheap to do. I would also probably use a 2N6426 to operate the relay coil. I think the cost of these two parts is less than $1. Anyway, this has peaked my interest in PIC chips. I have a BASIC Stamp 1 and also a BS2 (just for learning) but need to know more basics about the PIC chip for low cost control. Looking forward to that.

— **Mark Deltrich**

Response: Mr. Mitterer had the same complaint, so I designed a 555 circuit for him, which will appear in a future column. I did not think of your 45 degree solution; I wish I had because it is really best.

**Dear Russell:**

Re: July 2009 issue, page 32; Timer. In your answer to John S. Mitterer concerning a timer/train detection circuit, are you assuming that he has a PIC programmer? Not everyone does. Why not recommend a PICAXE-08M. No programmer is required – just a serial cable, two resistors, and the free-to-download Program Editor from www.picaxe.co.uk.

— **Al Hooper**

Response: A lot of people are beating me up on that, but I have a standing offer to supply a programmed PIC for $5 (postage included in the USA). Your suggestion of using the PICAXE is interesting; I checked into it and plan to use the PICAXE in a micro solution soon.

**Dear Russell:**

Re: July 2009 issue, page 34; Figure 6. You did not give a part number for the tri-color LED. I take it that you did not give values for the current limiting resistors because it would change with the LED device used.

— **Ted Mieske**

Response: I was lazy and did not look up a part number for the tri-color LED. With 20-20 hindsight, I think the part would have four leads with a common anode and the resistors should have been on the cathode side.

**Dear Russell:**

Re: December 2009, page 24; 60 volt, 13 amp power supply. I tried to look up the Magnetics, Inc., core that you suggested (45021-EC) but could not find it in the Ferrite Cores catalog (2006 rev1). Their website search function could not find this core either. Is this a discontinued core or is the core number in error?

— **Emile Moore**

Response: The correct part number is 42501-EC, I don’t know how the numbers got mixed up, and perhaps my dyslexia is showing.

**Dear Russell:**

Just received my July issue of NV. Have a question on pages 32 to 33 (60 Hz generator) for W. Thorp; Figure 3. Can this circuit be changed to run at 400 Hz? Preferably 60 to 480 Hz. Also am thinking of changing Q2, Q3 to a LM675 power op-amp to drive a transformer backwards.

— **Craig Kendrick Sellen**

Response: To change the frequency, just change the resistors R1 and R2 by the ratio: 60/400. The circuit does not lend itself to tuning and if you want to have more power, just add it to the output. I am sure feedback around two opamps would oscillate.

**Dear Russell:**

Re: Class D amplifier; June 2009, pages 31-32. There has been a thread on the N&V forum about your Class D Amp that needs your clarification.

— **Charles Ryberg**

Response: I understand the confusion; the design only does the positive alternation of the audio. It does not work; I don’t know what I was thinking. Perhaps the design could be salvaged by repeating and paralleling the circuit with the output diodes reversed to give the negative alternation of audio – much like a class AB linear amp.
R1 limits the current to prevent damage to the transistor. The transistor remains cut off until the capacitors C1 and C2 charge up enough to turn Q1 on again and start the cycle over. The eight turn winding heats the filament which allows the tube to light at a lower voltage. The layout is not critical; I used a plug-in breadboard to test the circuit. The tube is not as bright as normal and the circuit draw is 1/2 amp at 12 volts.

The ferrite core is RadioShack part no. 273-104; it comes with a snap-together case (not used). You will want to make a pair of bobbins for the windings. I put the 40 turn primary, and the 30 and eight turn secondaries on one bobbin and the 400 turn secondary on the other bobbin. I used #26 wire for the primary and secondaries on one bobbin and #30 wire for the 400 turn secondary. Use Scotch tape to hold the wires in place. Make the bobbin out of heavy paper; a business card works well. I used a 3/8 and 1/2 inch punch to make end pieces. Figure 7 is the bobbin and Figure 8 is the finished transformer. Note the nylon tie holding everything together. I put a piece of business card between the two halves of the core to make an air gap, so the core does not saturate too soon. I used a TIP41C transistor but RadioShack has TIP3055 (276-2020) which should work. Other parts are available from RadioShack:

- 278-1345 Three spool wire set; includes #26 and #30
- 271-1113 330 ohm, 1/2W for R1
- 272-1019 Use for C3
- 271-1118 1K, 1/2W for R2
- 272-1051 Use for C1
- 272-1069 Connect them in series for C2

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The entire circuit and wires should be in a metal container to minimize RF interference. Use the metal box as a heatsink for Q1; it will need it. 

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The ezVGA-LV graphics controller comes housed in a 100 pin TQFP package that conforms to JEDEC MO-047. The ezVGA-LV can be purchased by itself for $7.95 (single piece price). It can also be purchased with a video memory chip for $12.95 (single piece price). The video memory comes in a 32-pin TSOP II package. Quantity pricing is available.

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The knob assembly began its life as the control for a Sharp VCR. The VCR was given to me after it had stopped working. I let my son dismantle the unit because he enjoys opening things up and taking them apart. When the unit was disassembled, I took particular notice of the knob assembly — what it was comprised of, how it was assembled; I was impressed by how much control was put into such a small unit.

In the center of the device were three buttons for play/X2, stop/eject, and pause/still. Around the perimeter was a spring return dial which when rotated clockwise would fast forward and reverse when rotated counterclockwise. It was refined to the point that a lot of thought must have had to been put into its design, and I knew that sooner or later it would end up in one of my projects.

The knob sat in the spare parts pile for awhile before the idea came to me to use it as a media player controller for my computer. While some keyboards have the media player controls built into them, my trusty old IBM model doesn’t. (I still use this relic because I like the feel of the beefy keys when I’m banging away at them.) I had been meaning to do a USB based device and thought the combination of the knob assembly and a PIC16C745 programmed as a media player controller would make for a challenging and useful project. For those of you who may not be aware, the 16C745 is a one time programmable device with low speed USB built into it. If I were to build the controller today, I would make use of one of the full speed, Flash-based USB PIC controllers.

The hardware is simple and straightforward too (see the schematic) — a group of switches wired to a PIC programmed to send the required command codes to control the Windows Media Player through a USB port. The hardest part of the project was getting the device to enumerate properly.

I made use of a microEngineering Labs (www.melabs.com) PICPROTO 3 board on which to assemble the project. The USB cable is available from HVW Technologies (www.hwtech.com); (SKU 14120) and features a series A USB plug at one end and a locking connector at the other. When the knob assembly was
removed from the VCR, it had a unique connector attached to it. I removed the connector and soldered a short section of ribbon cable and an eight-pin connector to it to mate with the eight-pin header on the PICPROTO3 board. With the electronics complete, it was time to select a housing to put it in.

There were a lot of options to house the controller. I decided to put it into a wooden enclosure which I made from a solid block of sugar maple. This allowed me to make the enclosure as small as possible, making it just large enough to house the PICPROTO board and the knob assembly.

The block was drilled with forstner bits to hollow it out and to make the hole for the shaft of the knob assembly. (Drill the hole for the shaft from the outside first to prevent tear out). Next, I epoxied two screws to the inside of the hollowed block and fastened the knob assembly using nuts and lock washers.

After a bit of sanding, the block was finished with tung oil. The pins were removed from the locking receptacle and the USB cable was fed through a small hole in the housing. A knot was tied as a strain relief and the pins were put back into the receptacle housing. The board was mounted to a piece of polyethylene using threaded standoffs. The polyethylene was then “friction” fit into the wooden housing. A couple of rubber feet on the bottom and the unit was ready to rock ’n roll.

What interesting things have you made out of recycled components, pulled from electronics whose best days are behind them? Share your “recycled” creations with other readers and enter our Recycled Projects contest.

For details, go to www.nutsvolts.com.
My work in electronics to a high degree involves fine-pitch surface-mount devices and, because of this, I frequently encounter the test probe/device size mismatch. A Google search showed that micro-sized test probes are available, but they are quite specialized and usually very expensive. I decided to design and build my own micro-probe.

The initial design consisted of a long embroidery needle with an attached wire lead. The opposite end of the lead was terminated with a standard banana plug. Heat-shrink tubing covered 90% of the needle, with only the tip exposed. The drawback of this simple design was that the finished probe was very difficult to hold and caused hand fatigue. Clearly, the needle required a suitable housing to be of practical use on a test bench.

A brainstorming session with paper and pencil produced the answer: Use a mechanical pencil for the housing of the micro-probe. The probe tip would, like the pencil lead, be retractable — a great safety feature. The design was finalized and a prototype soon followed.

After several months of use, the micro-probe has proven itself an indispensable part of my test bench and feedback from colleagues using the probe has been very positive. I hope Nuts & Volts readers will enjoy building the micro-probe.

Construction

As the schematic in Figure 1 shows, the circuit is very simple since there are no electronic components involved. The micro-probe is easy to build and can be completed in a few hours. I’ll provide a very detailed assembly procedure for the benefit of less experienced hobbyists. The dimensions given in the assembly procedure are specifically for the Pentel “Side FX” mechanical pencil, because the Side FX is inexpensive (about $2 each) and readily available. Other pencils will work, but wire length and needle dimensions may need adjusting. The selected pencil should have a side lead-feed button rather than a top feed because the pencil top is the exit point for the lead wire and must remain unobstructed. Figure 2 identifies some of the Side FX components and it will be a useful reference during construction.

To begin, remove the lead from the pencil, then separate the top and bottom barrel sections by pulling them apart.
Locate a Suitable Needle

Finding a suitable needle to work in the pencil proved to be the biggest challenge of the project. The two critical requirements for the needle are sufficient length and proper diameter. The needle must be at least 1.5 inches in length. This is to prevent the fine-gauge wire attached to the needle “eye” from interfering with the pencil’s lead-feed mechanism. The needle diameter should be very close to 0.7 mm, the pencil’s lead size. I tried several sewing stores unsuccessfully before finding the perfect needle at Wal-Mart – part of a forty needle assortment (see the Parts List).

Select a needle that looks similar to the thickness of the pencil lead. Measure the thickness with calipers or test the “fit” of the needle by holding down the side-advance button of the pencil and inserting the needle, point first, into the lead-sleeve. The needle should slide smoothly into the sleeve with little resistance until it approaches the eye of the needle, where it gets tighter (needles are thicker near the eye).

If the needle passes this initial test, remove it from the sleeve and drop it, point first, into the lower barrel of the pencil, as if loading a standard pencil lead. Click the lead-advance button a few times until the needle extends out of the sleeve by about 3/16 inch. Then, check the slippage by pushing down on the lower barrel with the approximate force you would use when probing a component. If the needle holds tight and does not slip back into the sleeve, it will be suitable for use in the probe. If it slips, find another needle. (As an aside, I have a few extra needles of the correct size available to N&V readers for just a SASE. Send an email to dsiegel@radexelectronics.com if interested.

Open a Wire Path Through the Upper Barrel

The lead-wire must pass through the eraser and the upper-barrel of the Side FX. To open a path, two holes are required: one through the eraser and the other through the upper barrel. Remove the eraser by rotating the eraser-advance ring in a clockwise direction to advance the eraser out of the eraser-holder. Pull out the eraser and snip off the top portion, leaving about 3/4 inch of the eraser bottom. Then, rotate the eraser-advance ring counter-clockwise until the eraser-holder retracts fully into the upper-barrel. Secure the 3/4 inch eraser bottom in a vise or hold it with pliers for safety. Carefully drill a 3/32 inch diameter hole straight into the center of the eraser through its entire length. Next, insert the drill bit into the empty eraser-holder and carefully drill a 3/32” hole through the center of the eraser-holder. At this point, you should be able to see light through the entire length of the upper barrel.

Wiring

Cut off the mini test-clip from the Pomona patch cord leaving about four inches of wire on the clip end. This leaves 56 inches of 20 AWG lead wire terminated in a banana plug. Route the lead wire through the eraser hole, leaving 1/2 inch of wire exposed at the eraser bottom. Strip 1/8 inch of insulation from this wire. Next, strip 1/8 inch from both ends of the 28-30 AWG 3 inch stranded wire. Tin the three wires and the needle eye with solder. Solder the lead wire to one end of the 3 inch wire. Then,
solder the opposite end of the 3 inch wire to the eye of the needle (keep the wire straight and use solder sparingly). The finished assembly is shown in Figure 3.

Assembly Procedure

Route the needle into the top end of the upper barrel, through the eraser holder, and out through the lower end of the upper barrel. Push the eraser all the way down into the eraser holder. Because we cut the eraser short, there will be empty space above the eraser. Figure 4 shows the completed upper barrel assembly.

Drop the needle into the lead-feed mechanism. This is similar to loading a pencil lead, but a bit trickier because of the wire attached to the needle. Position the upper and lower barrels close together. Press and hold the lead-advance button while feeding the needle down into the lower barrel. Continue until the needle is visible in the transparent end-cap area. You may need to rotate the lower barrel back and forth while pushing on the needle to keep it moving, because you are pushing on a 28-30 AWG wire.

Once the needle reaches the end-cap, snap the upper and lower barrels of the probe together. Click the lead-advance button several times until 3/16 inch of the needle emerges from the sleeve. If the needle will not extend this far, the internal wiring may be too tight. If this occurs, push a bit more lead wire through the eraser. You might also try holding in the lead-advance button and gently pulling the needle out with pliers. Once the needle extends properly, verify that there is no needle slippage when using the probe and verify that the needle retracts fully into the sleeve. Test the probe for continuity with a meter. Resistance should be less than 0.5 ohms.

Potting

Fill the void in the eraser-holder with potting material to provide strain relief for the lead wire and to increase overall durability. I used white household glue because it was convenient, but RTV or other products will work just as well. Position the probe vertically in a vise. Center the lead wire and carefully fill the eraser holder with potting material. Let it set overnight and top it off if settling has occurred during the curing process. Figure 5 shows the completed micro-probe. Figure 6 shows the micro-probe and a standard Fluke probe next to a fine-pitch IC. Which tool would you choose to probe the pictured IC?

Going Further

You can extend the versatility of the micro-probe by fabricating adapter cords such as a banana-jack to BNC, banana-jack to mini-clip, etc. With a BNC connector, for example, you can connect the probe to a function generator for signal injection.

CONTACT THE AUTHOR

Dave Siegel is president of Radex Electronics, an SE Michigan design and fabrication firm. He has been active in electronics for a quarter century with interests in alternative energy and microcontrollers. He can be reached at dsiegel@radexelectronics.com.
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GREEN STANDBY

BY CARLOS COSSIO

There are still millions of older and not so old appliances that waste too much energy in standby mode. The device described here helps to save energy without compromising usability.

Most of today’s home appliances have no genuine off switch. They are instead equipped with standby circuitry over which users have no direct control. The main power switch controls only the low voltage circuitry and even when the machine appears to be turned off, it is still consuming a few watts of energy without any purpose.

Although solutions do really exist like the switchable mains outlet strip, they have a distinct disadvantage in home entertainment applications: Convenience vanishes if you can no longer switch the device on or off simply by zapping it with the remote control handset. Solutions of this kind have the key advantage that hardly any power is ever wasted on standby current. The downside is that you can no longer wake up the appliance with its remote control. With these semi-intelligent standby switches, you need to press an onboard button to rouse them again, wiping out half the attraction.

The proposed device (see Figure 1) reacts to virtually any key press of almost every infrared remote control on the market. It enables you to upgrade an existing appliance with poor standby characteristics, reducing standby current very significantly. It doesn’t need installation or any configuration.

The interface to the outside world comprises a 120 VAC mains input and output together with an infrared sensor and a power supply. When a button is pressed on the infrared handset and is registered by the IR sensor, the signal detector delivers a trigger pulse to the circuit’s microcontroller. This operates the relay and the 120 VAC outlet is powered. Additionally, current flow is monitored for a number of seconds. If the microcontroller

![FIGURE 1. This is the Green Standby device in action. Just plug in the appliance in the back and connect it to the grid to start saving energy!](image)

![FIGURE 2. High level block diagram of the Green Standby.](image)
recognizes normal operation, the relay remains activated. If the current drops below a preset threshold level, the relay is deactivated after a few seconds and the mains outlet is powered down. See Figure 2 for a detailed block diagram.

**Good for the Environment**

Standby mode of operation refers to the lowest power consumption mode which cannot be switched off by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer’s instructions.

Standby power is a relatively new phenomenon. An ever-growing number of consumer goods and appliances are now designed in a way that they draw power 24 hours a day, seven days a week, every week of the year.

Standby is often necessary to power certain core functions or to sense communication for those products that are waiting to provide full services. This power is consumed not while the appliance is being fully utilized, but while it awaits instruction. However, in many cases, standby power serves no useful function or operates at excessive levels.

Some studies estimate that the amount of energy wasted by running dormant devices left plugged in on standby power could light up, heat, and cool the homes of two-thirds of the planet. In the latest big study to track household energy use, the Australian government last year found that households squander 10 percent of their electrical bill on electronics that invisibly suck power.

As an example, other studies appraise that the annual collective standby power draw from households in the USA is around 8 Gigawatts — equivalent to the electricity production of eight large power plants. Globally, standby power consumption is estimated to be responsible for about 1% of the world’s carbon dioxide emissions.
Think about it. We could reduce 1% of the amount of carbon dioxide being spewed into the environment just by switching appliances off when not in use and all save some money on each power bill in the process!

**How It Works**

The installation procedure is really simple. There are not switches or complicated setup procedures to follow. As an example of use for a TV, simply connect the TV plug into the ‘Green Standby’ socket and finally connect the Green Standby to the power grid. A truly plug and play device!

As soon as the Green Standby is plugged into the mains, it flashes the red LED to show that the initialization process has finished successfully and enters in a much reduced power mode, waiting for a key press from the wireless infrared remote controller. Then, as soon as a key press is sensed, it wakes up and switches the TV on so you can choose your favorite channel to watch. Any subsequent key press from the wireless remote controller does not affect the Green Standby.

When the standby device is on, it is continually monitoring every half a second if the TV has been switched off by the user. If this is the case, it waits for five seconds to definitively switch the TV set off and enters into sleep mode, waiting for a new key press. See Figure 3 for a functional flowchart description.

**Circuit Description**

The hardware design (Figure 4) is built around the Freescale Flexis eight-bit MC9S08QE128 microcontroller. It has an impressive low power operation mode as required by this application. The use of the low power mode in the microcontroller allows a significant reduction in the overall power consumption.

All the hardware design is oriented to low power
consumption from the beginning. As a rule of thumb, the best way to reduce the overall power consumption is to minimize the number of active and passive components, as well as to choose low power components. Figure 5 shows the hardware schematic.

The type of power supply is an important issue for energy conservation. So, instead of using a conventional fixed voltage regulator such as the LM7805 with a residual current of up to 6 mA, I opted for a standard adjustable voltage regulator such as the LM317. It delivers a stable output voltage with a quiescent current of just around 1.5 mA. To power the microcontroller at 3.3V, I selected the LE33CZ fixed low dropout voltage regulator from ST Microelectronics with a quiescent current of just 1.5 mA. For further energy-saving considerations in the power supply, you can use a low overhead regulator, but take into account that they are more expensive and difficult to find. With respect to the transformer, although they have improved continuously over the past years, they still have some losses. So, using a good quality transformer makes good sense.

For the relay used, I decided to use a single-coil latching relay instead of a classic relay. This relay can pose a design challenge because coil current must flow in both directions through a single coil. Current flowing from a positive pin to negative pin causes the relay to latch in its reset position. On the contrary, current flowing from a negative pin to positive pin latches the relay in its set position. The relay maintains its position even when the coil current is removed, so power is saved by removing coil current after the relay latches.

The main advantage of a latching relay over a classic relay is that as soon as the relay has switched, it remains in that position without consuming energy. So, no current consumption means less heat production, hence smaller heatsinks. Best of all is a dramatic

![Figure 6](image.png)

**FIGURE 6.** Although initially the hardware was designed to work at 230 VAC (European standard), it can be easily modified for operation at 120 VAC (US standard) by changing the transformer.

### PARTS LIST

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<th>PART</th>
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<th>DESCRIPTION</th>
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<td>Freescale Semiconductor Flexis eight-bit microcontroller</td>
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<td>Transformer 120 VAC to 9 VAC</td>
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<td>120 VAC – 9 VAC voltage transformer</td>
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<td>1</td>
<td>Allegro Systems Hall-effect current sensor (5A)</td>
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<td>TSOP1236</td>
<td>1</td>
<td>Vishay Semiconductors IR receiver module for remote control</td>
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<td>1</td>
<td>ST Microelectronics relay Darlington buffer</td>
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<td>Fuse holder</td>
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<td>BDM six-pin connector</td>
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<tr>
<td>Three-pin AC power PCB connector</td>
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</table>
decrease in power consumption. In addition, the relay driver is built around a standard ULN2003A Darlington driver instead of using a half-bridge circuit. This simplifies the hardware.

There are several options available for the current sensing method used. The load current can be sensed by either using a current transformer or by passing the current through a very small resistor and then measuring the voltage across this resistor. As an advantage, a current transformer offers isolation through the transfer of current from the primary to the secondary winding. It can also handle higher currents than a
resistor and consumes less power. However, current transformers are more expensive and less accurate than resistors. Another disadvantage of current transformers is that the core can saturate in large current applications making the device highly non-linear, thus causing measurement errors. On the other hand, I discarded the use of a resistor as a current sensor because it might cause other nearby components to overheat.

In addition, both solutions need additional active components for signal conditioning and amplification. So, I decided to use an integrated Hall-effect chip such as the ACS712 from Allegro Microsystems. Its output can be directly connected to the analog to digital converter of the microcontroller, reducing the number of components and hence power consumption.

The IR sensor and signal detector are combined in the monolithic TSOP1236 IR receiver module from Vishay Semiconductors working at 36 kHz which is the standard frequency used in most of the wireless infrared remote controllers available on the market.

Additionally, there is an activity red LED to show when the device is switched on.

Finally, there is a standard Freescale six-pin BDM connector for in-system programming in order to update the Flash memory in case further updates or enhancements are planned in the future.

Summarizing, the entire electronics (Figure 6) draw less than 50 mW. Compared with the energy wasted by conventional standby equipment (around 3W), this is truly negligible!

**Firmware Design**

The microcontroller tools used to develop the Green Standby firmware were Freescale CodeWarrior version 6.2 and the P&E Multilink interface for debugging and programming the Flash memory. To download CodeWarrior Special Edition and test a trial version of the C-compiler, visit the Freescale website at [www.freescale.com](http://www.freescale.com).

All the software has been developed in C in a modular way so that maintenance and improvements are fairly simple to do. A module hierarchy of the design is shown in Figure 7.

Table 1 gives a brief description of each module and its hierarchy in the design. For more detailed information, you can take a look at the source code provided at [www.nutsvolts.com](http://www.nutsvolts.com).

**Green Electronics**

Green electronics is becoming an increasingly popular design trend. The importance of hardware that is environmentally friendly is gaining attention worldwide.

You have learned how to use the low power modes available on modern microcontrollers’ architecture so that with the help of a very basic firmware algorithm, your hardware can be considered as green electronics. In addition, you have also learned how to use a single coil latching relay instead of a classic relay in order to reduce the total power consumption of the system.

There is definitely room for improvement. For instance, you can modify the hardware to handle more than one appliance at the same time using just one wireless remote controller, making the Green Standby a true multi-appliance device controller. **NV**

**RESOURCES**

- **MC9S08QE128 Datasheet**
  Freescale Semiconductors, 2007

- **MC9S08QE128 Reference Manual**
  Freescale Semiconductors, 2007

- **DEMOE128 User Manual**
  PE Micro, 2007

- **USB HCS08/HCS12 Multilink Technical Summary**
  PE Micro, 2007

- **ACS712 Fully Integrated Hall-Effect Based Linear Current Sensor Datasheet**
  Allegro MicroSystems, 2007

- **LExxC Very Low Drop Voltage Regulators With Inhibit Datasheet**
  ST Microelectronics, 2007

- **LM117/LM317 Three-Terminal Adjustable Regulator Datasheet**
  National Semiconductor, 2007

- **TSOP12xx IR Receiver Modules For Remote Control Systems Datasheet**
  Vishay Semiconductors, 2007

- **ULN2003A 5-V TTL Seven Darlington Arrays Datasheet**
  ST Microelectronics, 1991

- **40 Series Miniature PCB Relays 8, 10, 16A, Finder, 2008**

**ABOUT THE AUTHOR**

Carlos Cossio (ccossio@hotmail.com) earned a B.S. in Physics (majoring in electronics) at the University of Cantabria in Spain. He is a senior smart card engineer with more than 15 years of experience designing trusted security platforms. In his spare time, Carlos enjoys repairing and bringing old electronics equipment to life.

The design described in this article was chosen as a top five finalist in the European first Green Freescale Technology Forum Design Challenge 2008.
Welcome back to our continuing series of articles on alternative energy experiments that are designed around the Parallax BS2 and PICAXE 28X2 microcontrollers. This time, I’ll show you how to build a solar powered battery charger – actually two of them. You can find all the details on my website at www.learnonline.com. Just click on Experimenter Kits on the menu links and select “Build a Simple Solar Powered Battery Charger.”

**Experiments with Alternative Energy**

Remember, these experiments are designed to introduce you to the fundamentals of alternative energy like solar, wind, and hydrogen, and how to apply them to model, real-world devices that you build and program around two of your favorite microcontrollers. They are meant to give you a starting point in your microcontroller design cycle so that you can improve on what is presented in order to optimize the hardware and firmware to your particular needs and wants. Along the way, it should improve your understanding of alternative energy including devices like rechargeable batteries that use it.

**Ni-Cad, NiMH, Li-ion - Choices, Choices, Choices**

The variety of rechargeable batteries available these days is quite remarkable, and the choice of which one to use is getting more difficult. Nickel-Cadmium (NiCad) varieties have lost ground to newer, more energy dense types like Nickel-Metal Hydride (NiMH) and Lithium-ion (Li-ion). These don’t have the dreaded and sometimes disputed “memory effect” of NiCads that shorten the life of portable electronics. Li-ion batteries are also better in that they don’t suffer from this condition, along with having a low self-discharge rate of approximately 5% per month. This is compared with over 30% per month for some common NiMH batteries (which is why your digital camera doesn’t work and needs a recharge after leaving it on the shelf for an extended period of time).

That said, for our solar powered battery charger I’ve chosen to use NiMH cells because they are relatively inexpensive and don’t suffer the thoroughbred shortcomings of Li-ion batteries (such as explosions if overheated by overcharging or that they may become irreversibly damaged if discharged below a certain voltage). Their internal resistance is higher than NiMH types and increases with both cycling and age – another permanent reaction. Rising internal resistance causes the voltage at the terminals to drop under load, thus limiting the maximum current that can be drawn from them. Eventually, they reach a point at which they can no longer
operate the equipment they are trying to power; kind of like the older NiCads but for different reasons. Lithium-ion technology is here to stay, but it’s still a work in progress.

**Battery Capacity — C**

Battery capacity, labeled as the letter “C,” is the battery’s current-energy rating as in 2,450 mAh (milliamp-hours). I used an Energizer AA size, model NH15BP-2 for testing. That means this particular battery can (theoretically) produce 2,450 mA for one hour, or 4,900 mA for 30 minutes, or 9,800 mA for 15 minutes (I doubt it). In reality, batteries do not respond in such a linear fashion. Battery manufacturers typically specify a discharge load of 0.1C or one-tenth of current capacity when rating their batteries; then they simply multiply this number by 10 for the published rating. Therefore, a battery that can deliver 245 mA for 10 hours will be rated at 10 x 245 or 2,450 mAh as in our test battery — specsmanship at its best or worst depending on your point of view.

The value of 0.1C has been chosen by manufacturers as it illustrates battery capacity in the best light because of the lower discharge value. A faster discharge rate will most certainly result in less energy being available from the battery, and therefore the measured capacity will be lower. It’s like specifying fuel mileage for cars; you can’t get the same range or mpg if you drive 70 mph versus seven mph. So, who can you believe — their specs or your tests?

**Setting Up the Test Bed**

You can determine the battery capacity under load by carefully discharging the battery while measuring the power at specific time intervals. However, you can’t do it unless it’s charged to some degree. This, then, brings us to the first phase of our experiment: charging the battery — slowly and carefully so as not to damage it. The hardware setups are illustrated in **Figure 1** and **Figure 2** for the Parallax BS2 and PICAXE 28X2, respectively. You will need to wire the circuit and download the firmware to the micro.

Note: If your battery is already fully charged or partially so, it is best to discharge it to approximately 0.25 volts (but not 0 volts — never fully discharge it) using a 10 ohm resistor before going to the next step. Use the test bed setup in **Figure 3** or **Figure 4** to monitor the voltage levels. It basically swaps the battery for the solar panel as the voltage source and uses the 10 ohm load to discharge the battery. You can monitor the voltage level on the computer. Return to the test bed setup in Figure 1 or Figure 2 when the battery is discharged to about 0.25 volts.

**Part 1: Manual Charging**

Set up the test bed in Figure 1 or Figure 2 in full sunlight and allow the battery to begin to charge. **Figure 5** shows the beginning of a normal charge cycle with the nominal voltage and current flowing from the solar panel into the battery. Notice that the battery voltage is above the 1.2 volt rating during charging; this is normal. Also notice that the current from our small solar panel is about 126 mA, which is a trickle charge level. Since our test battery is rated at 2,450 mAh, it will take about 24 hours “in the bright sun” to completely charge it at this small current level. Therefore, the charging cycle may have to be extended over several days to acquire a full charge. The charging time is totally dependent on your solar panel’s voltage and current capability. If you use a larger panel with greater current output, the charge time will be less. All things considered, it won’t hurt if you never get it to a fully charged state. Again, NiMH batteries don’t suffer the memory effect of partial charging so don’t be concerned.
Figure 6 shows what to look for as the battery reaches its fully charged state (if you have the time and patience to do so). Notice the slight peak in the voltage (solid plot line) before it dips back again; this means that the battery has reached its fully charged state. You will generally find this type of noticeable peak when the battery is being charged at 1C or more. If you are using a solar panel that delivers this kind of amperage, this is what to expect. Otherwise, you will experience plots like those with the dashed and dotted lines at lower currents. With lower currents, the voltage peak is much less pronounced and is even non-existent at very low trickle rates like our small solar panel produces.

**Delta-V or Delta-T**

We've already seen an example of Delta-V or the “change in voltage” in Figure 6 that indicates the end of the charge cycle. After the cell is fully charged and as it begins to overcharge, the voltage polarity of the electrodes inside the battery will begin to reverse, and this will cause the battery voltage to peak then decrease slightly. However, a disturbing characteristic about NiMH batteries is that “false” Delta-V events can occur before the real one does. New NiMH batteries can exhibit these voltage peaks early in their cycle, especially when they are cold (see Figure 5). So much for battery designers making it simple for us common folk to design battery chargers for them; but that’s the fun part, right?

Another method of detecting the end of charge is by using a temperature probe on the battery and looking for Delta-T or the change (rise) in the cell temperature. However, this is for high current, fast charge systems. Since we are trickle charging our batteries with the small solar panel, there is no need to do this; however, I wanted to make you aware of it should you ever want to use a larger, more powerful solar panel for charging. Just remember: As with solar panels, heat is the enemy of batteries, so keep things cool.

**One at a Time or All Together**

Another “gotcha” about NiMH batteries (unlike Lithium-ion or lead acid) is that you just can’t detect when the battery is fully charged by monitoring the voltage alone. Nickel metal hydride batteries like nickel cadmium don’t have a “float charge” voltage; they are current-based animals and, as such, each cell needs to be charged individually — not in series or parallel like lead acid or Lithium-ion — especially when using a high current charge. Take this into account if you build a multi-cell charger, because some cells will take on more current than others even when they are completely charged! This means battery damage will occur and about the only thing to do is balance the current input in some way, like using resistors in series with “each” battery in order to limit the current. Again, we won’t worry about this for our simple one cell charger, but just be aware of this for future reference.

**Part 2: Measuring Battery Capacity**

With a fully or partially charged battery, now comes the second phase of our experiment: measuring battery capacity. For this test, we want to measure power into a resistor load over a specific amount of time, a.k.a., energy. The battery’s mAh rating is not particularly useful in the real world as pointed out earlier. Instead of mAh, we want Wh or watt-hours, since a watt (voltage x current) takes into account any variation in battery voltage, as well as current, and gives a truer measure of instantaneous power, as well as power over time (energy).

In order to measure the battery’s stored energy, we will apply the same 10 ohm resistor load and periodically measure the power at set time intervals. This will be easy with the graphic software since all we need to do is hook things up and watch what happens. A feature of the graphic software allows you to capture an entire screen image for later viewing and analysis. This saves trying to copy down the voltage, current, power, and resistance...
values manually. Just click the Screen Capture icon (Figure 7) and a snapshot of the screen is captured and saved to the hard disk.

To view the snapshot, click on the Screen View icon (Figure 8) and use the small arrow keys at the bottom of the snapshot to scroll back and forth among the images. This is a great way to do any of the experiments in this series — especially the ones where data changes rapidly. Figure 9 shows a typical captured screenshot overlaid on the real-time plot.

Take a snapshot once every minute while the battery discharges. Then, add up the power readings and divide by the number of samples taken. The average power is now in watt-minutes. To convert to watt-hours, simply divide watt-minutes by 60. With either value, you have a true indication of the amount of total energy available in the battery — for the 10 ohm load, that is.

To be thorough about this, you should repeat the charge-discharge cycle several times to verify your findings, and in so doing, change the load resistance to something like five ohms or three ohms. For new NiMH batteries, it is necessary to cycle them three to five times before they reach peak performance anyway. This will show how well the battery performs under heavier loads which are common in model cars with DC motors that stop and start, go slow and fast, and travel up and down as they do, the motor’s resistance changes which causes more or less power to be absorbed from the car’s battery. As my college professors used to say “Proof left to student.” It got them off the hook for actually explaining things and put the onus on the students to do the grunt research work. Except this time it will be worth it to you to charge and discharge the batteries with different loads to fully understand the concept of battery capacity. Plus, you’ll improve your battery’s overall performance, as well.

**Part 3: Building an “On-Demand” Solar Powered Battery Charger**

With all this background information, you can now feel confident about knowing what to anticipate in terms of how a NiMH battery will behave and what an automatic battery charging circuit should do. The front end of our version is illustrated in Figure 10.

You will notice that I added an NPN transistor, Q1 (a 2N3904 or 2N2222 — your choice), between the solar panel and battery that acts like an ON-OFF switch to allow current to flow (or not) from the solar panel into the battery. Q1 is turned ON by setting the output pin connected to the 470 ohm base resistor to a HIGH. This allows current to flow from the solar panel into the battery in order to begin the charging cycle. Q1 is turned OFF by setting the output pin to LOW. I’ve also added an LED and another 470 ohm current limiting resistor to indicate when charging is taking place.

By “on demand” I mean the firmware will first test the battery for its voltage level and then decide whether or not to turn Q1 ON. If the battery is above the “full discharge” voltage (as indicated by a constant in both firmware code versions), Q1 will remain OFF and the battery will be allowed to discharge into the load. When the battery reaches the full discharge voltage, Q1 is turned ON and the battery is allowed to charge until it reaches and maintains the “full charge” voltage for a period of time. You will notice that the full charge and discharge voltages are far apart enough so that “toggling” between charging and no charging is avoided. The technical term for this is called “hysteresis.” Plus, the firmware has a timing loop to help prevent this, as well.

**How the Code Works**

The firmware that handles the battery charging is explained next. You will need to refer to the code and the algorithm in Figure 11 to follow along. Code files are listed at [www.learnonline.com](http://www.learnonline.com) and [www.nutsvolts.com](http://www.nutsvolts.com).

**Test Battery Voltage**

After initialization, the firmware enters the Test_
Battery Voltage loop where Q1 is turned OFF by setting its base resistor LOW. The LED is also extinguished. The routine does an A/D conversion of the battery voltage. If the voltage is above the full discharge voltage specified by the constant “fullDischargeVolts” in millivolts, nothing happens and the firmware loops back to the Test_Battery_Voltage label. If and when the battery voltage drops to, or below, the fullDischargeVolts level, the firmware branches to the Charge_Battery label.

**Charge_Battery**

At this point, Q1 is turned ON and several things are set into motion. First, the LED is illuminated indicating charging is taking place. At the same time, an “energy loop” is initiated that guarantees a minimum amount of charge, C, going into the battery (and maybe also into the load if one is connected). The energy loop consists of a 60 second time sample coupled with measuring the current flow into the battery. With it, we want to charge the battery with at least 0.05C (1/20 C) before exiting the charge cycle.

For example, a constant called “minEnergy” is established in the first part of the code that represents 0.05C of the battery. For our test battery, this is 122.5 mAh (2,450 mAh x 0.05 = 122.5 mAh). You can adjust this to any level based on your particular battery’s capacity and/or solar panel output. Because we are using a 60 second sampling loop, we need to convert mAh into mAm or milli-Amp-minutes. Since there are 60 minutes to an hour, we need to multiply the 0.05C value by 60. In our case, that would be 122.5 x 60 which makes our minEnergy value = 7,350 mAm. So, every 60 seconds the code will sample the current, add it to the previous current sample, and compare this value to minEnergy. Once the minEnergy value is achieved, the next part of the algorithm is engaged.

**Verify_Battery_Charged**

Next we look at the battery voltage at the Verify_Battery_Charged label. If it is at or above the fullChargeVolts, then we branch back to the Test_Battery_Voltage label and the process starts all over again. However, if the battery is still below the fullChargeVolts level — maybe due to a heavy load draining it as it tries to charge — the firmware stays in the Charge_Battery loop (with Q1 ON) until the fullChargeVolts level is reached (if ever, depending on the load and the sunlight striking the solar panel). The LED flashes (toggle instruction) to let you know that we are in the Verify_Battery_Charged loop.

And that’s it; that’s our “on-demand” battery charging algorithm that should keep our NiMH battery active without ever reaching full charge or overcharging, but always with enough energy to do the job of powering our load. Of course, you can change any of the constants and variables to match what YOU want the charger to do, like apply a deeper charge or change the voltage trip points. Remember, this is your experiment. I’m only here to give you guidance.

**The Middle Multiply Operator (*) Cell Equivalent Circuit**

In all the firmware code in all the experiments, I convert A/D counts directly to millivolts and milliamps.
This is a great help in understanding what is really going on with the circuits under test and it aids in computing power and resistance, as well. To do this, probably the most overlooked, most misunderstood, and possibly most powerful operator in the entire Basic language repertoire is employed; that is, the middle multiply operator known by its “*/” symbol. What it does is impart floating point math to Basic.

If you’ve ever wanted to multiply a number or variable by an integer-fraction like 1.22 (i.e., a floating point number), this is the operator to use. While it’s not a full-bodied floating point that will multiply your number to 10 digits after the decimal point, it will certainly get the job done in terms of what we need to do. And what we need to do is multiply a raw binary A/D count by the millivolts per count value that each bit represents. For example, our 12-bit A/D converter resolves each bit to 1.22 millivolts per count with a five volt reference (5,000 mv / 4096 = 1.22 mv/count). So, to convert raw A/D counts to millivolts, do the following:

1. First, separate the integer part (1) from the fractional part (.22).
2. Take the fractional part and manually multiply by 256, as in 256 * .22 = 56.32.
3. Round up the 56.32 to the closest integer (or 56, in this case).
4. Convert 56 decimal to 38 hex.
5. Convert the integer part to hex, as well as in 01 hex.
6. Combine the two hex numbers into a 16-bit Word variable as in 0138 hex.
7. Multiply the A/D count by 0138 hex as in 1000 */ $0138 = 1220 ($ ~ hex).
8. The answer is now directly in millivolts.

Parallax does a great job in explaining this in their BASIC Stamp Manual, which is how I first discovered it and began to use it. Other Basics need to follow suit with clearer, more functional explanations (I won’t mention any names). Do the same for our PICAXE 10-bit A/D converter that resolves each bit to 4.88 millivolts per count (5,000 mv / 1024 = 4.88 mv / count). Hint: The answer is $04E1. Proof left to student.

Summary

I’ve devoted this article to more on the background of battery technology and proper charging techniques than to pure alternative energy, but the two are closely linked since charging batteries this way obviously saves energy and doesn’t create air pollution. Next time, we’ll build a sun tracker-battery charger combination that will follow the sun all day instead of you needing to adjust the solar panel manually for maximum sunlight.

This is a cool experiment that I hope you will enjoy and, of course, it uses the BS2 and 28X2 micros as the main controllers. So, until next time, conserve energy and “stay green.” NV
After all these years dispensing treats, wouldn't it be fun to deliver a few tricks this year? The darkened porch is dimly lit by the glow of a single Jack-o-lantern. Riding a sugar buzz, the costumed trick-or-treaters swarm up the stairs and ring the bell. You open the door and they shout TRICK OR TREAT! You look at them gravely, then slowly raise your eyes to the ceiling above them. Puzzled, they look up just in time to see a big black bat come swooping down towards them! They shriek in surprise, then laugh and giggle when they see it's just a rubber bat that is now winding its way back up to the ceiling. You hand out candy and listen to the kids talk about how cool and scary that bat was and who they're gonna bring to see it. You smile slyly as you think to yourself "This is gonna be a fun night!" then push the door shut to await your next victims.

DROP WHAT YOU'RE DOING!

How fun would it be to drop a Spooky Spider, a Ghoulish Ghost, or a Scary Skeleton right out of "thin air" above unsuspecting trick or treaters? The Prop Dropper is a "quick and dirty" Halloween project you can probably put together in a single night with just a small micro-controller, a couple of servo motors, and a few bits and pieces from the ol' junk box. The Prop Dropper is designed to detect the presence of a person, rapid-deploy a small prop, display it for a moment, then wind it back up out of view, ready for its next victim!

WHERE THE HECK DO YOU GET THESE IDEAS?!

It's not uncommon for folks to ask where the inspiration for this type of project comes from. Sometimes it's just a matter of necessity guiding the development. Other times, it's simply an accident. The idea for this particular project was sparked when I was carrying a small spool of hookup wire. I shifted the spool from one hand to the other as I reached to open a door and the spool turned sideways, dumping a length of wire right off the spool to the floor (similar to the photo shown in Figure 1).

As I was grumbling and winding the wire back up, it occurred to me that it might be possible to make a purpose-built device that would do this very same "drop" effect. If there hadn't been a flange on the downward facing spool edge, it seemed likely that the entire spool would have emptied. Based on this observation, I guessed I could put together something that would use this method to quickly drop an item into view and then retrieve it.

STOP, DROP, AND SCREAM!

As I've been involved in putting on various private and commercial haunted houses in the last decade (see Resources), I've seen lots of mechanisms used to pop an item into view. Most of them incorporate sophisticated designs using pneumatic systems or mechanical linkages (Figure 2). I wanted something that would perform a similar deploy/retrieve function, but I really wanted it to be simple in operation and easy to build.

After sketching a number of designs, I finally settled on using one continuous-rotation modified servo as a winch and one standard servo to position the winch servo. To drive them, I chose the EFX-TEK Prop-1 controller board that features our old friend the Parallax BASIC Stamp
microcontroller. The Prop-1 control board was specifically designed to be used in commercial devices and has proven to be very robust. To allow the Prop Dropper to operate without requiring an operator, I used a low-cost PIR (passive infrared) motion detector as a trigger (Figure 3).

**SCARE BY NUMBERS**

In this month’s article, I’ll walk you through making the Prop Dropper step-by-step from hardware assembly through wiring, and then on to software and testing. First thing to do is get all the parts together (see Parts List). If you have a reasonably stocked junk box, you may be able to come up with everything you need just by digging around your workbench. If you don’t have all the parts at hand, an entire kit of parts can now be ordered from the Nuts & Volts website (see resources for link). Either way, once you’ve gathered the parts, start with assembling the servos.

**THE POSITION AND WINCH SERVOS**

For the first step, get the winch servo, the position servo, the large round servo horn, the small round servo horn, and the wire nut together on your workbench (Figure 4). Begin by attaching the small round servo horn to the position servo (Figure 5). Manually rotate the servo horn so that the position servo is placed at approximately 90° (i.e., roughly centered). This is an important step, as you want to have the ability to move the winch servo to a straight-down position to deploy the prop, as well as a slightly up-canted position to allow you to wind the prop back up.

Using a hot-melt glue gun, attach the small round servo to the body of the winch servo as shown in Figure 6. Next, mount the large round servo horn on the winch servo as shown in Figure 7. As the winch servo has no "stop" points, you do not need to take any precautions on pre-positioning the horn before you screw it down. Next, use a few drops of hot-melt glue to attach the wire nut to the center of the large round servo horn as shown in Figure 8. Once the glue has set, you should have a nice positionable winch assembly!
At this point, you need to drill a hole in the large round servo horn to allow you to attach the string that connects to the prop (Figure 9). For testing, I fabricated a temporary hanging bracket using an old PC back plate that I glued to the back of the position servo (Figure 10). I then attached a small rubber bat to the large round servo horn and hung the completed assembly from the ceiling in my shop for testing (Figure 11). A video of the Prop Dropper in action is available online (see resources).

**WIRE IT UP**

Strangely for an electronics project, the wiring for this device is one of the simplest steps! The EFX-TEK Prop-1 controller makes it a literal matter of plug-and-play — there is no soldering involved in assembling this entire project. To illustrate, the schematic is shown in Figure 12 and a photo of how the servos and motion sensor are attached is shown in Figure 13. (Note: This simple assembly process makes the Prop Dropper an ideal project to share with youngsters!)

Following the schematic, plug the winch servo into the P0 header, the position servo into P1, and the motion detector into P7. When connecting the servos and the motion detector, be sure to watch the polarity of the plugs to make sure the white lead is connected to the "W" pin of the jack. The pins are clearly labeled at the top of the Prop-1 with W, R, and B to help guide you.

**DROPPER CODE**

Now that we're all wired up, it's time to get familiar with the software. The basic software used to operate the Prop Dropper consists of a single loop with one decision point in it. The flow chart is shown in Figure 14. Following the flowchart, you can see we begin by waiting in a loop for the input to be triggered. Once a trigger has been detected, we send pulses to the position servo that causes it to move the winch servo to its "pointing down" mode. This causes the string to fall off the end of the wire nut and allows the prop to drop.

Next, we wait a bit while the prop dangles in the air, then send pulses to the position servo to position the winch servo pointing up to the retrieve angle. Once the retrieve angle has been reached, we send pulses to the winch servo to cause it to wind the string back up. The amount of time the winch servo runs is based on the length of the string, i.e., longer string = more wind time. Once the winch servo has retrieved the prop, we then pause for a bit to keep the prop from being prematurely re-triggered immediately after deployment.

**DOWNLOADING AND TESTING**

You can download the source code for this
Once you've made the changes above, download the source code into the Prop-1 and test the values until you get it dialed in.

PROJECT CASE IDEAS

Depending on your intended mount point, it is possible to operate the Prop Dropper "uncased" as I did when testing (Figure 11). However, I found that a small plastic bucket made a very good case for the unit while also providing a place to hide the prop before it is deployed. Check out Figure 15. If the bucket is painted black, it will likely disappear into the darkness. I added a length of wire to allow me to hang the bucket from a single attachment point and drilled a hole in the center of the bucket to allow an exit point for both the DC power supply wire and the motion sensor lead (Figure 16).

I found it best to attach the motion sensor to a point adjacent to the bucket (not directly on it). I did this for two reasons: first, to make sure that the sensor wouldn't be affected by the swinging of the bucket when the prop deploys; and second, to allow me to aim the motion sensor at a specific location. I also added an (optional) RCA female jack with two wires that I can attach to the P7 trigger input. This allows me to test-deploy the Prop Dropper with an external input like a simple pushbutton.

OPTIMAL PILL BOTTLE BUTTON TRIGGER

Though I love the effect of having the unit drop when...
it detects motion (I've even managed to startle myself!), I wanted to experiment with other methods of triggering. If you're wanting to have pin-point control of when things drop, you can use this simple pill bottle button trigger (Figure 17). I found that palm-sized prescription drug bottles with child proof caps make for very good enclosures for a home-brew handheld trigger. The device is created by drilling a hole in the bottom of the pill bottle (Figure 18) and mounting a small pushbutton switch. Though pretty much any pushbutton momentary switch will do, I used a RadioShack CAT #275-1571 model switch (Figure 19). Next, drill a hole in the cap and mount a female RCA jack (Figure 20). By using a female RCA jack on the button and also on the Prop Dropper itself, it's easy to get the right length of cable by simply using any male to male RCA cable you happen to have lying around (Figure 21).

VARIATIONS ON A THEME

At this point, you should have a fully operational Prop Dropper to use for Halloween. However, I want to point out that this little design has quite a bit of hack potential. In the course of developing this device, I came up with a bunch of improvements and modifications, some of which I've already built and tested. As a way to excite your imagination, I've compiled a list of the various ideas I had on how you can alter, update, and re-use the Prop Dropper design:

Use a Different Prop — Though all my examples above show the Prop Dropper being used to drop a Halloween scare, the Prop Dropper could just as easily be used to drop snowflakes, Christmas ornaments, a sprig of mistletoe (that should get you thinking!), Easter eggs, or even a Birthday card. You don't have to limit the Prop Dropper to the Halloween decorations bin as you can surprise your guests or family with any seasonal or occasional item that the servo motor can hoist. In fact, you could reduce the design to a single servo that held a small paper cup. Fill the cup with confetti and you could have a synchronized confetti drop for a party!

Smaller or Stronger — The first Prop Dropper I constructed used standard servos only because they were what I had handy. It is quite possible to build a much smaller or even much larger Prop Dropper using some of the more powerful or more compact servo motors available on the market.

More Droppers = More Fun! — The EFX-TEK Prop-1 can accommodate up to six servo motors along with a motion sensor and still have one I/O pin left over! It is possible to connect six servos and have the software trigger a sequence of drops down a hallway.

Sound Effects — Since the Prop-1 board uses a Parallax BASIC Stamp 1 chip, it is capable of using the SOUND command to create noise. It's possible to add some lines of code to create a siren-like sound or a loud chirp to help draw attention to the prop when it drops.

Pull Up or Sideways! — Using some pulley, or even a couple of cup-hooks, you can place the Prop Dropper on the floor and have it drop "up." This may allow you to drop something from a space that normally wouldn't accommodate the entire mechanism overhead, or allow you to place a scare without the bulk of the Prop Dropper overhead to give it away. Also, consider that if you need the deployment to be soundless, you could move the Prop Dropper to another location and just
Synchronized Sound Effects! — You can add a serially controlled sound effect unit such as the CAR P300 Audio Board kit from the Nuts & Volts store. This will allow you to trigger just the right sound when your prop drops! Make a scary synchronized scream, play a Happy Birthday tune, play the graduation march, or launch into a Christmas carol to accompany just about any surprise reveal.

Add a Limit Switch — Rather than using the timed retrieve method, it's possible to place a marker or device to indicate that the prop has been completely retrieved. One implementation would be to use a lever switch and a bead on the string. Cut a hole in a Popsicle stick, then run the drop line through the stick. Write a process that continues to loop waiting for the switch closure before it stops winding up the prop. This would allow different string lengths without having to re-program the chip with new winch time values. It would also allow a consistent retrieve distance even if the string stretched a bit with use.

Add a Variable Time Control — By adding a small potentiometer and using the POT command in PBASIC, you should be able to adjust one of the values of the device on-the-fly. For example, you could adjust the amount of time for the hold off or the length of time the prop is left dropped before it's wound back up. By changing some of the hard-coded values to POT created values, you could adjust for line length without having to build a limit switch or adjust how far you prefer the prop to retract after use.

Use RANDOM to Create Variety — Use the RANDOM function to have the Prop Dropper dispense a different surprise on each trigger or to have it set a random hold off value. The random function can be used in various ways to alter the device's deployment to make it less predictable, especially if you're using the motion sensor to activate your Prop Dropper.

IN CLOSING

As you can see, with a little imagination the Prop Dropper can become a very fun and useful little gadget to have around. I hope you build one and use it. If you do, please write and let me know how it went. I can be reached at vern@txis.com. NV

PARTS LIST FOR THE PROP DROPPER

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The Prop Dropper now in KIT FORM!

Due to some fancy footwork from the folks at EFX-TEK and the good folks over at the Nuts & Volts Store, you can get a complete kit of parts to make your very own Prop Dropper. This is great if your junk box is a little light on parts or if you don't have the time to scrounge around for stuff. The Prop Dropper kit includes both a continuous-rotation and a standard servo, as well as the Prop-1 unit from EFX-TEK. All you need to do is spend a bit of time assembling it with a hotmelt glue gun and you should be ready to go! The Prop Dropper kit is a fantastic foundation for more experimentation in special effects.

A kit can be purchased online from the Nuts & Volts Webstore www.nutsvolts.com or call our order desk at 800-783-4624.
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A revolution in budget engine management. Extensively tested on a wide range of high performance cars, this unit gives you complete control of the air/fuel ratio at 128 points across the entire engine load range, providing incredible mapping resolution and br
If you had the opportunity to attend the 2009 Microchip MASTERS TCP/IP class I hosted this year in Scottsdale, AZ you got a sneak peek at a couple of (then) future Design Cycle hardware designs. You also had a chance at winning a copy of Nuts & Volts Magazine containing a Design Cycle column that augmented the TCP/IP class or an assembled and tested EDTP Ethernet MINI.

The first of the MASTERS sneak-peek Design Cycle columns appeared last month. We completed the conversion of an EDTP Ethernet MINI from a legacy RS-232 to a USB interface that was also configured to power the Ethernet MINI. This month, we’ll uncloak the second design: a 16-bit USB front end for the newly announced Microchip ENC624J600 Stand-Alone 10/100 Ethernet Controller.

**THE MOTHERSHIP CONNECTION**

My first inclination was to design and build this application on a custom printed circuit board (PCB). However, to take that route would limit our ability to experiment freely with the SPI and parallel port interfaces offered by the ENC624J600. So, rather than commit to an application-specific PCB at this time, I decided to go with the current set of off-the-shelf Microchip development tools that are specifically aimed at the ENC624J600. With that, we’ll be working with the Microchip Fast 100 Mbps Ethernet PICtail Plus daughter board you see in Photo 1.

The backbone of this month’s project hardware is a Microchip Explorer 16 development board like the one lying under the lights in Photo 2. In addition to supporting the Microchip family of 16-bit and 32-bit microcontrollers, the Explorer 16 development board’s resources can be complimented with various PICtail plug-in boards. The Explorer 16 displayed in Photo 2 has a 100-pin PIC mounted via a 100-pin PIM (plug-in module). The

PHOTO 1. The Fast 100 Mbps Ethernet PICtail Plus Daughter Board offers parallel and SPI paths to the ENC624J600 which is mounted to the lower right. Our discussion will focus on the SPI channel terminated at edge connector J2.

PHOTO 2. The Microchip Explorer 16 Development Board is a multi-purpose development platform. The Explorer 16 can accommodate differing 16-bit and 32-bit PIC devices by simply mounting a PIM (Plug-In Module) which hosts the desired microcontroller device.
Explorer 16 will also accept 16-bit 44-pin devices like the PIC24FJ64GA004. The smaller pin count parts are adapted to interface with the same 100-pin PIM used by the larger 100-pin parts.

As you can see in Figure 1, the Explorer 16 board is made up of an on-board USB interface based on the PIC18LF4550, a legacy RS-232 port, a Microchip ICSP programming/debugging portal, and a 16 x 2 LCD. The 100-pin Explorer 16 bundle comes standard with a PIC24FJ128GA010 PIM. If you’re interested in working with the lower pin count 16-bit PICs, you can also get a development board bundle that includes a PIC24FJ64GA004 PIM.

Our design will replace the standard equipment PIC24FJ128GA010 PIM with a PIC24FJ256GB110 PIM, which is the 16-bit USB-capable variant. The PIC24FJ256GB110 also contains twice as much program memory as the PIC24FJ128GA010. We may need the additional program memory as we’ll be working with and loading firmware based on both the Microchip TCP/IP Stack and the Microchip USB Framework.

**FUEL FOR THE ELECTRON ENGINE**

The ENC624J600 has all of the tools it needs to operate on an Ethernet LAN. However, the ENC624J600 does not contain a program memory area, data memory area, or the CPU necessary to execute instructions that make up an application. So, we must pair it up with a suitable microcontroller to be able to utilize the facilities of the TCP/IP stack and MCHPFSUSB Framework.

The PIC24FJ256GB110 in Photo 3 is a formidable microcontroller that sits on a 16-bit Modified Harvard Architecture frame. Modified Harvard Architecture allows program instructions and data to reside in the same memory area. Thus, initial data values programmed into the program memory area can be copied from program memory to data memory once instruction execution begins. Some PICs also allow data memory to be written to program memory under program control. If the data that is placed into program memory is application constant data, the constant data need not be moved to data memory to be accessed by the CPU. So, Modified Harvard Architecture is really a combination of specialized machine language instructions coupled with a hardware pathway that allows program memory locations to emulate data memory locations.

The PIC24FJ256GB110 has a large number of peripherals. In fact, it has more peripherals than can be mapped into its 100 pins. Every application should never need all of the peripherals and every application doesn’t need the same peripherals. So, this PIC has the ability to assign its pool of peripherals to a fixed set of remappable I/O pins under program control. This feature is officially called peripheral pin select. The PIC24FJ256GB110 has 44 pins available for peripheral pin select operations.

On the USB side, the PIC24FJ256GB110 is USB v2.0 On-The-Go (OTG) compliant, which means that it’s a dual-role USB device and can be configured as a USB host or USB peripheral. In this project, we’ll use the peripheral configuration and run the PIC24FJ256GB110 in USB full-speed device mode. Everything we need USB is contained within the PIC24FJ256GB110 silicon including a USB transceiver, USB engine voltage regulators, USB pull-up resistors, and the 48 MHz USB clock.

The plan is to use the PIC’s USB interface as a replacement for a legacy RS-232 portal. This will allow us to pass data to and from the attached Ethernet LAN via the USB interface. The native USB interface found on the Explorer 16 development board only supports the on-board PIC18F4550. So, we’ll need to add a USB PICtail.

**PHOTO 3.** This is an up-close look at the PIC24FJ256GB110 that gives the Explorer 16 Development Board the microcontroller resources we need for our USB-to-Ethernet application.
Plus Daughter Board to the development board to gain access to the PIC24FJ256GB110's USB subsystem. The USB PICtail Plus Daughter Board is grinning at us in Photo 4.

HOUSTON, WE HAVE A PROBLEM

The TCP/IP stack templates default to the use of the #1 SPI channel on the PIC24FJ128GA010 to communicate with the ENC624J600. So, one would think that the easy thing to do in our case would be to simply use the #1 SPI channel on the PIC24FJ256GB110 in the same manner. Take a look at Figure 2. The PIC24FJ128GA010’s #1 SPI channel pins SDO1, SDI1, and SCK1 are neatly arranged back-to-back. Now move your attention to Figure 3. Pin 53 of the PIC24FJ256GB110 represented in Figure 3 is a remappable I/O pin instead of the permanently assigned #1 SPI channel's SDO pin found on the PIC24FJ128GA010 in Figure 2. Figure 3’s graphic also tells us that the rest of the PIC24FJ128GA010 #1 SPI channel pins in Figure 2 have been reassigned to USB duty on the PIC24FJ256GB110. What this all means is that we can’t use the TCP/IP stack template’s default to the #1 SPI channel with a PIC24FJ256GB110 microcontroller in charge. The PIC24FJ256GB110’s USB I/O subsystem and a remappable I/O pin occupy the pins that the PIC24FJ128GA010 reserves for its #1 SPI channel. (Uhoh!)

Fortunately, the fix is an easy one. The PIC24FJ256GB110 has three SPI channels. We will use the PIC24FJ256GB110’s #2 SPI channel instead. To do this, we simply plug the Fast 100 Mbps Ethernet PICtail Plus Daughter Board into the Explorer 16 as shown in Photo 5.

Note that the Explorer 16 Development Board and Fast 100Mbps Ethernet PICtail Plus Daughter Board triangular Pin 1 markers don’t match up. The Fast 100Mbps Ethernet PICtail Plus Daughter Board is plugged in to align its SPI channel interface with the Explorer 16 Development Board’s #2 SPI channel interface. Figure 4 is a representation of the USB PICtail Plus Daughter Board’s view of the PIC24FJ256GB110’s I/O subsystem. Note that we are not using pins 1 through 30 which hold the #1 SPI channel I/O pins. The Daughter Board is plugged in with its SPI channel aligned with the #2 SPI channel interface on pins 33 through 62.

Embedded electronics is akin to solving an algebra problem. What happens on one side of the equation must be offset by actions on the other side. In our case, the hardware side has been adjusted to accommodate the differing SPI channel pinouts with the offset plugging of the Daughter Board. We also have to do a bit of twiddling on the software side.

The first order of software business is to tell the application that we are using the PIC24FJ256GB110’s #2 SPI channel to drive the Plus Daughter Board. This is easily done in the HardwareProfile.h file. All we have to do is...
change SPI1 to SPI2 in the register set definitions:

```c
#define ENC_SPI_IF (IFS2bits.SPI2IF)
#define ENC_SSPBUF (SPI2BUF)
#define ENC_SPISTAT (SPI2STAT)
#define ENC_SPISTATbits (SPI2STATbits)
#define ENC_SPICON1 (SPI2CON1)
#define ENC_SPICON1bits (SPI2CON1bits)
#define ENC_SPICON2 (SPI2CON2)
```

Note that everything in the previous code snippet is now aimed at SPI2 instead of SPI1. With that bit of work behind us, the next firmware step we’ll take is to define the new PIC24FJ256GB110 SPI I/O pins. This reassignment is done inside of the `HardwareProfile.h` file:

```c
// SPI pinout
#define ENC100_CS_TRIS (TRISFbits.TRISF12)
#define ENC100_CS_IO (TRISFbits.TRISF13)
#define ENC100_POR_TRIS (TRISFbits.TRISF13)
#define ENC100_POR_IO (LATFbits.LATF13)
#define ENC100_SO_WR_B0SEL_TRIS (TRISGbits.TRISG7)
#define ENC100_SO_WR_B0SEL_IO (PORTGbits.RG7)
#define ENC100_SI_RD_RW_TRIS (TRISGbits.TRISG8)
#define ENC100_SI_RD_RW_IO (LATGbits.LATG8)
```

If you look back at Figure 4, you’ll see that the new PIC24FJ256GB110 SPI pin assignments we just coded match up with the pin set composed of pins 33 through 62. You can also see that we had to move the SPI2 CS pin from RD14 to RF12. Our application doesn’t use the POR signal. However, I didn’t see a need to eliminate it. So, I moved it as well from RD15 to RF13.

Before we can use the new PIC24FJ256GB110 SPI pinouts, we must invoke the peripheral pin select functionality to map the #2 SPI pins to a set of the PIC24FJ256GB110’s remappable I/O pins. The reassignment is performed in the function `InitializeBoard`, which is called from the main application code:

```c
static void InitializeBoard(void)
{
    // Inputs
    RPINR22bits.SDI2R = 26;        //SDI2 = RP26
    // Outputs
    RPOR10bits.RP21R = SCK2OUT_IO; //RP21 = SCK2
    RPOR9bits.RP19R = SDO2_IO;     //RP19 = SDO2

    // Lock the PPS
    asm volatile ( "mov #0x55, r0 
                   mov #0x55, r0 
                   bset OSCON, #6" );
```

Here’s what’s going on in the `InitializeBoard` function code snippet. The SDI2 input pin is mapped using bits 0 through 5 of the RPINR22 register. Another look at Figure 4 tells us that SPI input SDI2 is associated with the PIC24FJ256GB110 RG7 pin. Figure 5 associates RG7 with remappable I/O pin RP26. So, to map SDI2 to RP26, we...
write 26 decimal (0x1A) to bits 0 through 5 of the RPINR22 register.

Mapping peripheral pin select output pins is a bit different. Let’s work through the SCK2 output pin assignment. According to Figure 4, we want to associate SCK2 to the PIC24FJ256GB110 RG6 pin. Figure 5 shows us that RG6 is kin in the peripheral pin select world to RP21. Peripheral pin select register RPOR10 contains the output mapping bits for RP21 (bits 8 through 13). To map SCK2 to RP21, we must load bits 8 through 13 of peripheral pin select register RPOR10 with the output function defined by SCK2OUT_IO. Here’s the peripheral pin select output function table as written in HardwareProfile.h:

```c
// Peripheral Pin Select Outputs
#define NULL_IO 0
#define C1OUT_IO 1
#define C2OUT_IO 2
#define UL1TX_IO 3
#define UL1RTS_IO 4
#define UL2TX_IO 5
#define UL2RTS_IO 6
#define SDO1_IO 7
#define SCK1OUT_IO 8
#define SS1OUT_IO 9
#define SDO2_IO 10
#define SCK2OUT_IO 11
#define SS2OUT_IO 12
#define OC1_IO 18
#define OC2_IO 19
#define OC3_IO 20
#define OC4_IO 21
#define OC5_IO 22
```

The HardwareProfile.h peripheral pin select list is taken from the table in Figure 6. Thus, writing an output function number value of decimal 11 to bits 8 through 13 of the RPOR10 peripheral pin select register maps the #2 SPI channel SCK2OUT output to pin 10 of the PIC24FJ256GB110.

Using the same peripheral pin select methodology for output SDO2, we write an output function number of decimal 10 to the peripheral pin select register RPOR9 to map the SDO2 output pin to remappable I/O pin RP19, which is associated with PIC24FJ256GB110 pin RG8.

The peripheral pin select lock code is optional. Executing the lock assembler instructions only allows one write to the peripheral pin select registers. Only a device Reset will allow another write to these registers.

At this point, we can add the Daughter Board to the hardware configuration by attaching it to the development board’s J9 edge connector. The hardware and the firmware behind its configuration are ready to roll.

### BRINGING UP USB

Most of the USB work is already done for us. All we really have to do is integrate the MCHPFSUSB Framework components into our MPLAB IDE configuration. To help you get USB up and running quickly, I’ve supplied the entire MPLAB project for you to use as a reference. I don’t think you’ll have any problems as we have walked this USB road together before in past Design Cycle discussions.

The only modification I made to the MCHPFSUSB Framework files was a purely cosmetic change in the usb_descriptors.c file:

```c
//Product string descriptor
ROM struct{BYTE bLength;BYTE bDscType;WORD string[23];}sd002={
  sizeof(sd002),USB_DESCRIPTOR_STRING,
  {'M','A','S','T','E','R','S','2','0','0','9','U','S','B','-','T','O','-','T','C','P'};
};
```

Otherwise, you’ll find that the USB code follows the MCHPFSUSB Framework flow unhindered. If you examine the MASTERS-Demo.c file, you’ll see that USB functionality is initialized and activated in...
the InitializeSystem function.

**POWERING UP TCP/IP**

Like the MCHPFSUSB Framework, all we really need to do to get the TCP/IP stack running is integrate it correctly into our MPLAB project configuration. Again, you can follow my lead on the TCP/IP stack configuration as it too is part of the same MPLAB project configuration as the MCHPFSUSB Framework.

The MASTERS Demo application operates in an identical fashion to the Ethernet MINI application you saw in the September ‘09 issue. We have simply replaced the low pin count PIC USB front end and the MCU portion of the PIC18F67J60 with a 16-bit PIC24FJ256GB110. The only operational change you will have to consider is that the PIC24FJ256GB110’s USB2TCPBRIDGE_PORT is set to 9762 instead of 9761. The new USB2TCPBRIDGE _PORT value for this month’s project can be found in the MASTERS-Demo.c file.

The MASTERS_Demo.c file contains a function I assembled called USB2TCPBridgeTask which has its roots in the native UART2TCPBridgeTask application. The USB2TCPBridgeTask is based on the use of the Berkeley Sockets APIs, which are part of the Microchip TCP/IP stack package. The source code is heavily commented and you should be able to follow the action without a lot of head scratching.

**WHAT HAVE WE DONE?**

On the hardware front, we have loaded an Explorer 16 Development Board with a USB-capable PIC24FJ256GB110 16-bit microcontroller that is driving a Fast 100 Mbps Ethernet PICtail Plus Daughter Board.

Firmware in your hands following your download operation includes an application that transfers data between a Tera Term Pro session on the USB side and a Telnet session on the Ethernet side. You also have a working C source code template and MPLAB project configuration that you can use to bring up your own USB and TCP/IP applications.

Finally, you have me if any questions arise. Meanwhile, gouge another notch into the handle of your Design Cycle gun.

Fred Eady can be contacted via email at fred@edtp.com.
SPI, SCI
CAN, RS232
10-bit A-to-D
Hardware PWM
Input Captures
Output Compares
32K or 128K Flash
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Before we do, however, we have a bit of “unfinished business.” Since the previous installment of the Primer was published, three readers emailed me with questions that were similar enough to make me realize that a little clarification is in order. Essentially, the questions came down to: “How can a PICAXE project implement serial communication with a PC?” So, before we move on to the topic of USB programming adapters, let’s take a brief look at PICAXE/PC serial communications.

COMMUNICATING WITH A PC

The serial ports on all modern PCs operate on the Electronics Industries Association (EIA) RS-232 standard, which defines a logic 0 data signal (RxD and TxD) as being between +3V and +15V, and a logic 1 data signal as being between –3V and –15V. (Voltages between +3V and –3V are not valid data signals in the RS-232 standard.) In other words, the EIA standard is based on negative logic because negative voltages represent a logic 1 (high) signal and positive voltages represent a logic 0 (low) signal. This is why PICAXE chips use the Nxxxx format for serial communication with the PC (e.g., “serout 2, N2400, (b0)”).

Of course, all PICAXE chips operate on positive voltages only (typically +5V). If you were to directly connect a PICAXE I/O pin to a PC’s serial port, it’s possible that you would damage or destroy the I/O pin. The function of the serial download circuit is to protect the PICAXE from any possible damage. Although the 22K and 10K resistors in the serial circuit look like a voltage divider, they actually serve a different purpose.

The 22K resistor (in combination with the internal diodes on the serin pin) clamps the input voltage levels to the PICAXE supply voltage and limits the current to prevent possible damage. The 10K resistor to ground keeps the input line from “floating” whenever the download cable is disconnected. (See the PICAXE Manual, Part I, page 37.)

Essentially, you have three options for implementing a serial connection between a PICAXE project and a PC. The first approach is to duplicate the serial download circuit (i.e., the 22K, 10K, and 180 Ω resistors) on two I/O pins (one for serial input and one for serial output) and use the serin and serout commands (with the Nxxxx format) to communicate with the PC. With a standard serial cable connected to the PC, you can use the Terminal Window of the Programming Editor (or your favorite terminal program) for the I/O connection to your PICAXE project. If you would rather avoid the hardware aspect of duplicating the serial download circuit, you could use a self-contained circuit such as SparkFun’s RS-232 Shifter Board Kit (PRT-00133; www.sparkfun.com).
which also includes a female DB-9 connector for attaching a standard serial cable.

The second option involves using an RS-232 level-shifter chip such as the MAX3232. These chips include the necessary charge pump circuitry that enable them to be connected to a +5V supply, and internally generate the positive and negative voltages needed for RS-232 communications. The advantage to this approach is that the greater voltage difference between logic 0 and logic 1 levels enables serial communication over much longer distances than the TTL-level (+5V only) serial link provided by the PICAXE serial download circuit. If you want to construct your own circuit, SparkFun carries the ICL3232 chip (SKU: COM-00316) which is functionally compatible with the MAX3232. If you would rather use a PC board version, Pololu (www.pololu.com) carries a 23201a Serial Adapter board (fully assembled or as a kit).

In any case, it's important to remember that all RS-232 level-shifters also convert the RS-232 negative logic to positive logic on the TTL-level side, so you will need to use the T0xx format for all your serial communications whenever a level-shifter is involved.

The third option is to simply leave the PICAXE download cable in place and use it for serial communications when your program is running. In this case, you can't use the serin and serout commands — only serrxd and sertxd will work with the serial input and output pins. (See the relevant documentation in Part II of the manual.) Also, the baud rate is fixed at 4800 (9600 for the X2 chips).

At first glance, this option may appear to be the simplest of the three. However, there is an additional software requirement due to the way in which PICAXE program downloads are implemented. Whenever a program is running on a PICAXE chip, in the background the chip is also repeatedly checking the serial input pin to see if the Programming Editor is about to initiate the downloading of a new program. This is a good feature; without it, we would need to have some form of a program/run switch to manually enable a new program download which would be a minor nuisance. The way the PICAXE handles this completely automates the process for us. However, if we want to use the serial input pin for a program to receive data from the PC, it's necessary to disable the background checking of the serial input pin. The disconnect command does exactly that, but you never really need to use it because whenever a serrxd command is executed, the background checking is automatically stopped anyway. However, immediately after any serrxd command is executed it's necessary for your program to issue a reconnect command to resume the background checking of the serial input pin. Failure to do so will result in not being able to download a new program to the chip. If you forget the reconnect command, the only way to re-enable program downloading is to perform a “hardware reset” — turn off power to the PICAXE, initiate a new download, and quickly turn the power back on.

A SIMPLE PC COMMUNICATIONS PROGRAM

PCserialDemo.bas is a simple demonstration of the above concepts. It's a little too long to include here — you can download it from the N&V website (www.nutsvolts.com). If you have trouble finding it, email me (Ron@JRHackett.net) and I'll send you a copy. It's also available as a Word file that includes line numbers to facilitate the following discussion. Download that version as well, and print it out for reference. The program runs on a 14M because the 08M doesn't support the required serrxd command. (It does support the sertxd command — go figure!) I didn't include a schematic because it's just the basic 14M circuit with an LED on output 5.

There are a few aspects of the program that are worthy of comment. First, the directive in Line 22 (#terminal 4800) automatically opens the Terminal Window when the program is downloaded to the 14M. In Lines 30, 37, 48, and 53, the CR and LF are pre-defined constants in PICAXE BASIC. CR stands for Carriage Return (ASCII character 13); LF stands for Line Feed (ASCII character 10).

Readers who are “mature” enough to remember typewriters will recall that both actions were required to get to the next line which is what the combination of CR and LF accomplishes. Lines 32 and 50 contain the reconnect command that must immediately follow a serrxd command in order to re-establish the automatic scanning for new downloads.

Line 34 requires a slightly more detailed explanation. As you may know, all serial data is encoded in the standard ASCII format. For example, when the user enters the 2 character from the PC keyboard, what is actually transmitted is the corresponding ASCII value. If you look on an ASCII chart (Google is your friend if you don't have one — an ASCII chart, that is), you will find that 2 corresponds to a value of 50. For all the digits (0–9), the ASCII value is 48 greater than the digit itself, so Line 34 in effect converts the entered value back from ASCII to binary so we can use it as a numerical value in our program.

Compare this to Line 52, where y and Y are used. Whenever a character (or a string, as in all the sercmd commands) is contained in quotes, we are dealing with the actual ASCII values. Finally, the end command in Line 54 is contained within the then clause of the if statement. As a result, if the user transmits either a y or a Y, then the program terminates immediately. Any other key press (including n) will cause the program to loop back to the beginning and ask the user for another number.

Okay, enough didactics! Wire up the circuit, download the program to the 14M, and leave the programming cable in place. The Terminal Window should open automatically; if it doesn't, you can always open it manually by accessing the PICAXE > Terminal menu or by pressing the F8 key. You will soon discover that (unlike most other terminal programs) you can't press the enter key in the Terminal Window to send an entered character — you need to click the send button.
to do so. In fact, if you do press enter (and then click send as I did a couple of times), the program will misbehave because a CR character (and possibly a LF, as well) will be transmitted. As a result, the program will reject the character as not being between the values of 1 and 9, and gently admonish you to follow the directions.

You may want to experiment with modifying the program to see what happens. However, it already uses 247 bytes of the 14M’s 256 bytes of program storage memory, so you won’t be able to add much unless you also remove something. The easiest way to accomplish this is to shorten the two long ser1x strings. (Of course, you could always switch to a 28X1 chip which has 16 times the program memory of the 14M.) Once you are clear about how the program functions, we’re ready to move on to our main topic this month.

MIGRATING TO THE AXE027 USB PROGRAMMING CABLE

It would be reasonable to assume that the topic of PICAXE USB programming adapters would be a no-brainer, since so many manufacturers already offer USB to serial adapters. However, most of them simply don’t work with the PICAXE Programming Editor. Currently, the most reliable upgrade path is to use the AXE027 USB programming cable produced by Revolution Education and available at SparkFun (SKU: PGM-08312). (As an aside, if you are currently using a different USB to serial adapter and it is working reliably with your PICAXE projects, I would love to know about it. If you can send me the make, model number, and vendor from whom you purchased it, that would be great.) When I recently upgraded to a new laptop (with no serial ports), I also purchased the AXE027 USB programming cable which terminates in a mini-stereo plug that provides the necessary sin, sout, and ground connections for programming all the PICAXE chips. RevEd chose this connector because it stands up well in an educational environment where students sometimes bend and even destroy adapters that have pins on them. However, a mini-stereo plug is obviously not the most breadboard-friendly option. Also, if you are a regular Primer reader, you know that we have developed a variety of stripboard projects that are based on a standard 5X2 serial ribbon cable connection. Of course, we would want all these projects to continue to be functional with the AXE027 cable, so I quickly realized that we need an adapter for the new cable.

CONSTRUCTING OUR FIRST USB PROGRAMMING ADAPTER

The first adapter I made (the SUSB-5X2) simply connects a mini-stereo jack to a 5X2 female header so that the pinout of the header matches that of the serial ribbon cable connector I have been using for the last three years. (See the wiring diagram in Figure 1.) As a result, none of my current programming adapters or project boards have become obsolete; they all can be used with either a serial ribbon cable or with the AXE027 USB programming cable attached to the SUSB-5X2 adapter. If you are still using a serial programming cable, RevEd also makes an AXE026 serial programming cable (SparkFun SKU: PGM-08313) that uses the same mini-stereo plug, so this cable can be used with the SUSB-5X2 adapter we are about to construct.

The stripboard layout for the SUSB-5X2 adapter is presented in Figure 2. As you can see, it’s very simple. The only parts are the mini-stereo jack and the 5X2 female header (both of which are available on my website). If you use your own jack, be sure there is enough room underneath for the jumper wires when the jack is inserted into the stripboard.

The holes in the stripboard are slightly too small for the pins of the jack that I used. If you use the same one, you will need to either drill the three holes slightly larger (a 3/64th drill bit works fine) or file the pins so they are slightly thinner. Either approach is relatively easy because it doesn’t take much to get the pins to fit. (It also helps to straighten the pins before inserting them into the stripboard.)

There are two additional minor modifications that need to be made to the mini-stereo jack before it’s soldered into place. First, there is a plastic post that would sit at position C3 of the stripboard layout – snip it off. Second, there is a pin that would fit in the hole...
at position C4 – again, snip it off.

The 5X2 female header also requires a minor modification. Before soldering it in place, remove the pins at the positions marked with (X). This is surprisingly simple to do – they easily pull out from the bottom using needle-nose pliers. The actual assembly of the stripboard is very straightforward.

First, install all the jumpers but don’t solder the jumper connections at C1 and C2 yet. Next, insert the 5X2 header (making sure that the missing pins are in the correct locations) and solder the header in place. Finally, insert the mini-stereo jack and bend the jumper on the bottom of the board from C2 to C1 so that it’s touching the jack’s pin at C1. Then, solder the connections at C1, C2, C5, and A3.

When all the connections have been soldered, sand or file any sharp edges and clean the bottom of the board.

Figure 3 is a photo of the completed SUSB-5X2 adapter and Figures 4, 5, and 6 show how it’s used in three different situations. In Figure 4, the SUSB-5X2 connects the AXE027 USB cable to the Tiny-08 project board. Figure 5 shows how the SUSB-5X2 can be used to convert the UPA-4X4 programming adapter for a USB connection to the PC. You don’t see a power supply in Figure 5 because the breadboard is mounted on a small plastic project box with a battery-powered five-volt supply inside. (See the December 2008 installment of the Primer for construction details.)

Don’t forget to include the 100K resistor that ties the serin line to ground. Without it, any program you have installed in the PICAXE won’t run when the programming adapter is removed from the circuit. In Figure 6, the SUSB-5X2 is flipped upside-down, inserted into the 5X2 male header on the School Board with the AXE027 cable attached. As you can see, this simple little adapter enables all of our previous serial connections to continue to function in the Brave New [USB] World! Nevertheless, I couldn’t stop at just one adapter.

Our next programming adapter (the SUSB-01) combines the mini-stereo jack and the standard PICAXE programming circuit into one convenient stripboard circuit. Its schematic is presented in Figure 7. You will notice that I haven’t included the BAT85 diode. Since the AXE027 cable converts the voltage levels to standard five-volt TTL, the diode is not necessary. The stripboard layout for the circuit is shown in Figure 8.

The only thing that is unusual about the circuit is that the stripboard has a small notch in it. The notch is not at all necessary — the board will function perfectly well without it. I just wanted as much room as possible on the breadboard for the necessary connections to the PICAXE processor.

Construction of the board is very straightforward, with one caveat. The three resistors must each be the smaller 1/6 watt version in order to fit under the stereo jack. Install the resistors first, but don’t solder the 10K lead at B4 yet. Also, don’t forget to bend and extend the other 10K lead on the bottom of the board from C2 to C3 and solder it at both positions. (That’s exactly what I forgot to do and it took me a while to figure out why the board didn’t work at first!) Next, reverse-mount the two three-pin male headers. (Don’t forget that they need to be the longer version to be suitable for reverse-mounting). On the bottom of the board, bend the 10K lead from B4 to B5, snip it so that it just touches the header pin at B5, and solder the six header pins and the 10K lead at B4. Next, insert the mini-stereo jack and attach a short jumper on the bottom of the board from its pin at A3 to the adjacent trace at A4. Finally, solder the pins at E3, C1, and A3, and the
jumper to the trace at A4. **Figure 9** is a photo of the completed SUSB-01 adapter. In it, you can see that I have painted the tops of the male header pins in my standard color scheme (black = ground, yellow = sout, and green = sin) to help me make the correct connections to the PICAXE processor. **Figure 10** shows the SUSB-01 installed on the same breadboard I used earlier in Figure 5. Again, be sure to include the 100K resistor that ties the serin line to ground so that your project will still function correctly when the SUSB-01 is removed from the circuit.

With these two additional boards in our arsenal, all of our previous stripboard programming adapters and project boards will continue to function, either with a serial or a USB programming connection. As I mentioned earlier, if you have a USB adapter other than the AXE027 cable and it has been working with your PICAXE projects, let me know. I would like to develop a list of PICAXE-compatible USB adapters and place it on my website. I know there are several USB adapters for the Arduino processors but apparently they don’t work with the Programming Editor, at least not without modification. As soon as I get the time, I plan to do some experimentation with a couple of them – I’ll keep you posted on my progress (or lack thereof).

### WHAT’S NEXT?

In the next Primer installment, we’re going to turn our attention to seven-segment LED displays. First, we’ll conduct a couple of simple programming experiments with a single-digit LED display and a 20M processor. Then, we’ll turn our attention to the MAX7219 serially interfaced LED display driver which greatly simplifies the circuitry normally required to interface multiple LED displays with a microcontroller. We’ll take advantage of this simplification to develop a four-digit peripheral LED display for use in our upcoming projects.

In the meantime, if you want to familiarize yourself with the 7219, you may want to download a copy of the datasheet (available at [http://datasheets.maxim-ic.com/en/ds/MAX7219-MAX7221.pdf](http://datasheets.maxim-ic.com/en/ds/MAX7219-MAX7221.pdf)).

See you next time! **NV**

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by Mike Rigsby

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Book $44.95

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This is a cookbook for communicating between a PC and a microcontroller using the FTDI FT232R USB UART IC. The book has lots of software and hardware examples. The code is in C# and Visual Basic Express allowing you to build graphical user interfaces and add serial port functions to create communications programs.

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The Getting Started Combo includes: Getting Started in Electronics by Author Forrest Mims and the DIY Electronics Kit. In his book, Mims teaches you the basics and takes you on a tour of analog and digital components. He explains how they work and shows you how they can be combined for various applications. The DIY Electronics Kit allows for the hands-on experience of putting circuits together — the kit has over 130 parts! No soldering is required and it includes its own 32 page illustrated manual. Combo Price $62.95 Plus S/H
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ENLIGHTENED ABOUT SOLAR

I have been tossing around solar PV system ideas for a number of years and am inspired by the Solar Tracker project and the solar energy article in the August issue. This is an interesting and important subject and I would love to see more like it. I've noticed that most of the commercial and residential solar installations are fixed, although possibly a few track the sun from east to west. Almost all are tilted to compensate for the latitude and I would guess that the gain in power does not merit the added power and maintenance of active aiming in the north-south plane.

For that configuration in a residential installation – with tax incentives – I estimate payback is about 30 years (Southern Oregon). Even so, I'm still interested in pursuing solar power if only for exterior/garden lighting and attic exhaust fans.

As the author begins his engineering career, he will realize that completing a prototype is just the first or second step in building a product. The next step is characterization to demonstrate the correctness and limits of his design. If he has the time, it would be interesting to know how much power is actually generated by the array and I would guess that the power does not merit the added power and maintenance of active aiming in the north-south plane.

Would it save energy to skip the control and computation blocks of the system? How much power is dissipated by the system? These are important subject and I would love to see more like it. I've noticed that most of the commercial and residential solar installations are fixed, although possibly a few track the sun from east to west. Almost all are tilted to compensate for the latitude and I would guess that the gain in power does not merit the added power and maintenance of active aiming in the north-south plane.

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Thank you for writing! You’re right; as I am a new engineer, there are many things I have yet to learn and experience. For example, during the design phase of the Solar Tracker, I built several small prototypes of its different sub-systems before completing what I considered to be the finished product. Little did I realize that my finished product was merely a prototype itself! Yes, if I were actually trying to take this to market (with the necessary time and capital), there would be many more tests to run and a reevaluation of the design. There are several areas that could be improved upon, but this was only a Senior Design project (the first one to actually work in several years) and we were pleased. My day job now is lighting, power, and system design for new and renovated buildings; so product design isn’t something I do on a daily basis. I have, however, worked in the petro-chemical field and have designed dozens of very large, very complex industrial systems for oil refineries. I run the West Virginia Robotics Club (www.wvrc.us), design many electronics/robotics projects, and have just completed a kit for the WV Department of Education. I’m new at this, but I’ve hit the ground running!

You’re absolutely right about the altitude tracking vs. extra energy consumption trade-off, which is why most (if not all) commercial solar tracking devices only perform azimuth tracking, if not entirely fixed, with perhaps adjustment screws to compensate for the earth’s tilt on its axis. Believe it or not, solar panels (as the technology exists today) are only about 43% energy efficient at best, and solar tracking doesn’t really add that much benefit. Thanks again for writing!

Steve McCHRISTAL

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Samuel Aaron Ward
Radio Read Interrogation Device

My city has installed an Invensys water meter with a sensus radio read transceiver. I would like to build/buy an interrogator device so I can transfer daily/hourly water use to my computer in order to monitor water consumption. Is this possible without buying an industrial reader?

#10091 Burkhard Lehmann
Brentwood, CA

Flashing LEDs

I need a parts list and schematic on how to create flashing lights on small scale emergency vehicles to be used on a slot car racing layout.

#10092 Bob Farrell

Flip-Style Enclosure

I want to use the flip style package (like a "flip-style" cell phone) for an electronics project. It’s sometimes referred to as a book-style package solution, where there are electronic functions integrated on both sides of the hinge. I am having trouble identifying the best interconnect products to use for the hinged interface. Can I develop a prototype on a (reasonably) low budget?

#10093 William Quillen
Laurel, MD

High Current Heater

I’m trying to raise the temperature of a tungsten heater from room temperature (25 C to 900 C) with a ramp of one hour. My filament is very small and hence has a small resistance — 0.08 ohm at 1,200 C. At room temperature, its resistance is 12-13 times smaller. Powering the filament is a huge 50 amp variable transformer. I am also using a temperature controller (Omega cni32). Most power supplies I have seen use a phase angle firing SCR with soft start and current limiting capabilities.

#10094 Hugo Leon
Champaign, IL

Remote Temperature Logger

I want to monitor the temperature of my attic during the summer months. Ideally, I’d also like to know how long the roof fan runs for, but it’s hard wired and probably more difficult. I considered doing this by using a sensor to detect the sunlight. As the fan blades spin, the device would count the turning of the fan blades.

I’ll settle for a simple temperature detector that can send the data to my PC and some program that will graph the temperature over time.

The attic isn’t used so a long averaging time constant isn’t required because nobody is walking by disturbing the surrounding air.

I considered a simple thermistor with a 5-10 second RC circuit going into a Linx device that will transmit the data back to the PC. I would also need...
some program that would receive, interpret, and graph the data.

Peter
Boston, MA

Outdoor DTV Antenna Tuning Control
I have a RadioShack antenna rotor that I would like to have automatically controlled to the signal strength of the DTV station I have selected. Is there a circuit I can attach to the antenna control knob that will adjust it to the DTV station that I am viewing?

John Szymanski
Mt. Airy, MD

Lead Acid Batteries
Does anyone know of a supplier of re-buildable batteries or even parts suppliers for them? I need a small battery for experimental use. I must be able to change the plates as needed.

Harry Pedersen
Yelm, WA

ANSWERS

DC Motor and Inverters
Can I run a permanent magnet 90 VDC motor on a 1,500W inverter? I need to reverse the motor and was going to run the inverter output through a full wave rectifier.

The best way to hook up your 90V DC motor is through a DC/DC converter. Your inverter has a "front end" which is basically a DC/DC converter up to about 135-145 volts with a chopper on the other end. A "modified" sine wave is the result. The only thing necessary is the DC/DC converter.

An eight amp 90 VDC motor is approx. 1 HP, but requires about 250-600% starting current, depending upon load and motor design. Centrifugal pumps and fans are easy loads while compressors and positive displacement pumps are the worst; 1,500W is only about 200%, but some inverters are specifically designed to handle large surge currents.

Walter Heissenberger
Hancock, NH

Three Volt LED Solar/Charger
Most, if not all, outdoor pedestal lights are 1.5 volts with a very weak LED. With the advent of super bright >10,000 mcd white LEDs, we need a circuit we can drop in after getting the old one that will give a meaningful light source. I entertained a Maxim DC-DC step-up but the existing circuits are current limited. So, how about a 3.x solar source, photocell, a pair of 1.5 VDC batteries, and the charger circuit with photocell switch?

Actually, I believe that a constant current DC-DC converter would be the best way to drive an LED for this purpose. This allows for the LED to remain at a constant brightness, even if the voltage from your battery sags. Also, if you want even brighter lights you can string several LEDs together in series, and still have the same current through them.

Although there are plenty to choose from, I have experience with and would recommend Linear Technology’s LT1932. It is small in size, requires few external components, and is fairly flexible and easy to use. Also, you can continue to use a single cell rather than complicating the project by changing the power source. A schematic using this driver is shown in Figure 1.

One thing to be careful of no matter how you decide to drive your LED, is not to drain your battery too far. Discharging a NiMH battery completely will likely cause permanent damage. If you find that your light is not glowing the whole night, you might want to consider adding either a timer, a sensitive brownout detector, or larger solar cells to fill the battery faster.

Hal Emmer
Setauket, NY

Autoranging Digital Panel Meter
Does anyone know of a self-contained, autoranging digital panel meter? There are lots of fixed, 200 mV range, self-contained digital panel meters that simply require a power supply and appropriate voltage divider to measure a fixed range of input voltages. I would like to measure from 1 mVDC to 400 VDC with three or four digit accuracy. Or, is there a way to make a self-scaling, autoranging voltage dividing input circuit that would then utilize a standard self-contained panel meter to accomplish the same task? There are many good quality DMMs that are fully autoranging, but they are very difficult to disassemble and implement into a stand-alone system. Most have auto power-off circuits and other features that make them too cumbersome to implement.

Ralph J. Kurtz
Old Forge, PA

Figure 1
#1 Trumeter makes an autoranging panel meter called the APM (advanced panel meter). You can find more information at rswww.com/automation.

As an alternative, you can easily build your own or modify existing ones by adding a voltage divider. The divider is switched by either the panel meter circuitry (see Intersil AN046) or a microcontroller such as the PIC12F675. Figure 2 shows the principle. The switches can be CD4066s or DG200-series switches available from several manufacturers. Linear Technology and Maxim make high performance switches based upon the 200 series, which are superior. The software is fairly simple: If the count is too low, switch to a lower range. If it is too high, switch to a higher range. The outputs of the PIC also control the decimal point. The PIC can do everything, with either an internal 10-bit A/D converter or an external one for higher accuracy.

Walter Heissenberger
Hancock, NH

#2 Intersil application note AN046 describes an autoranging digital panel meter based on the ICL7106 LCD DVM chip. "This application note describes a technique for auto-ranging a battery operated DVM suitable for panel meter applications." [1] This application note also provides hints on adapting the ICL7107 LED version to autoranging.

If you can find a panel meter based on one of these chips, it should be adaptable by adding the circuitry described in AN046 to a small circuit board. Though, considerable additional circuitry is required.

Open a prospective panel meter to see if the analog-to-digital converter chip is identifiable. If you find a blob of epoxy hiding a bare die, identification will not be possible. The formerly available ICL7106EV/KIT evaluation kits with a circuit board do not seem to be available anymore. The alternative of laying out a circuit board is a major project if only a couple of meters are needed. Consult the ICL7606 datasheet for critical analog components if building from scratch. [2]

The obsolete NJU9212 digital multimeter chip with auto-ranging built in might also be of interest. [3]

References:

Dennis Crunkilton
Abilene, TX

#6094 - June 2009
Monitor Home UPS

I would like to be able to use an oscilloscope PC application to monitor the 120/240 output of my UPS. I found a couple of applications that utilize the PC's sound input.

Can the 240V output be effectively and safely reduced to the voltage level of the PC mike input?

I'm assuming you want to feed an AC signal to your PC's sound card. Since you're using the Microphone input (per your letter), you need a very small signal as the input is designed for a low level dynamic microphone.

Figure 3 should do the trick. The transformer (L1) provides electrical isolation between the 220 VAC UPS output and the rest of the system. B1 (pilot lamp) provides a load for the transformer, gives an indication the UPS output is active, and helps keep "extraneous noise" from appearing on the transformer's output. The resistor divider (R1, R2) is designed to send a six millivolt AC signal to the microphone's input. Adjust R2's value if you need a larger or smaller signal to the PC's microphone input. Use WELL-SHIELDED audio cable between R2's output and the 3.5 mm phone plug to minimize stray noise, pickup, etc. and do your best to keep that cable away from other transformers and AC cords.

Wiring isn't too critical point-to-point will work and keep the SHIELD connections of the audio cable ends as short as possible. Because you're dealing with LETHAL VOLTAGE at the transformer's primary input, make sure you HEAVILY INSULATE the transformer's PRIMARY SIDE connections. Install everything in a metal hobby box for extra shielding. IMPORTANT: The listed Jameco transformer is designed for 120 VAC or 220 VAC primary operation. For 220 VAC input, make sure you connect both primary wirings in series (pins 2 and 4) or the transformer may be damaged!
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**October 2009 NUTS & VOLTS 81**
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.

**Item # CS1720**

$1,399.99

60MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

**Who Says you can't take it with you? With the DSO1060 YOU CAN!**

You get both a 60 MHz Oscilloscopes and a multi-function digital multimeter, all in one convenient lightweight rechargeable battery powered package. This powerful packed package comes complete with scopemeter, test leads, two scope probes, charger, PC software, USB cable and a convenient nylon carrying case.

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- 150MSa/s Real-Time Sampling Rate
- 50GSa/s Equivalent-Time Sampling Rate
- 6.000-COUNT DMM resolution with AC/DC at 600/800V, 10A
- 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**

$549.00

An SMD rework station & soldering station in one handy unit! Perfect for shops & labs dealing with todays SMD board designs. Comes with an ESD safe soldering iron and a Hot Air Wand with 3 Hot Air Nozzles. A wide range of nozzles are also available.

**Item # CS1206**

$99.00

34 Channel USB Logic Analyzer

The CS15034 is a sophisticated, portable, and easy-to-use 500MHz, 34-channel logic analyzer equipped with features found only in more expensive bench type analyzers. Using advanced large-scale integrated circuits, integrated USB 2.0, CPLD, FPGA, high-frequency digital circuitry, embedded systems, and other advanced technology, make the CS15034 your best choice in pc-based logic analyzers The CS15034 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 ignored by other logic 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.
- Inuitive and flexible viewing screens to facilitate analysis of the system under test. Data can be 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.

**Item # CS15034**

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Triple Output DC Bench Power Supplies

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

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One Dollar Upgrade !!

Wow! Now thats a lot for only a Dollar more!!

You get the CSI2205D MM in the 45-1 Protective Case for only one dollar more than the price of the CSI2205D alone.

The CSI2205D Micro Control Unit auto-ranging DMM is designed for measuring resistance, capacitance, DC & True RMS AC voltage, DC & True RMS AC current, frequency, duty cycle, temperature, along with the ability to test diodes, transistors and continuity.

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**NEW ITEM**

$88.00 if purchased Separately! Save $11.00!!!
**Premium All-In-One Repairing Solder System**

The BlackJack SolderWerks BK6000 Repairing System is a digital multipurpose rework 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.

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**Hot Air System w Soldering Iron & Mechanical Arm**

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

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$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 BK2000+ 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

---

**Temperature 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 (PCBs). The system utilizes microcontroller to effectively and efficiently 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.

**Item# HHL3000**

$949.00

---

**380 watt Pure Sine Wave Inverter**

Continuous Output: 380W
Surge Output: 650W
Voltage (AC): 110V~120V
Frequency: 60Hz
Waveshape: Pure Sine Wave
Regulation (Typ.): ±1/3%
Total Harmonic Distortion: THD <3%
USB Output/Typ.: 5V DC ±/±1A, 500mA
Input Voltage: 12V
Low Battery Alarm: 10.5V
Low Battery Protection: 10V
No Load Current: 50mA
Efficiency: >83%
Size: 240 x 119 x 60 mm

**Item# SI-12038E**

$129.00

---

**Rugged 6000 Count AutoRanging DMM**

This is a very solid and versatile DMM manufactured by Precision Master. The MS8240C auto ranging DMM features a full scale count of 6000 and a 3 1/2 digit LCD display with 61 segment graph. This meter is designed to meet IEC1010-1 CAT III over voltage protection and implements a double insulation design.

**Item# MS8240C**

$39.00

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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.

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<td>CS1000X5 0-20V/0-5A</td>
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The Easy Bluetooth Serial Module (#30085; $69.99) is an effective and low-cost solution to free your hardware applications from wires. The module is small in size, and with its SIP header design, it can fit on any 0.1” spacing breadboards for rapid prototyping. The module is compliant with Bluetooth 1.x and 2.0 allowing it to communicate with a broad range of Bluetooth devices. The Easy Bluetooth Module is compatible with all the Parallax microcontrollers.

The module has two parts, the RBT-001 module and the SIP with voltage regulator PCB. With the on-board regulator, the module can be connected to voltages higher than 3.3 VDC (such as the Parallax Board of Education 5 VDC regulated supply) without worry of damaging the unit, while the RX and TX can utilize serial communication at CMOS and TTL levels.

**Application Ideas:**
- Control a Boe-Bot® robot via Bluetooth from a PC, mobile phone, or another Bluetooth module
- Communicate with a device or project wirelessly

**Features:**
- 1.x & 2.0 Bluetooth compliant
- Easy serial communication
- Class 2 operation (nominal range up to 30 m)
- Low power consumption
- On-board regulator for safe operations across various voltages

**Key Specifications:**
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- Dimensions: 1.40 x 1.79 x 0.49 in (34.41 x 45.65 x 12.51 mm)
- Operating temperature range: 32 to 113 °F (0 to 45 °C)

Order the Easy Bluetooth Module (#30085; $69.99) online at www.parallax.com or call our Sales Department toll-free at 888-512-1024 (Monday - Friday, 7 a.m. - 5 p.m., PDT).

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