■ PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

NUTS AND VOLTS

EVERYTHING FOR ELECTRONICS

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July 2011

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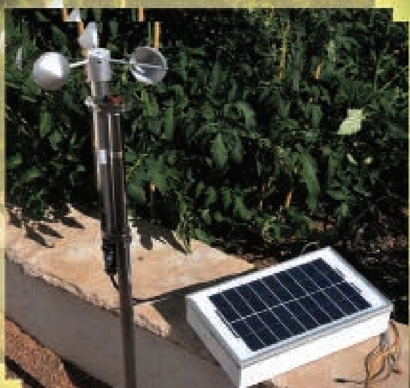
I2I Controls Shows You With A Solar Powered Data Acquisition System



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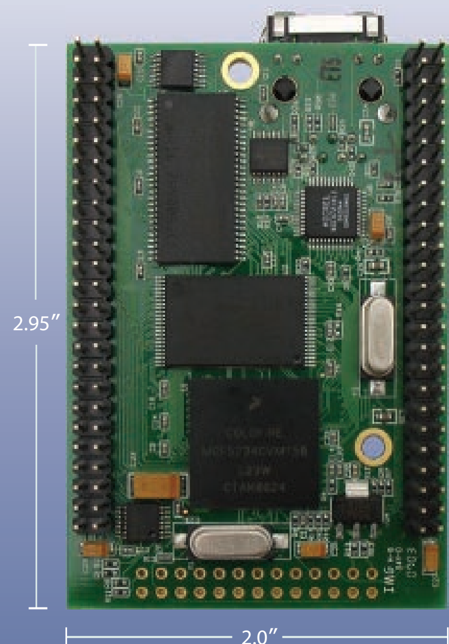

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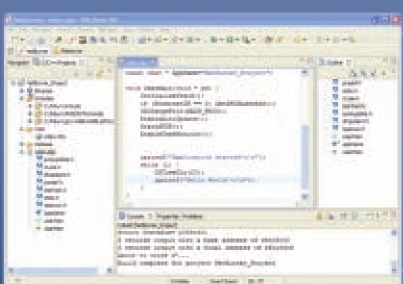

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KIT OF THE MONTH

Hearing Loop Receiver Kit

KC-5497 $25.50 plus postage & packing

A hearing loop is an inductive assisted listening system for the hearing impaired. They're typically installed in venues such as churches and conference rooms to enable listeners to receive in-ear communication via a wireless induction loop. You can now install this technology on your own TV, home theatre or hi-fi system. This will enable someone who's hard of hearing to hear at their own volume level without having to turn the volume up to a level too high for everyone else. The receiver will drive a pair of headphone or earbuds from the signal picked up from the hearing loop. The whole unit is completely self-contained and can be carried around in a pocket or you can add your own belt clip, so the user isn't constrained by a set of headphone leads. The kit is complete with case, label, PCB and components.

- Current consumption: 10mA
- Frequency response: 100Hz - 5kHz
- S/N ratio: 67dB
- Battery voltage indication: Down to 7V
- PCB: 65 x 86mm

Note: Transmitter not included

Improve Your Hearing Without The EXPENSE!

Clifford The Cricket

KC-5178 $12.50 plus postage & packing

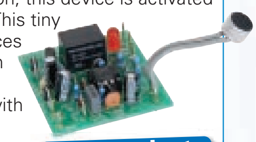
Clifford hides in the dark and chirps annoyingly until a light is turned on - just like a real cricket. Clifford is created on a small PCB, measuring just 40 x 35mm and has cute little LED insect eyes that flash as it sings. Just like a real cricket, it waits a few seconds after darkness until it begins chirping, and stops instantly when a light comes back on.

- PCB, piezo buzzer, LDR plus all electronic components supplied
- PCB: 41 x 36mm

"Minivox" Voice Operated Relay

KC-5172 $12.00 plus postage & packing

Voice operated relays are used for 'hands free' radio communications and some PA applications etc. Instead of pushing a button, this device is activated by the sound of a voice. This tiny kit fits in the tightest spaces and has almost no turn-on delay. 12VDC @ 35mA required. Kit is supplied with PCB electret mic, and all specified components.



- PCB: 47 x 44mm

Communicate Hands Free!

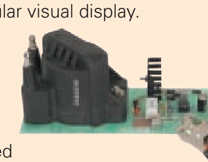
SCI-FI Kits

Jacob's Ladder High Voltage Display Kit MK2

KC-5445 $31.00 plus postage & packing

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display.

Kit includes PCB, pre-cut wire/ladder and all electronic components.



- 12V automotive ignition coil and case not included
- 12V car battery, 7Ah SLA or >5Amp DC power supply required and not included
- PCB: 170 x 76mm

Warning: The Jacobs Ladder Kit uses potentially dangerous voltage.

Theremin Synthesiser Kit MkII

KC-5475 $54.00 plus postage & packing

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna. It's now easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.

MORE INFO AVAILABLE ONLINE

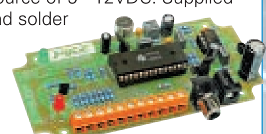
- Complete kit contains PCB with overlay, pre-machined case and all specified components
- PCB: 85 x 145mm

Don't just sit there BUILD SOMETHING!

45 Second Voice Recorder Module

KC-5454 $31.75 plus postage & packing

Will record two, four or eight different messages for random-access playback or a single message for "tape mode" playback. It also provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9 - 12VDC. Supplied with silk screened and solder masked PCB and all electronic components.



- PCB: 58 x 120mm

Bridge Mode Adaptor

KC-5469 $20.25 plus postage & packing

Enables you to run a stereo amplifier in 'Bridged Mode' to effectively double the power available to drive a single speaker. There are no modifications required on the amplifier and the signal processing is done by this clever kit. Supplied with silk screened PCB and components. Requires balanced (+/-) 15-60V power supply.

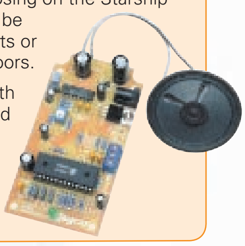
- PCB: 103 x 85mm

Starship Enterprise Door Sound Emulator

KC-5423 $29.00 plus postage & packing

This easy to build kit emulates the unique sound of a cabin door opening or closing on the Starship Enterprise. The sound can be triggered by switch contacts or even fitted to automatic doors.

- Kit supplied with PCB with overlay, speaker, case and all specified components
- 9-12VDC regulated
- PCB: 84 x 148mm



Audio Kits

Studio 350 - High Power Amplifier

KC-5372 $126.00 plus postage & packing

The studio 350 power amplifier will deliver a whopping 350WRMS into 4 ohms or 200WRMS into 8 ohms. It offers real grunt using a high power MJ21193/4 transistor and is super quiet with a very low signal to noise ratio and harmonic distortion. This kit is supplied in short form with PCB and electronic components. Kit requires heatsink and (+/-) 70V power supply as described in instructions. See website for more specifications.

- PCB: 136 x 241mm

Balanced to Unbalanced Audio Converter

KC-5468 $23.75 plus postage & packing

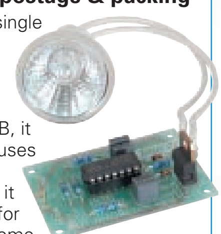
This kit will adapt an unbalanced input to balanced output and vice versa and allows domestic equipment to be integrated into a professional installation while maintaining the inherent high immunity to noise pick-up on long cable runs provided by balanced lines. Kit supplied with solder masked PCB and all specified components.

- PCB: 85 x 103mm

Flickering Flame Lighting

KC-5234 $12.50 plus postage & packing

This lighting effect uses a single 20 watt halogen lamp (the same as those used for domestic down lights) to mimic its' namesake. Mounted on a compact PCB, it operates from 12VDC and uses just a handful of readily available components. Use it for stage performances or for unique lighting effects at home.



- Kit includes 20W halogen lamp
- PCB plus electronic components
- Includes ceramic base for halogen lamp
- PCB: 38 x 58mm

Post & Packing Charges

Order Value	Cost
$25 - $49.99	$7.50
$50 - $99.99	$20
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$200 - $499.99	$60
$500+	$75

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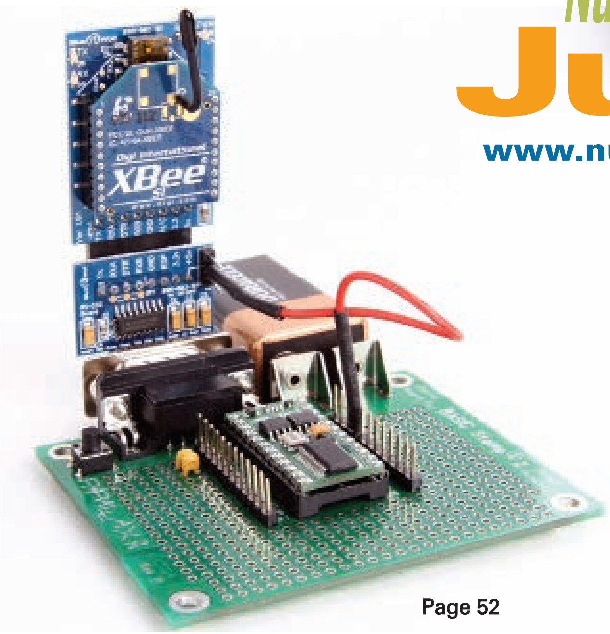

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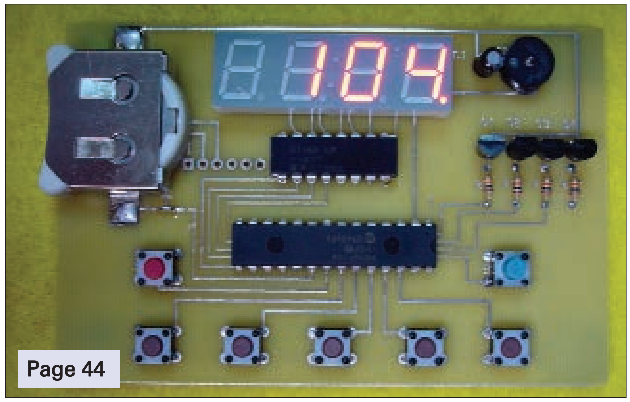
Projects & Features



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DEVELOPING PERSPECTIVES

Emergency Preparedness

Given the recent events in Japan, I was reminded of my youth working with civil defense in southern Louisiana. In addition to official communications, our group installed a 2M repeater system for local amateur operators. There was regular training on the use of Geiger counters and decontamination procedures, how to keep the diesel generators operating, as well as basic first aid. Fortunately, we never had to use the radiation monitoring equipment or consume any of the Army rations, but we did use the communications and first aid training on numerous occasions. It seemed that every other summer there was a major hurricane to contend with, including the flooding and manning of shelters.

Today, I keep a backpack with emergency supplies in my closet, ready to go. Interestingly, a large component of the backpack by both weight and volume is devoted to electronics. For example, there is a pair of Motorola walkie-talkies that work independently of any repeater system that might be down. The pair provides 22 channels with privacy codes in the theoretical range of over 20 miles, as well as reception of the NOAA weather channels. Of course, in the city, the $40 pair of walkie-talkies is good for about five miles, but that should be more than enough to provide communications between me and my significant other.

There's a small AM and FM radio, an LED headlamp for hands-free lighting, and an inexpensive analog multimeter. I considered one of those hand-crank radios with a built-in light, but opted for a lightweight, palm-sized radio with 20 hour playtime on a pair of AA batteries. Similarly, I considered tossing in one of those heavy-duty Maglites with four D cells, but my experience suggested that a hands-free headlamp powered by a set of AA batteries is both more useful and easier to carry. I chose an analog multimeter because it doesn't require a battery for AC/DC voltage and current measurement. A multimeter can be invaluable in determining the state of batteries — whether in a radio or your car. It can also be useful in checking fuses and circuit breakers in your house.

Given the low odds of a nuclear event in my area, I don't keep my Geiger counter in the backpack. However, it is easily accessible and I keep a fresh set of batteries nearby. In case you're considering picking up a Geiger counter, take a look at one of the inexpensive models available on eBay. The old analog type with a waterproof yellow chassis will provide just as much information as one of the newer all-digital models. Moreover, the older units are lighter weight, more rugged, and easier to repair given that they're built with discrete components. I bought a CD V – 700 Geiger counter on eBay a couple years ago for about $50. I noticed that during the Japanese event, the same model was going for about $200. Assuming the reactors in Japan are contained by the time you read this, the price of Geiger counters should be more reasonable.

In addition to the electronics, my pack contains basic medical supplies – bandages, antibacterial ointment, alcohol pads, aspirin, tourniquet, and suture kit. There's also a half-dozen food bars. If you assemble your own backpack, include only the medical supplies that you know how to use. For example, if you don't know how to properly use a tourniquet, you can do more harm than good. Check your local Red Cross for first-aid training.

Depending on your lifestyle and the most likely man-made and natural threats in your area, you might find it better to keep a box of supplies in the trunk of your car instead of in a backpack in your house. Regardless of where you keep the equipment, it's a good idea to mark your electronic or paper calendar to remind yourself to check the status of your emergency equipment on a quarterly basis. This means ensuring that batteries are in good condition, that the medical supplies have not expired or become wet or otherwise useless, and that you know where the equipment is. It's also a good idea to occasionally take out the walkie-talkies and practice using them to get an idea of range and how to operate the controls. It's much easier to review operating manuals and emergency procedures at your leisure than when you're in the midst of a storm or other disaster.

I also replace the food bars with new ones every quarter. Military rations might be good for five or 10 years, but a food bar that's been in the trunk of a car for a year can be hard on your teeth. **NV**

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EVERYTHING FOR ELECTRONICS

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READER FEEDBACK

UNITS GREEK TO READER

I just read about the bat detector in the June '11 issue and am confused by some of the component units. Is a resistance of "470R" 470 ohms? What about a capacitance in units of "n?" Are these British abbreviations?

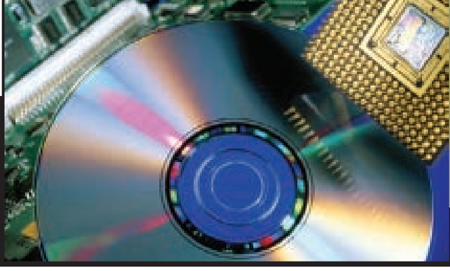
The circuit also calls for headphones rated at approx. "300R." I'm not sure what I should be looking for. The headphones I'm familiar with are all in the 8 ohm to 32 ohm range.

Randy Sprague

Response:

The Greek letter omega is generally used as the symbol for ohms,

Continued on page 51



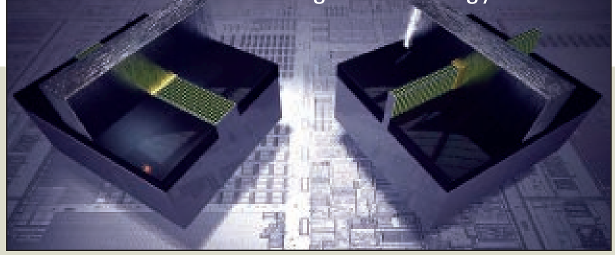
TECH KNOWLEDGEY 2011

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

TRI-GATE TRANSISTOR READY TO GO



■ Standard 32 nm planar transistor (left) compared with Intel's new 22 nm tri-gate technology.

It seems like most innovative, amazing, earth-shaking technologies never actually make it out of the research labs, so it's gratifying to report that Intel's (**www.intel.com**) tri-gate transistor technology — first disclosed back in 2002 — is ready for ramped-up production. Some 63 years after the invention of the silicon transistor, a fundamentally different design will be implemented within a 22 nm microprocessor codenamed "Ivy Bridge."

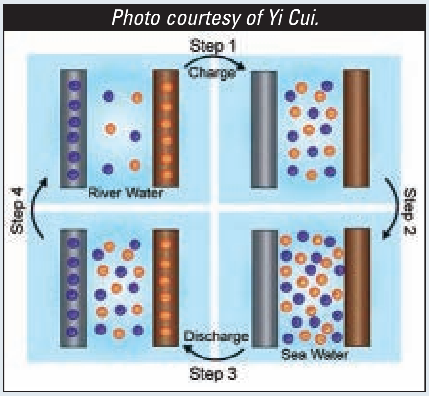
"Intel's scientists and engineers have once again reinvented the transistor, this time utilizing the third dimension," said Intel president and CEO Paul Otellini. "Amazing, world-shaping devices will be created from this capability as we advance Moore's Law into new realms."

Even the above-referenced Gordon E. Moore agrees. "For years, we have seen limits to how small transistors can get," he observed. "This change in the basic structure is a truly revolutionary approach, and one that should allow Moore's Law and the historic pace of innovation to continue."

The concept is revealed in the illustration. On the left is a 32 nm planar transistor in which current (shown as the yellow dots) flows in a plane beneath the gate. On the right, we see the current flowing on three sides of a vertical fin. Control of the current is accomplished by using a gate on each of the three sides of the fin rather than just one on top. This layout is said to produce improved drive current and reduced off-state leakage, resulting in up to 37 percent higher performance at a lower voltage as compared to the planar devices. It also allows for a further reduction in the size of transistors. In fact, more than 100 million tri-gate transistors could fit on the head of a (1.5 mm dia) pin. High-volume production of the Ivy Bridge-based Core processors should begin before the end of this year, with Atom processor products coming along later. If you want to download a technical paper with all the photos, graphs, and gory details, visit **jkeckert.com/freedownloads/tri-gate.pdf**. ▲

LOVE THAT DIRTY WATER

Photo courtesy of Yi Cui.



■ Energy-producing cycle of the battery developed at Stanford.

The Standells (**www.facebook.com/Standells**) probably weren't thinking about power generation when they expressed fondness for the contents of the Charles River, but perhaps they will take note of a process developed at Stanford University (**www.stanford.edu**) that could allow us to generate power from river water, storm runoff, or even treated sewage. The basic idea is to use the difference in salinity between fresh water and salt water to produce electricity, which is pretty simple in theory. You start with a battery consisting of one positive and one negative electrode, both immersed in a liquid containing positive and negative ions. (The enabling secret is that manganese dioxide nanorods are used to create the positive electrode, eliminating the need for fragile membranes.) In step one, you fill it with fresh water and charge it with a small current. You then drain off the fresh water and replace it with salt water which contains up to 100 times as many ions. This increases the potential between the electrodes, making it possible to harvest more energy than you used for the initial charge. Once the battery is discharged, you drain off the salt water and start over. A nice consideration is that a power generation plant using this technique would be essentially nonpolluting. One would siphon off river water that's headed for the sea anyway, and send it to its original destination when done with it.

A "limiting factor" is the amount of fresh water available, and you would need a lot of it. According to Yi Cui, Associate Professor of Materials Science and Engineering, a power plant processing 50 cubic meters of fresh water per second could produce up to 100 megawatts of power — enough electricity for about 100,000 households. He noted that the fresh water doesn't have to be all that fresh. "I think we need to study using sewage water," he said. "If we can use sewage water, this will sell really well."

But is all of this practical? Well, 50 cubic meters per second equals about 1,140,480,000 gallons per day. That's nearly four times the entire flow of the Charles River. Oh, well. The Standells aren't really from Boston, anyway. ▲

COMPUTERS AND NETWORKING

NEW MOBILE WORKSTATIONS

Photo courtesy of Dell, Inc.

■ Dell's M6600 mobile workstation, fitted with a 17.3 inch screen.

The average laptop is pretty decent for word processing, net surfing, and so forth, but it you need professional-level 2D or 3D computing, need to do massive amounts of data analysis, and need to do it on the go, a little more horsepower is in order. The answer is a mobile workstation, and Dell has launched two next-generation models. The Dell Precision M6600 comes with a 17.3 inch screen, and the M4600 is the 15.6 inch version. Both are certified for the top applications from Autodesk, Dassault, PTC Siemens PLM Software, and others. Billed as the most powerful machines of their type, they are based on a second-generation Intel Core i7 processor Extreme edition and 1,600 MHz system memory options. The M4600 now sports a numeric keypad, 32 GB memory capacity, and a HDD that stores up to 750 GB. The M6600 is designed for more demanding tasks, and it offers optional storage including a second HDD and a 128 GB SSD. It also will soon be available with NVISIA Quadro 5010M graphics with 4 GB of GFX memory. Both use an aluminum and magnesium chassis and are tested to MIL-STD-810G for temperature, vibration, dust, altitude, and shock. You also get five USB ports (including two USB 3.0) and three video options. The AMD Eyefinity technology supports up to five simultaneous displays. The units start at $1,678 and $2,158. Details, of course, are available at **www.dell.com**. ▲

DATABASE FOR YOUR iPHONE AND iPAD

FileMaker Pro — the cross-platform relational database program — has been around for years and, in fact, is now in Version 11. But a new twist is FileMaker Go for the iPhone and iPad, and the latest version (1.2) offers the ability to view and edit charts created with the Pro version, including bar, line, area, and pie charts. It also offers digital signatures, so you can digitally sign such documents as contracts and invoices without printing hard copies first. The documents can then be exported to a desktop or uploaded to databases on FileMaker Server. Other features include enhanced PDF creation and wireless printing via AirPrint-enabled printers. The iPhone version will run you $19.99, and the iPad one is priced at $39.99, but current users can get the upgrade for free. Both run on iOS 4.2.1 or later. ▲

IS THAT A SPY IN YOUR POCKET?

■ The Cellebrite UFED cell phone hacking device.

If you have been troubled by recent revelations that your cell phone can be used to reveal details of your personal life, this item will probably boost your concern level. It turns out that there is actually a commercially available device specifically designed for sucking data out of your handheld. In fact, Cellebrite Ltd. (**www.cellebrite.com**) has just released Version 2.0 of its Universal Forensic Extraction Device (UFED), designed to provide "law enforcement and government intelligence agencies with new capabilities for improved extraction, retrieval, and analysis of mobile phone data." Three new features are included in the latest release. The UFED Physical Analyzer is a parsing tool and report generator that offers upgraded ability to analyze and parse iPhone and Blackberry devices. It includes an instant search function, plug-in support, and Python scripting. The support base has been enhanced to include nearly 6,000 devices, including Samsung, LG, and Sony Ericsson products, and "historically challenging" CDMA memory dump capability has been expanded by 200 devices. Finally, V. 2 includes the UFED Phone Detective which lets users instantly identify the specific model phone you are using.

The bottom line is that the product "enables military, law enforcement, and intelligence agencies to easily extract deleted data, passwords, contacts, text messages, call logs, emails, GPS locations, web history, calendar entries, and much more. New parsing capabilities such as iPhone Skype support, browser cookies, Wi-Fi and cell tower locations, and more make it the most advanced end-to-end solution available to the mobile forensic community." At $4,799 a pop, it's not exactly cheap, but probably well within the budget of your local constabulary. If I ever used my phone, I think I'd be worried. ▲

CIRCUITS AND DEVICES

ATOMIC CLOCK ON A CHIP INTRODUCED

■ The Symmetricom CSAC, the world's first atomic clock on a chip.

The folks at Symmetricom, Inc., recently introduced the QUANTUM family of atomic oscillators, billed as the industry's first commercially available chip-scale atomic clock (CSAC). The device — created by researchers at Symmetricom, Draper Lab, and Sandia National Labs — measures only about 1.5 in square and less than 0.5 in deep, weighs just 35 g, and runs on100 mW rather than the 10W typical of its predecessors. Lest you be misled, please note that the CSAC does not actually use radioactivity as an energy source, so you don't have to worry about radiation poisoning. The unit hits some cesium atoms with a tiny laser beam and counts the frequency of emitted electromagnetic waves to keep track of time. When the clock has counted exactly 4,596,315,885 cycles, it determines that one second has passed. Obviously, you don't need this kind of accuracy in your digital watch — even if it's a Rolex. But the $1,500 chip is said to be useful for synchronizing underground or undersea activities where miners or divers can't receive GPS signals, providing backup timing for cross-country telephone and data lines, and supporting other military and commercial applications. Technical details are available at **www.symmetricom.com**. ▲

NO MORE FREE TOWELS

If you are in the habit of keeping your linen closet full by snagging an occasional towel from a hotel room, it's probably a good time to lose the habit. A Florida company called Linen Technology Tracking, LLC (**www.linentracker.com**) has partnered up with RFID company Fluensee, Inc. (**www.fluensee.com**), and is now marketing its Linentracker® product line to upscale hotels. Based on Fluensee's AssetTrack platform, it aims to "optimize the utilization, inventorying, tracking, laundering, and replenishment of towels, linens, hampers, and related assets to its many hotel customers." One might think that linen loss is not such a serious problem, but a Linen Tech representative — noting that the system is in operation in three major hotels in Manhattan, Miami, and Honolulu — claimed that the latter has reduced the theft of pool towels from 4,000 per month to only 750, thus saving more than $16,000. This won't have much effect on those of us who stay at the Motel 6 where the towels aren't worth stealing, anyway. But you high rollers need to be careful. ▲

INDUSTRY AND THE PROFESSION

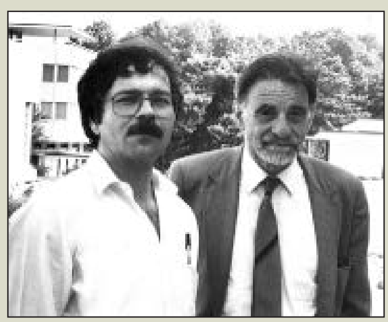
■ Superconductivity discoverer Heike Onnes (left), along with his teacher, Johannes van der Waals, with some liquefaction equipment in 1908.

SUPERCONDUCTIVITY TURNS 100

In 1908, Dutch physicist Heike Kamerlingh Onnes became the first to achieve the liquefaction of helium, thus making it possible to study the properties of matter at extremely low temperatures. Three years later, he discovered superconductivity, and to this day it remains one of the most mysterious phenomena in physics. In 1913, Onnes received the Nobel Prize for Physics in recognition of his achievements.

However, 2011 is not only the 100th anniversary of superconductivity, it is also the 25th anniversary of "high temperature" superconductivity. For 75 years, scientists dreamed of finding a material that could remain superconductive above absolute zero (-273.15°C). Progress was very slow, but in 1983, IBM scientists J. Georg Bednorz and K. Alex Müller achieved superconductivity in an oxide material at the relatively balmy temperature of -238°C, earning them the same Nobel Prize in 1987.

■ Bednordz and Müller.



So come on, folks, somebody get that room-temperature superconductivity thing going. Fame and fortune await. **NV**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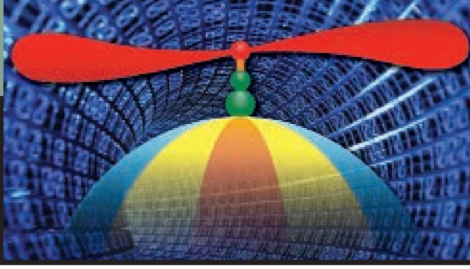


SPIN ZONE

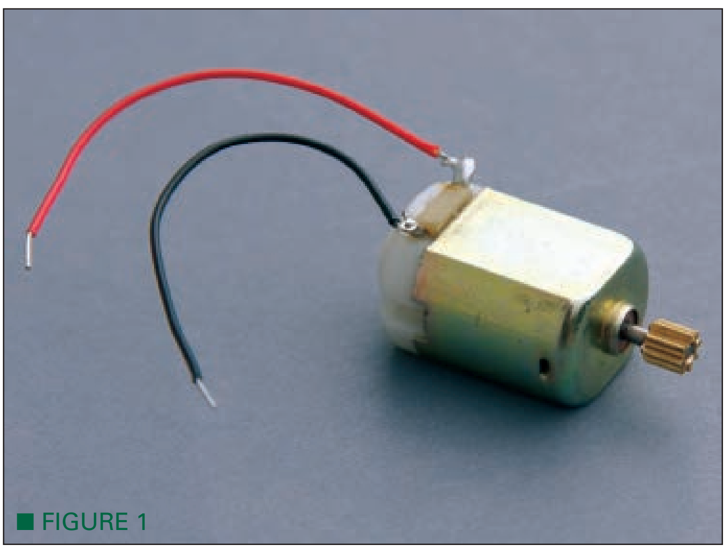
ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

SMALL MOTOR CONTROL MADE EASY

It's stating the obvious that the growth of personal robotics has absolutely exploded in the past 10 years. And why not? Robots are fun and a fantastic way to introduce technologies like electronics, programming, mechanics, etc., to youngsters. The coolest robots are no longer in cartoons or movies. They're in our high schools and universities. With processors like the Propeller, sophisticated robotic programming is becoming available to everyone. Luckily (for all of us who have not darkened the hallways of a school in a while), we have publications like *Nuts & Volts* and *SERVO Magazine* to feed our hunger for knowledge of robotics-related technologies.

For my part, the branch of robotics that interests me most is generally called animatronics: moving props and characters (e.g., puppets), usually as part of a show. Still, it is robotics and the control aspects are the same. Those of us that build small robots and animatronics will often use DC motors — which could be gear motors or hobby servos (which is a specialized gear motor). In this article, I'm going to show you how to take advantage of the Propeller's architecture to create a virtual DC motor driver that provides speed and direction control through your favorite H-bridge. The best part is that the code is very simple; no Assembly required!



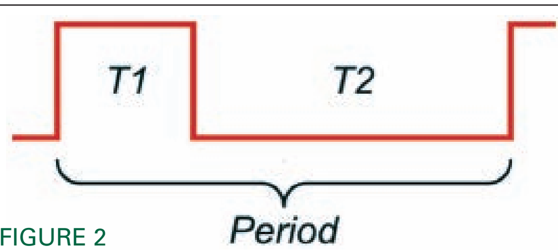
■ FIGURE 1

DC MOTOR CONTROL BASICS

Most of us have connected a battery to a small DC motor like the one shown in **Figure 1**, which I "liberated" from a discarded toy. When we reverse the leads to the battery, the motor runs in the opposite direction. Using a battery and a direct connection though, we have no speed control; the motor runs as fast as it will given the battery voltage.

Enter PWM (pulse width modulation). By modulating the connection of power to the motor, we can affect its speed; the greater the "on" time within the PWM period, the faster the motor runs. Have a look at **Figure 2**. In this case, the on time (T1) of the signal is 30% of the overall period (T1 + T2), so the motor will run at 30% of its maximum speed. Now ... that is if the other side of the motor is connected to ground.

What if the other side of the motor is connected to the supply voltage? Of course, the motor will run at 70% of its full speed but in the other direction. This means that we're going to use two control outputs for



■ FIGURE 2

the motor: one to apply the PWM (speed) signal; the other to control the motor direction. It's a small matter of programming (SMOP, as my friend, John, likes to say) to have the controller set the PWM duty cycle and the direction control pin to respond to our desires.

The Propeller processors (cogs) are not very fancy and — unlike many other small micros — do not include predefined peripherals like UARTs, ADCs, DACs, etc. What each cog does include, however, is two multi-mode counters that — with a bit of code — can be configured to do things like create an ADC or DAC and, in fact, they make DC motor control a breeze.

The counter mode we'll use is called PWM/NCO. It's important to note that in this mode, when using the counter in a set-and-forget configuration (i.e., without additional support code), we can control the duty cycle but not the frequency of the output (which will vary with duty cycle). What we want to do is create a fixed-frequency PWM output, and that is easily accomplished using **waitcnt** in a synchronized loop.

Each counter has two control registers: **FRQx** and **PHSx**. When set for PWM/NCO mode, the value of the **FRQx** register is added into the **PHSx** register and then bit 31 (MSB) of **PHSx** is moved to the specified output pin (in single-ended mode; there is also a differential mode that outputs the compliment of bit 31 to a second pin).

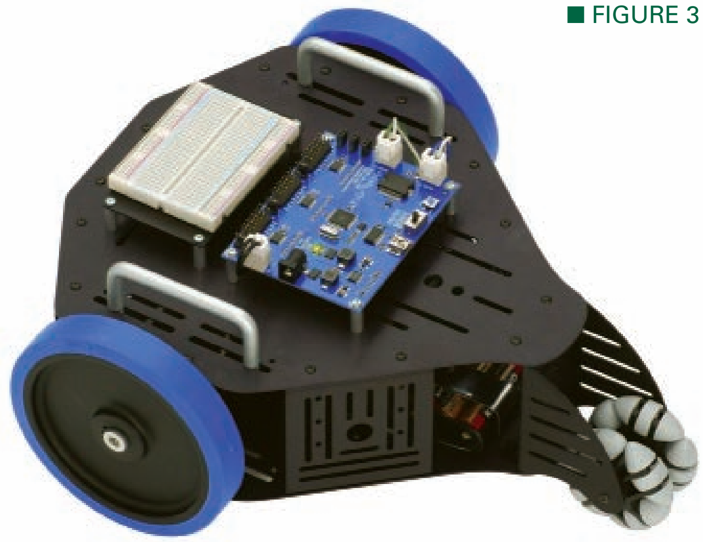
Let's have a look at a generalized version of the PWM code and then I'll explain how it works:

```
pri pwm1x(pin) | sync

  ctra := (%00100 << 26) | pin
  frqa := 1
  dira[pin] := 1

  sync := cnt
  repeat
    phsa := -duty
    waitcnt(sync += PWM_PERIOD)
```

First things first: While this looks like a standard method, it's not. This method is designed to run in its own cog, making it independent of yet concurrent with our main program cog. Note the **repeat** loop at the end; if we called this like a standard method, the program would get trapped in that loop. By starting this method it its own cog (using **cognew**), it will do its thing vis-à-vis PWM output while our main program controls the duty cycle with a global variable (*duty*), to which all Spin cogs have access.

This example method is using just one of the counters; for a dual PWM setup (which is great for robots like the Parallax Stingray in **Figure 3**), we can use the second counter in the same loop (we'll see this later). The counter is set to PWM/NCO mode and assigned the desired pin. The **FRQx** register is set to one to give us precise control of the duty cycle relative to the period. Finally, we need to make the PWM control pin an output to drive something.

■ FIGURE 3



It's important to remember that all cogs have their own direction registers and as this code will be running in its own cog, we have to set the PWM pin to output mode here. If we did this in the main program cog, the PWM signal from the counter in this cog would not make it to the pin.

Now for the working code: In order to create a specific PWM period, we will construct a synchronized **repeat** loop; the timing of this loop is controlled with **waitcnt**. You can see that the timing is set with a constant called *PWM_PERIOD*. I tend to use 20 kHz as my PWM frequency so the constant definition could look like this:

```
con

  PWM_FREQ   = 20_000
  PWM_PERIOD = 80_000_000 / PWM_FREQ
```

This assumes, of course, that the Propeller is running at the (standard) setting of 80 MHz. In actual practice, I have a self-adjusting (at compile time) constant that accounts for the crystal input speed and the PLL setting. This allows me to redefine the speed at which the Propeller runs without having to update the *PWM_PERIOD* definition.

Now that we know how many clock ticks are in the period that describes the PWM frequency, it's a simple matter to create a synchronized loop. So, how do we create the output pulse? This is pretty neat: We apply the negative value (in clock ticks) of the desired "on" time to the **PHSx** register. That's it! Then, we wait for the period to end and reload it.

Here's why this trick works: Remember that I told you that bit 31 of the **PHSx** register is applied to the output pin? When we load a negative value into that register, bit 31 will be set and the output will be on. During every clock cycle, the **FRQx** register — which we've set to one — will be added to **PHSx**. By adding one to the negative value in the **PHSx** register, it will move toward zero every

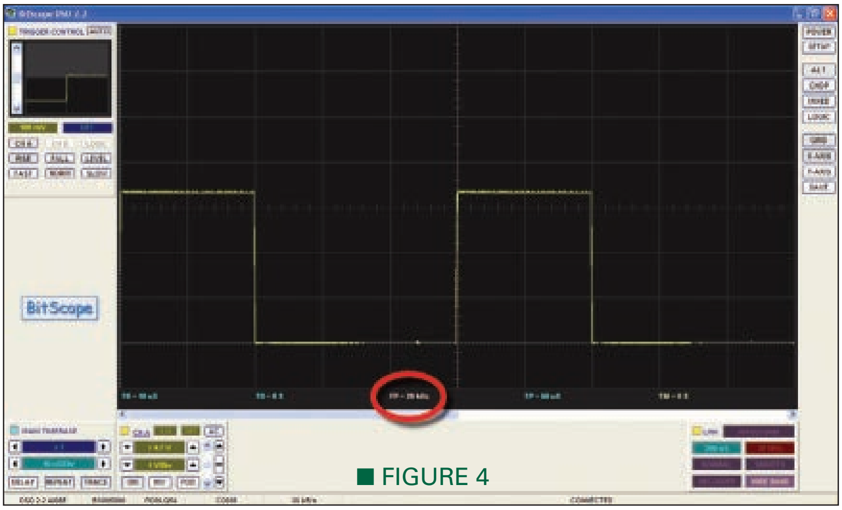
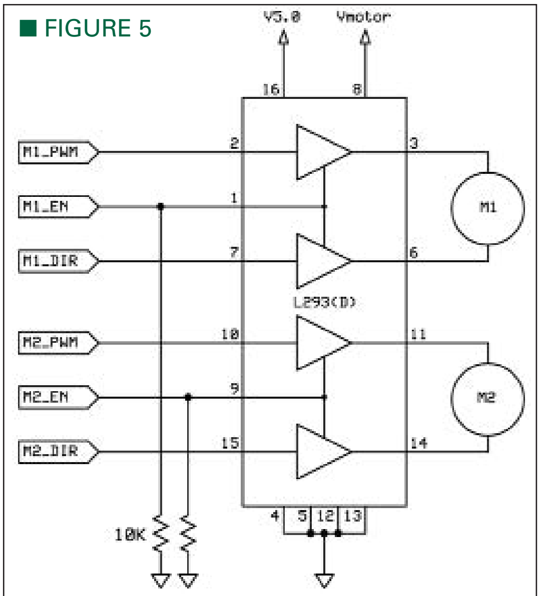


FIGURE 4

FIGURE 5


clock cycle. When the **PHSx** register gets to zero, bit 31 is cleared and the output will go low. How cool is that?

In practical use, we'll want a support method that converts our speed range — say -100 (full reverse) to +100 (full forward) — to the value required by the **PHSx** registers. This method will also handle the inversion of the value and direction control output when we want to reverse the motor. Again, here's a generalized view assuming control of only one motor:

```
pub setmotor(speed)

  speed := -100 #> speed <# 100

  case speed
   -100 to -1:
     duty := PWM_PERIOD * (100 + speed) / 100
     outa[M_DIR] := 1

  0:
     duty := 0
     outa[M_DIR] := 0

  1 to 100:
     duty := PWM_PERIOD * speed / 100
     outa[M_DIR] := 0
```

This is a method that runs in the main program cog. It ultimately updates a global variable called *duty* which is also visible to the PWM cog. This is the real fun of launching another Spin cog: We can easily exchange values via global variables.

At the top of this code, the speed input is limited to the legal range of -100% to +100%. If you want more steps in the overall range, you can change 100 (steps) to whatever suits you. In one project, I used -500 to +500 to give very precise control. That said, for most projects I do, in fact, use 100 as this directly corresponds to percent.

A **case** structure takes care of updating the *duty* variable with the new speed setting. As you can see, zero (stopped) is easy; we set the *duty* to zero and reset the direction control pin to low. Forward is also easy; we're setting the value of *duty* to the percentage of overall period clock ticks.

When reverse is designed, we have to invert the speed value. This is accomplished by subtracting the new speed setting from the full speed value. For this to work, though, we must also set the direction control output to match.

Booyah! Bob's your uncle! With that incredibly simple code, we now have the ability to provide speed and direction control to a DC motor. And, in case you were wondering if we could really control the PWM period using high level code, **Figure 4** should put you at ease. As you can see, the PWM output signal from the Propeller is dead on at 20 kHz. We're able to do this with simple code by using the counters and a synchronized loop.

Let me be completely fair, though. Using Spin (at 80 MHz) and providing the flexibility to use either or both counters in the PWM loop, the PWM frequency is limited to about 22 kHz — which should be fine for most motor control needs. On a recent project where both motors were always used and the code was fixed, I found the maximum PWM frequency was about 30 kHz. To get a higher PWM frequency, we would have to port the code to PASM.

Of course, there is a final step before running a motor: We need to connect an H-bridge to buffer the signals to the motor. There are lots of really great H-bridge designs available, and the specific design will depend on

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the voltage and current requirements of the motor you want to drive.

For very small motors, we can use a simple single-chip solution like the L293 or L293D (the former has slightly better current specs; the latter has built-in protection diodes). The L293 has four push-pull outputs, and two sets of two outputs are connected to an active-high enable pin. As you can see in the schematic (**Figure 5**), the enable pins are pulled down. This is important to prevent the motor from running while the Propeller is going through its start-up process and configuring I/O pins.

In many applications, the enable pins are set when the other pins are configured and that's that. In some applications, though, we may want to use the enable pins to "coast" the motors. Let me share a real-world example. My friend, Lou, builds motorized pan/tilt heads for movie cameras. His master controller uses a Propeller, code identical to what I've described here, and an L6205N driver (same as in the Stingray robot).

One of Lou's customers uses a very large telephoto lens on the rig. The lens is physically long, hence has some serious mass at the end of what becomes a lever. Simply stopping and locking — which happens when the enable pins are left high — can cause the image to vibrate when the rig comes to a stop due to the lens's inertia.

The mass at the end of the lens wants to carry it past the stop point (this is what causes the vibration). Lou solved the problem by allowing a coast input. When the motor is coming to a stop and reaches a speed near zero, the enable pin is released and the motor is allowed to coast. This lets the rig come to a stop on its own without any nasty vibrations.

CODE ONCE, REUSE MANY TIMES

It just makes sense, given the modularity of the Propeller, that we take this code and bundle it into an object that we can use when needed. By creating an object, we can control up to two motors with each, and by using multiple copies of the object, we can control more than two motors.

Most objects have a ***start()*** method; in this object, it allows us to choose which pins to use and the PWM frequency. I think it best to allow this per project instead of locking the PWM frequency into the object code; this would limit the object's flexibility with different motors:

```
pub start(m0p, m0d, m1p, m1d, freq) | ok

  stop

  if (m0p => 0)
    mxpwm[0] := m0p
    mxdir[0] := m0d
    dira[m0d] := 1

  if (m1p => 0)
    mxpwm[1] := m1p
    mxdir[1] := m1d
    dira[m1d] := 1

  pwmtix := clkfreq / freq

  ok := cog := cognew(dualpwm, @stack) + 1

  return cog
```

You can see that there is a "p" (PWM) and "d" (direction) pin for each motor, as well as a setting for the PWM frequency (expressed in Hertz). If we only want to use one motor, then we'll pass -1 as the pin numbers for the unused motor.

As with most Propeller objects, this one allows the user to reconfigure on-the-fly by including a ***stop()*** method. This is pretty simple: It unloads the current cog (if it was already running) and sets the motor PWM pins to -1 (which is the flag value for "not used").

If a motor set is used (PWM pin is 0 or greater), then that value (as well as the direction pin value) is copied to a global array for access by main program methods as well as the PWM cog. Note that I don't include a lot of error trapping here. I'm of the opinion that most people are smart enough not to assign the same pin number to the PWM and direction pins. Note, too, that the direction pin is set as an output in the main program cog because this is where it gets controlled. As we saw during the discussion of the PWM cog, the PWM pin is controlled there, hence it is set to an output there.

This is important: You don't want to make the PWM pin an output in the main program cog. The reason is that the outputs of each cog get OR'd together. If two cogs have the same pin defined as an output and either one is high, the output will be high no matter what is happening with the other cog. There are applications where this behavior is useful (IR modulation is one example), but with motor control it is not what we want.

With the motor pins defined, the ticks for the PWM period are calculated using **clkfreq** (a run-time variable that expresses system clock ticks per second) and, finally, the Spin cog is launched with **cognew**.

When launching a Spin cog, we have to define a stack for it. The stack is allocated variable space used by the Spin interpreter for intermediate values, parameters, and local variables. Stack definition can at times seem like black magic. For simple methods like this, I find that a stack of 16 longs is plenty. When in doubt, there are tools available (in ObEx) to analyze stack usage. It's important that we declare enough stack space, but we don't want to make it so large as to waste RAM that could be used elsewhere.

Here's how we construct a dual PWM cog that can use any set(s) of pins:

```
pri dualpwm | sync

  if (mxpwm[0] => 0)
    ctra := (%00100 << 26) | mxpwm[0]
    frqa := 1
    dira[mxpwm[0]] := 1
  else
    frqa := 0
    phsa := 0

  if (mxpwm[1] => 0)
    ctrb := (%00100 << 26) | mxpwm[1]
    frqb := 1
    dira[mxpwm[1]] := 1
  else
    frqb := 0
    phsb := 0

  sync := cnt
  repeat
    if (mxpwm[0] => 0)
      phsa := -mxtix[0]
    if (mxpwm[1] => 0)
      phsb := -mxtix[1]
    waitcnt(sync += pwmtix)
```

The primary difference between this version of the method and the first is that we don't pass the PWM pins as parameters; they are part of the global array. The same is true for the PWM period timing; this is calculated and stored in a global variable. Finally, with two counters at our disposal we are able to use both if desired. As described earlier, PWM pin designated as -1 is not used.

The sample code (which you can download from the article link) includes the final object and a demo program that lets us test the code using a keyboard interface. Connect your favorite H-bridge, a motor, and let 'er fly.

I think that's about enough for this time. Next time, I'll show you how to use a similar trick with the counters to create a virtual servo controller, and we'll even take steps to fix the problem some find with "walking" servo outputs.

Until then, get your motors running and keep spinning and winning with the Propeller! **NV**

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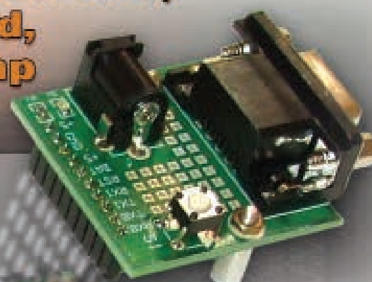

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Just like the days of "plugs, points, and condenser" are over, so are the days of having the hardware store grind out a spare key for your car! Now when your keyless access system doesn't work, you need to accurately detect what part of the system is malfunctioning. This could be anything from a dead battery in the key fob, a "brain-dead" key fob, to malfunctioning sensors, antennas, or other system components in the vehicle. The WCT3 is designed for both the car dealer service shops as well as the consumer. Until now there was no way to determine where the system was failing. Please note that the WCT3 simply verifies the generation of the control signals. Indication of signal presence is not an indication the encoded data is valid, nor is it a reader of that code, so don't worry, this will not help anyone steal your car!

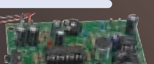
First, let's cover a few basics about vehicular keyless entry. In general, (not all systems are created equal), the vehicle itself generates a signal at 125 kHz or 20kHz. This is the signal that is used to "talk" to your individual key fob. Upon receiving the signal, your key fob "returns" a 315MHz signal uniquely encoded with an identification code and unlock command. If the embedded codes of the vehicle and your key fob match, you're in! Once you have "unlocked" the vehicle, and are inside the vehicle, the presence of your key fob is detected in the same way when the "start" button is pressed. If the codes match, the vehicle can be started. Some manufacturers also use Infrared (IR) signals in their key fobs to add additional user control functions to the vehicle. In that case, the key fob generates a modulated IR signal that is received by the vehicle's IR detectors placed throughout the perimeter of the vehicle.

Testing your system is easy. To test the complete 125 kHz/315 MHz communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. We should rename this "the handy-dandy, universal, wireless remote control tester"!

The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery. The test set is available as a do-it-yourself hobby kit or factory assembled and tested. For the kit builder, the WCT3 contains both SMT and through-hole components, with 170 solder points. If you're a car dealer, independent service shop, or simply an owner of a newer vehicle with keyless entry, or have wireless entertainment controls you can't afford not to have a WCT3!

WCT3	Four-Mode Keyless Entry Test Set Kit	$59.95
WCT3WT	Four-Mode Keyless Entry Test Set, Factory Assembled & Tested	$99.95

Digital Voice Changer



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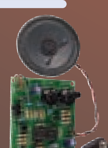
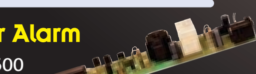
Steam Engine & Whistle



Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

MK134	Steam Engine & Whistle Kit	$11.95

Laser Trip Senser Alarm



True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1	Laser Trip Sensor Alarm Kit	$29.95

Electronic Watch Dog

A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike the Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655	Electronic Watch Dog Kit	$39.95

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- ✔ Beginner's non-soldering kits!

For over 3 decades we've become famous for making electronics fun, while at the same time making it a great learning experience. As technology has changed over these years, we have continued that goal!

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PL500 The ultimate electronics lab that includes 500 separate projects that cover it all, from the basics all the way to digital programming.

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AMFM108K We not only take you through AM and FM radio theory but we guide you through IC's. When you're done you've built yourself an IC based AM/FM radio that works great!

KNS10 With a reversible PEM fuel cell that combines electrolysis and power conversion into a single device you end up building your own fuel cell car! Learn tomorrows technology today!

KNS11 Learn alternative fuel technology while you build your own H-Racer car and refueling station!

KNS13 Convert ethanol alcohol to run a PEM fuel cell and watch it all work in front of your eyes!

KNS1 A great beginner's kit for the dinosaur enthusiast in the family, young and old! A wooden hobby kit that teaches motor and gear driven operation that requires no soldering.

PL130A	130-In-One Lab Kit	$39.95
PL200	200-In-One Lab Kit	$69.95
PL300	300-In-One Lab Kit	$89.95
PL500	500-In-One Lab Kit	$219.95
SP1A	Through Hole Soldering Lab	$9.95
SM200K	SMT Practical Soldering Lab	$22.95
AMFM108K	AM/FM IC Lab Kit & Course	$34.95
KNS10	Fuel Cell Car Science Kit	$82.95
KNS11	H-Racer & Refueling Station Kit	$144.95
KNS13	Bio-Energy Fuel Cell Kit	$129.95
KNS1	Tyrannomech Motorized Kit	$17.95

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Digital Controlled FM Stereo Transmitter

- ✔ PLL synthesized for drift free operation
- ✔ Front panel digital control and display of all settings and parameters!
- ✔ Professional metal case for noise-free operation
- ✔ EMI filtering on audio and power inputs
- ✔ Super audio quality, rivals commercial broadcasts
- ✔ Available in domestic kit or factory assembled export versions

For nearly a decade we've been the leader in hobbyist FM radio transmitters. We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters! The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting. Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power. A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use! Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish black metal case measures 5.55"W x 6.45"D x 1.5"H. Call for FM35BWT export information. *(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)*

FM30B Digital Controlled FM Stereo Transmitter Kit, 0-25mW, Black $199.95

Ultimate 555 Timers NEW!

This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

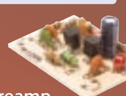
UT5A Through Hole 555 Timer/Osc Kit $24.95
UT5AS SMT 555 Timer/Osc Kit $26.95

OBDII *CarChip Pro*

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 CarChip Pro OBDII Monitor-Asmb $79.00

RF Preamplifier



The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 RF Preamp Kit $19.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 Touch Switch Kit $9.95

Doppler Direction Finder

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

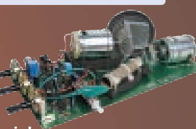
DDF1 Doppler Direction Finder Kit $169.95

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 Mad Blaster Warble Alarm Kit $9.95

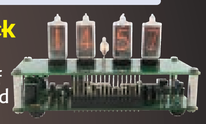
Laser Light Show



Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 Laser Light Show Kit $49.95

Retro Nixie Tube Clock



Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! This compact unit is great to build into your own enclosure or order our custom plexiglass enclosure. Requires 12VDC 500mA.

K8099 Compact Nixie Clock Kit $139.95

Water Sensor Alarm

This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

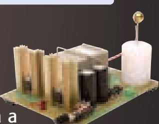
MK108 Water Sensor Alarm Kit $6.95

USB DMX Interface

Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.

K8062 USB DMX Interface Controller Kit $67.95

HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

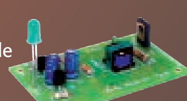
PG13 HV Plasma Generator Kit $64.95

Air Blasting Ion Generator

Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 Ion Generator Kit $64.95

Tickle-Stick Shocker



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 Tickle Stick Kit $12.95

Speedy Speed Radar Gun

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7 Speed Radar Gun Kit $69.95

Tri-Field Meter Kit

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C Tri-Field Meter Kit $74.95

Passive Aircraft Monitor

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for air-shows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 Passive Aircraft Receiver Kit $89.95

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

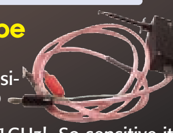
PR2 Broadband RF Preamp $69.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

MC1 Mini Electret Condenser Mic Kit $3.95

Sniff-It RF Detector Probe



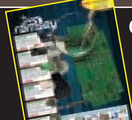
Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 Sniff-It RF Detector Probe Kit $27.95

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U 3-In1 Multifunction Solder Lab $134.95



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Q&A

WHAT'S UP:

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

- ✔ Theremin Coils
- ✔ Leak Noise Correlator
- ✔ Modified Beeper/LED Circuit

■ 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**

LEAK NOISE CORRELATOR

Q I volunteer for my local water department. The pipes are all cast iron — four and six inch — within the water district. We have several and expensive breaks each year, mainly during the winter and spring thaw. Our water operator currently locates these leaks with a sounding device he acquired years ago. As you can imagine, it is labor-intensive and often we have to dig up whole sections of road just to find a leak or broken pipe.

Lately, a new device has come on the market which can accurately locate the break. The only thing about it is the cost is out of sight. The principle on how these leak noise correlators work has been described as a microprocessor-based system that uses cross-correlation to determine the time difference between signals.

The ping sensor with an amplifier maybe ideal for this, although I do not know. Any help you could give with the design and assembly of one of these devices would be greatly appreciated.

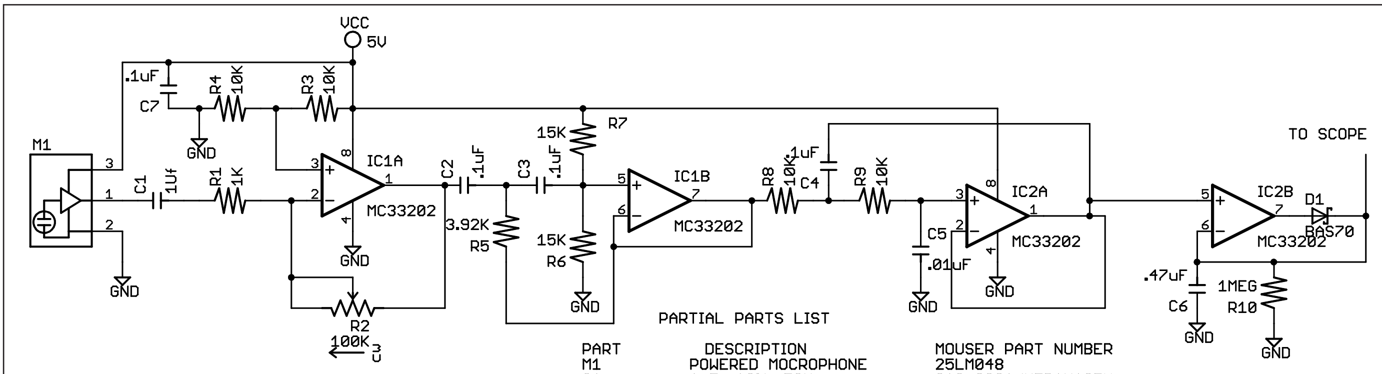
— Howard Epstein

A The system that I envision includes a digital storage oscilloscope because the human brain is the best correlator you can find. I found a USB powered unit on eBay that you could use with your laptop computer for about $30 (shipping included). The item number is 220651026871.

From the microphone attached to the pipe, I would put a band pass filter to eliminate low frequency traffic noise and limit the upper frequencies so the correlation will be easier. Follow this with a rectifier circuit (envelope detector), then to the scope. The scope is two channels so you can measure the time difference between signals, and then apply the formulas to determine the distance to the break.

There will have to be some experimentation, and I am willing to work with you to optimize the system. To start, assume that a 300 Hz to 1 kHz band pass will attenuate traffic noise and provide a usable signal envelope. The acoustic sensor could be a microphone epoxied to a ring magnet. The circuit for each sensor would be something like **Figure 1**.

I expect the sensors will be attached to a fire hydrant. You will need to measure the velocity of sound in the pipe. To do that, make

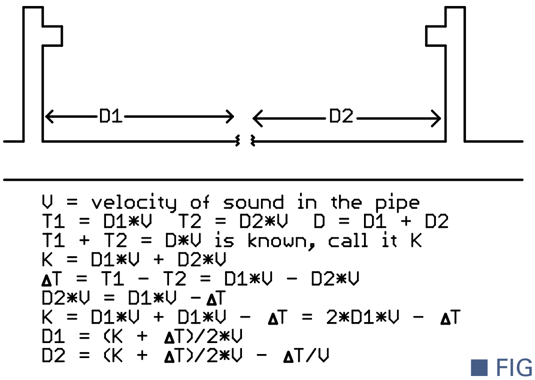


PARTIAL PARTS LIST

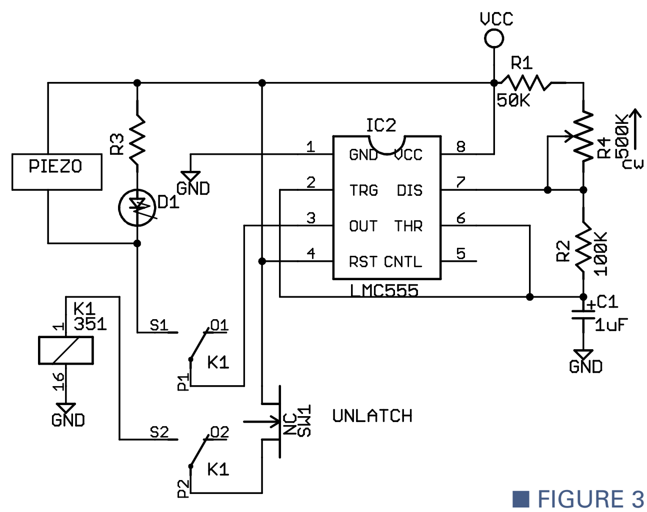
PART	DESCRIPTION	MOUSER PART NUMBER
M1	POWERED MOCROPHONE	25LM048
C1	1uF, 10%, 50V	810-C3216X5R1H105K
C2, C3, C4	.1uF, 5%, 50V	77-VJ0805Y104KXATBC
C5	.01uF, 5%, 50V	77-VJ08705Y103KXACBC
C6	.47uF, 10%, 25V	810-C3216X7R1E474K-2
D1	70V, 0.2A, SINGLE SOT-23	625-BAS70-00-V
IC1, IC2	DUAL OP AMP, RAIL/RAIL	863-MC33202DG
R2	100K POT	785-392JB100K

ALL RESISTORS 1% 1206 SURFACE MOUNT

■ FIGURE 1



■ FIGURE 2



■ FIGURE 3

the measurement in a section with no break. Hit one hydrant with a small hammer and measure the time for the sound to reach the other hydrant. The velocity (V) is: V = T/D, where D is the distance between hydrants. I have derived the equations that determine the distance to the break; refer to my sketch in **Figure 2**.

If you want to use an RF link, Qkits has a transmitter (TX433B) for $9.95 and a receiver (RX433) for $7.95 (**http://store.qkits.com**). You can't use two transmitters on the same frequency, so I recommend that you hard-wire one of the sensors to the correlator. You will need antennas and an amplifier for the transmitter modulator at least.

MODIFIED BEEPER/ LED CIRCUIT

Q I saw a schematic in *N&V* for a beeper/LED and would like to add an SCR to it, but don't know if it's placed in the right position.

Please indicate if the SCR is correctly inserted into the schematic (refer to **Figure 3** in the answer); if not, please modify it.

— Don

A The SCR will not work because the worst case holding current is 3 mA and there will not be that much current when the 555 output is high. Even the best case (0.3 mA) probably won't work. The only way I see to do this is with a latching relay, as in **Figure 3**.

THEREMIN COILS

Q Back a year or two, I designed a Theremin tube circuit. The PITCH and VOLUME coils are a kind of transformer or modified RF coil. The pitch frequency is about 350 to 450 kHz. The volume operates at a 250 kHz frequency. My request is: Can you give me data on these coils for the pitch and volume RF coils? It must be sensitive to hand capacitance. The BFO is also needed for data to wind coils.

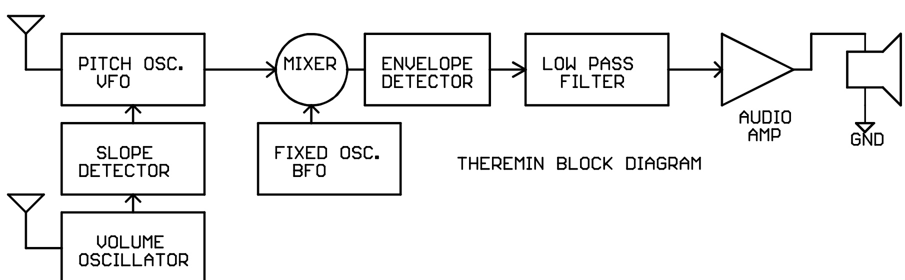
The two IF transformers are 455 kHz radio types which operate as a filter for the first and second harmonics. Can these be made out of the RadioShack cores #276-104? Also, the volume detector transformer needs data on this to wind coils too. Can RadioShack core #276-104 be made from this core too? I'm trying to get a prototype built, but I need coil windings on all of these. If you can help me out on the coils/transformers for this design, it will be greatly appreciated.

The inductor in series with a capacitor helps make the antennas more sensitive by resonating at the coil's frequencies. If I made any mistakes in this design, just let me know. It started out as something to work with.

— Craig Kendrick Sellen

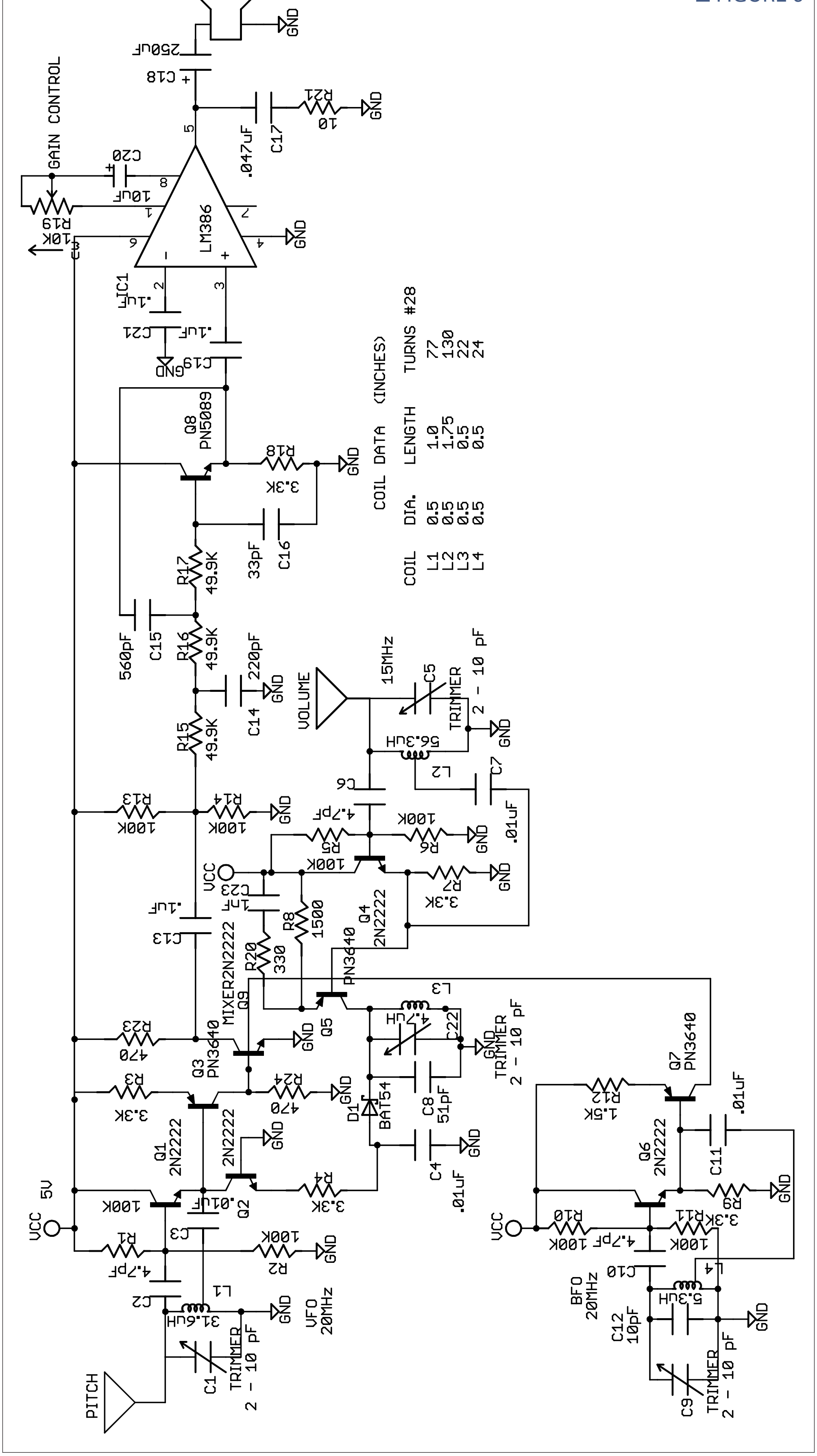
A I didn't print your tube circuit because I do not fully understand it. The series L-C at the antenna will not work because it is not a complete circuit. I don't understand the use of a 455 kHz IF after the mixer; I would use a low-pass filter (see **Figure 4**). The RadioShack core will not operate at the high frequency; a ferrite AM antenna core would work but is difficult to cut to length.

The Theremin operates by beating two oscillators such that the difference in frequency is in the audible range. One oscillator (the VFO) is varied by hand capacitance near the antenna. A high L low C design is necessary for this to work.



■ FIGURE 4

■ FIGURE 5



The other oscillator is fixed (the BFO); a higher C–L ratio is best for this oscillator to improve stability.

The volume can be varied by running the signal up and down the triode transfer curve or by directly varying the VFO amplitude. **Figure 4** is arranged to vary the VFO amplitude by controlling the current. A frequency discriminator or slope detector is needed for this to work.

I will raise the frequency to about 20 MHz in order to use easily wound coils; refer to **Figure 5**. The handbook formula only works for single-layer solenoid coils; that is the limitation. I simulated one of the oscillator circuits; the frequency was much lower than I calculated, but the frequency is not important as long as the VFO and BFO are the same. The volume oscillator is at 15 MHz so it does not interfere with the VFO.

Two oscillators at nearly the same frequency will pull together unless there is good isolation. I am hoping that Q3 and Q7 will provide sufficient isolation, and coils L1 and L4 must be mounted at right angles to each other and as far apart as practical.

In **Figure 5**, Q1 is the VFO oscillator and Q2 controls the current, and thereby the volume. I was surprised to learn that more current gives lower volume; I had expected the reverse. L3 in the volume circuit is tuned lower than L2 so that hand capacitance increases the DC output and reduces the volume. It might be better to tune L3 to be the same frequency as L2, and then hand capacitance will increase the volume.

I had initially used a diode mixer but the output was too low for the envelope detector; an amplifier is needed (now I see why you had an IF

MAILBAG

Dear Russell: Regarding Geff Waite's Q&A query in *N&V* March '11 (page 29) for a quick and cheap solution to remotely monitor temp, wind, and for a camera, perhaps the solutions at **www.iobridge.com** would suffice. Ironically, their advertisement appears two pages after Wait's query, in N&V.

— John Triplett

Response: Thanks for the feedback, John.

Dear Russell: In the Q&A section of the April '11 issue (page 23), there was a piece about SPICE modeling using the MC33201 SPICE model from ON Semiconductor. The author reported some issues with the model and I was curious to know what types of circuits were used. We recently updated the model and I ran a few quick simulations in Cadence PSpice with expected results. I could not see issues even with the small supply rails (±1V); I although, I have not run a simulation in LT Spice.

If there is a problem, I can look into the cause and have the model tweaked for better performance.

— Wayne Little

Response: I re-checked the MC33201 model in a simple inverting and non-inverting circuit and it worked as I would expect down to ±0.5 volts, so I was wrong. I don't recall what I was doing that I concluded that it didn't work below 1.5 volts, but it wasn't a simple circuit so it could be a circuit problem. I will let readers know that the model does work as it should.

Thanks for writing.

Dear Russell: Re: DC Power Supply, March Q & A, page 26: Q3 seems to get warm rather quickly. I have a small heatsink on it now. How warm should I expect this to get? Should it be a large heatsink? I have not run it for more than 15 seconds at a time. On a side note, can you recommend a PC/USB type oscilloscope? One would be very useful here.

— Jeff Shearer

Response: Q3 was not intended to supply long term power; it is getting hot because there is not enough voltage from the bootstrap winding. The solution is to increase the winding from seven turns to nine turns, but for a quick fix you can change D8 (the 12 volt zener) to 10 volts. The system should still work although the drive to Q1 and Q2 is reduced.

I can't recommend a USB scope but I am thinking of getting one for myself. There is a storage scope advertised on eBay for $30 from China that I am thinking of trying.

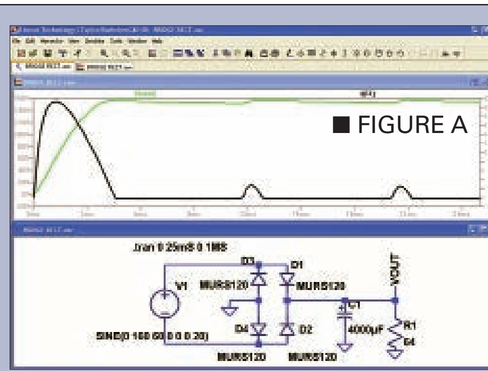
Dear Russell: Re: Power Supply, March '11, Q & A, page 26:

1. You get 21,000 µF after solving the equation C=IxdT/dV. I take exception with the fact that the cap(s) had to supply 2.5 amps. The majority of the current should be coming from the full-wave bridge rectifier. True — however on startup, if the caps are discharged there is A LOT of inrush current that could amount to two amps or more.
2. Concerning the Q3 transistor — you say the base-emitter junction could 'zener?' Please elaborate — I have never heard of a BJT junction acting like a zener diode.
3. When you solve for L using the inductive reactance equation ... please check your math. You have L=800/2/pi/100 kHz when I think you intended for L=800/(2*pi*100 kHz). I choked on the quick assumption that XL = E/I without any discussion of phasors or voltage/current phase relationships. True that R=V/I in a DC circuit but we are talking AC here.
4. Just an observation concerning safety: Why isn't there some kind of isolation transformer on the power input of the circuit? Bringing wall current/voltage directly to the full-wave bridge rectifier makes me nervous. Perhaps this is done to reduce cost, weight, or board real estate.

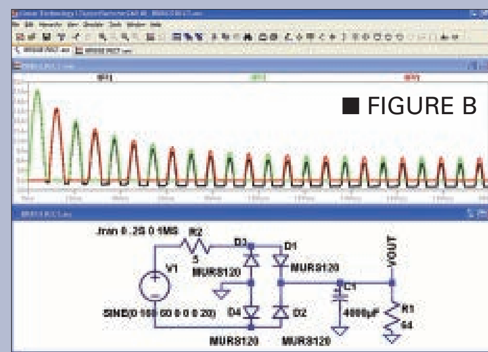
Thanks Russell. My questions/comments are not meant as a cheap shot. I just wanted to clarify.

— Don Moore

Response: Thanks for writing, Don. I am pleased to clarify my thinking on this subject.



■ FIGURE A



■ FIGURE B

1. Actually, all the current comes through the bridge rectifier but it is in pulses. The capacitor has to supply the current in between the pulses; see ***Figure A****. The peak inrush current may not be 200 amps in a real circuit; the capacitor in the simulation has no loss resistance.* ***Figure B*** *shows the reduction in peak current with the inrush current limiter. Actually, the resistance of the current limiter decreases with time, so the steady state peak current will be higher; see* ***Figure B****.*

2. The reverse breakdown of the base-emitter junction is like a zener. The zener voltage for a 2N2222 is about 7.5 volts.

*3. I may be wrong but I always thought that 800/2/PI/100 kHz was the same as 800/(2*PI*100 kHz). When the inductor is lossless, Xl does equal E/I. In this case, I assumed that the loss was small enough to neglect. In my designs, the objective is to make it work, not make it perfect.*

4. The reason for using a switching power supply is to avoid having a large transformer. The circuit should be enclosed so the uninformed can't get their fingers in it, but no matter how hard you try to make something foolproof, some fool will find a way.

Dear Russell: Re: On/Off Switch Needed, March '11, page 30.

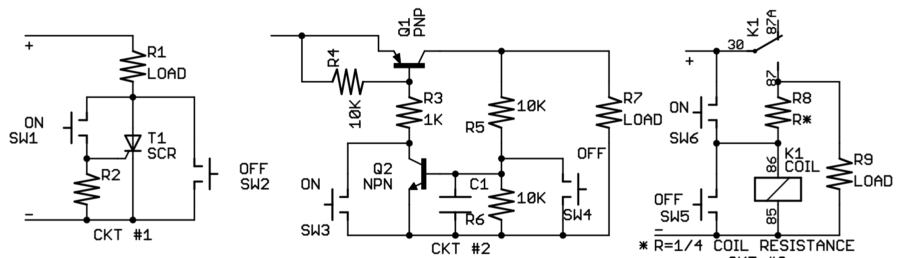
I enjoyed the question on the

ON/OFF switch and seeing the simple solution offered in the schematic of Figure 3 in the March issue. I have sent a few other simple solutions that may be of interest to readers. Please see **Figure C**.

Circuit #1 is a simplified version of the circuit shown in the answer that uses only one SCR. The OFF pushbutton shorts out the SCR, thus unlatching it. Power through the load is removed when the OFF switch is lifted. The OFF switch can also be used as a momentary power-on if needed.

Circuit #2 is a basic two transistor latch using a PNP for the pass transistor and an NPN for the PNP driver. The PNP is turned on by a momentary closure to ground. The NPN is turned on through the 10K resistor connected to the PNP collector. To unlatch, the base of the NPN is briefly shorted to ground, thus causing the NPN to unbias the PNP and the circuit shuts off.

Circuit #3 shows a similar latch function using a relay. A relay with extra contacts can be used to switch other voltages for loads needing isolation. The resistor in series with the coil keeps the relay pulled in and allows the OFF button to work.



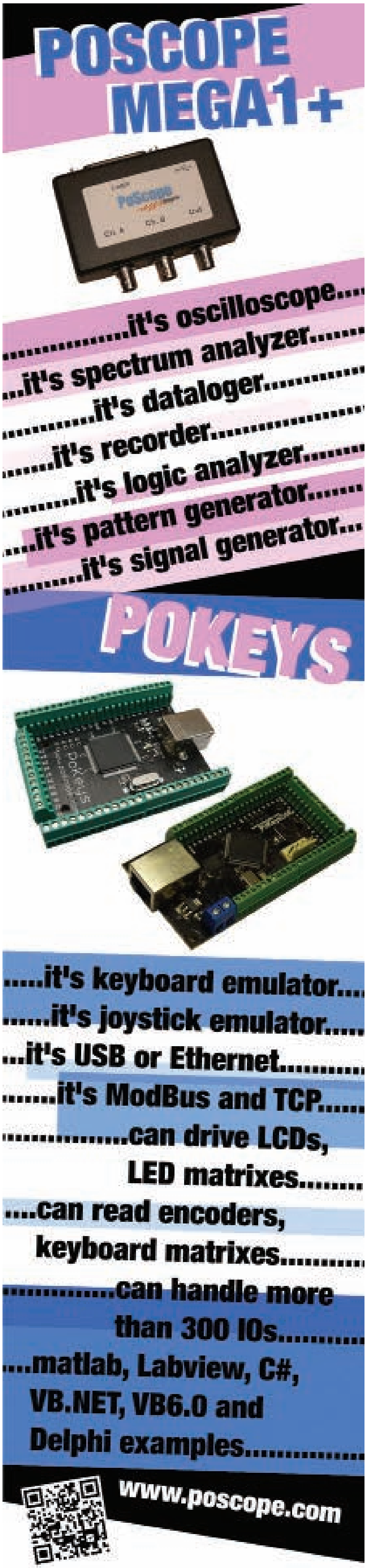
■ FIGURE C

— Bob Henry KD5MHQ

Response: Thanks for writing, Bob. These are interesting circuits.

transformer). I changed the diode to Q9 which provides gain and also doubles as an envelope detector. The Q8 circuit is a three pole, low-pass filter at 20 kHz.

When winding the coils, the wire size is not critical, but if the size is larger you won't get 77 turns in one inch for L1. In that case, use 77 turns close wound. I recommend drilling a hole in the coil form at the length specified and wind from hole to hole. Coat the coil with shellac or varnish for stability. **NV**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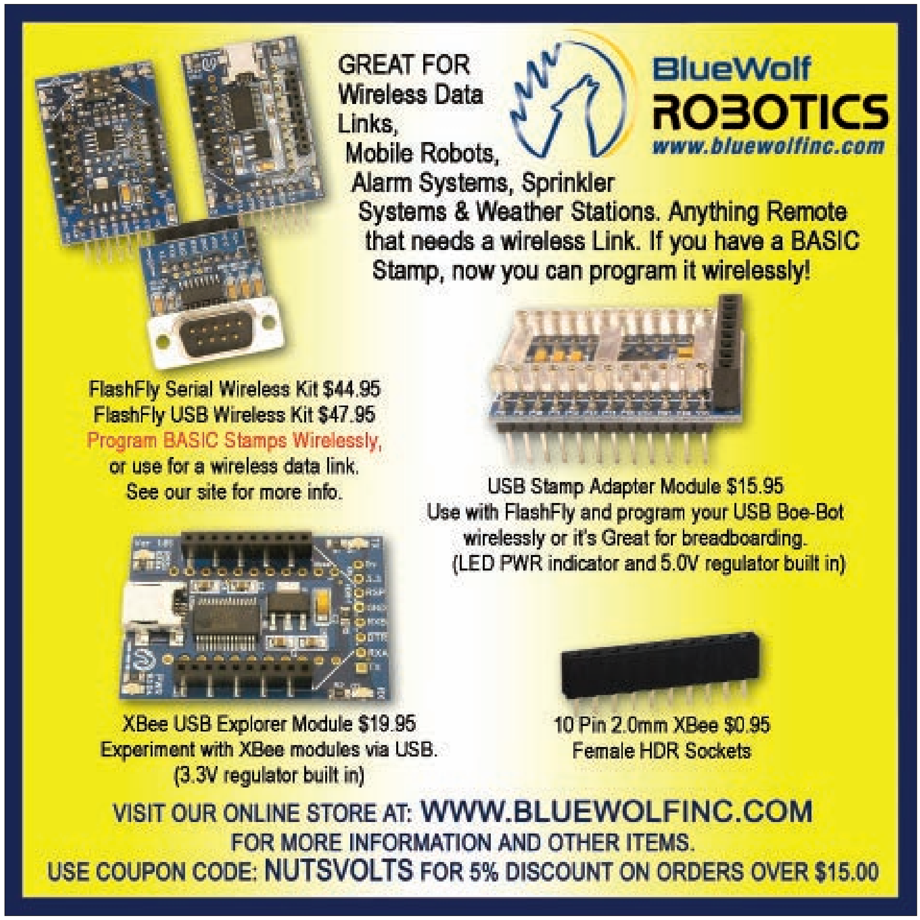
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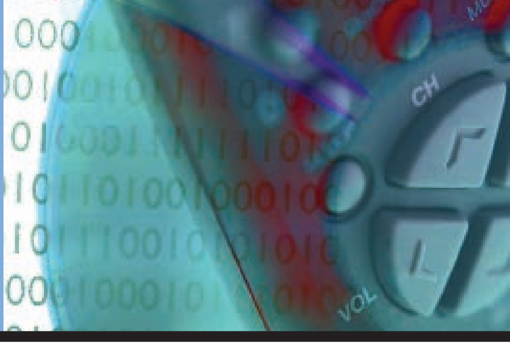

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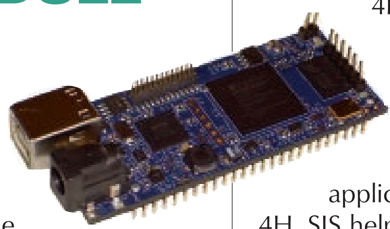

DLP Design, Inc., announces their new DLP-HS-FPGA2 high speed FPGA module based on silicon from Xilinx and FTDI. This new version has a larger FPGA, but is otherwise identical to the DLP-HSFPGA. The new version uses an XC3S400A-4FT256C from Xilinx. It has the same high speed USB 2.0 interface based on the FTDI FT2232H, and 32M x 8 DDR2 SDRAM from Micron as the previous version. The module also comes with a working reference design, and is available from both Digi-Key and Mouser. Price is $179.95.

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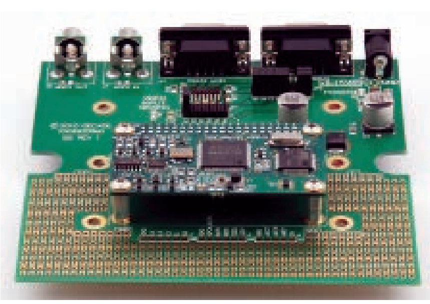

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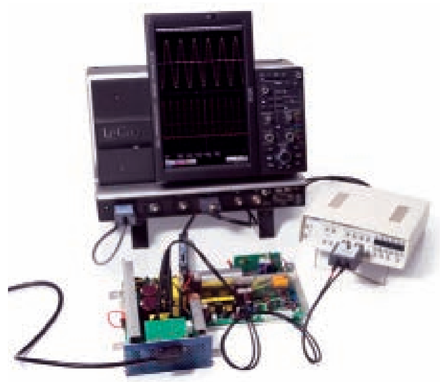

LeCroy Corporation introduces a new line of 12-bit resolution WaveRunner® oscilloscopes — the WaveRunner HRO™ 6 Zi. The WaveRunner HRO (High Resolution Oscilloscope) features an industry leading 12-bit Analog-to-Digital Converter (ADC), deep memory of 256 Mpts/ch, and superior DC accuracy specifications. These features are in addition to the extensive analysis capabilities of the WaveRunner 6 Zi. Engineers no longer have to compromise the analysis functions of an oscilloscope to get the high resolution they need.

Designed for the medical, automotive, power, and electro-mechanical markets, the WaveRunner HRO has higher resolution and greater measurement precision than eight-bit alternatives.

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In addition, LeCroy provides a pivoting display that permits viewing signals vertically, as well as horizontally to obtain more detail for

Continued on page 81

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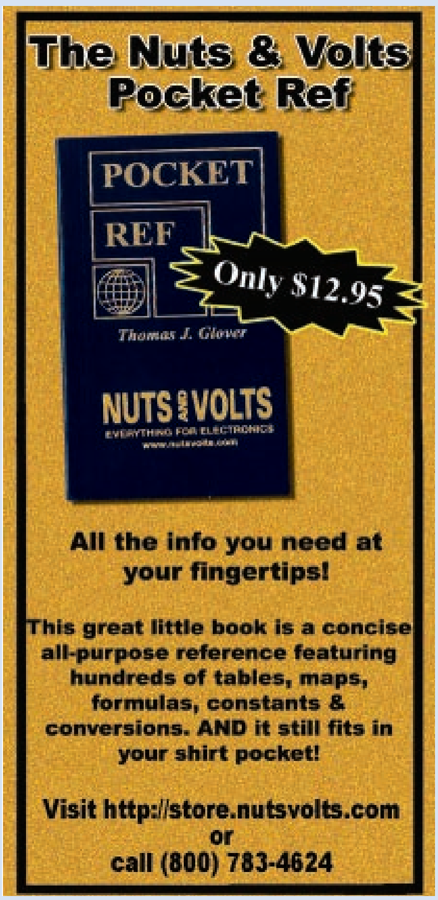
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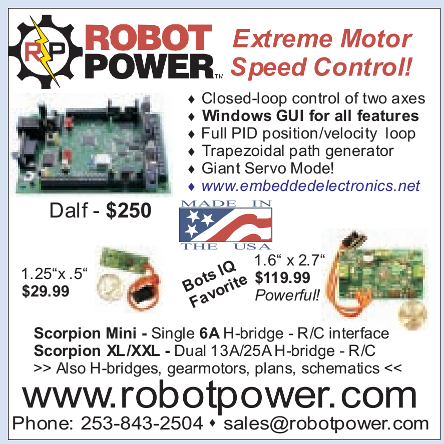
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By John Katausky

A SOLAR POWERED DATA ACQUISITION SYSTEM

John Katausky is a consultant with I2I Controls. He has written this article to demonstrate the usage of I2I's new Spectrum-ACE family of products in a real-world application.

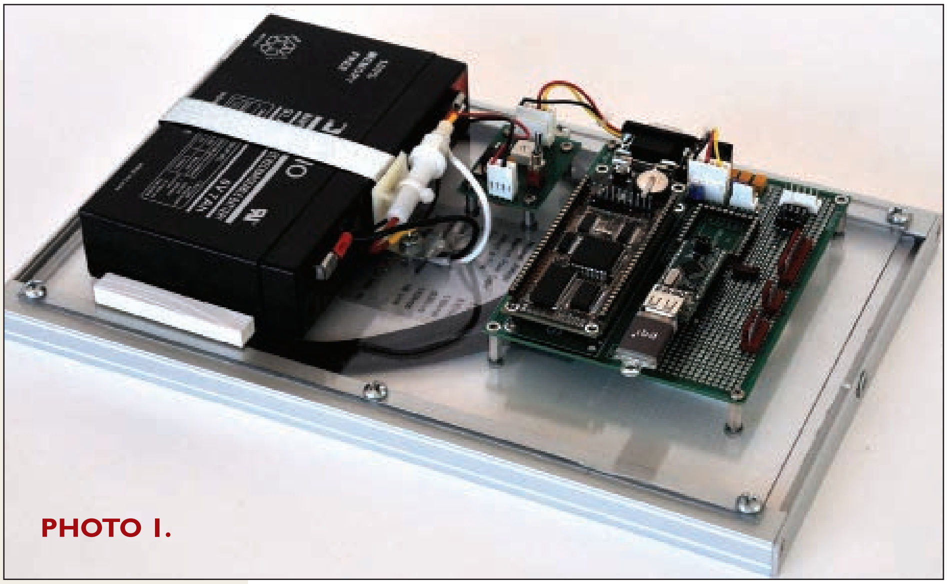


PHOTO 1.

Previous issues of *Nuts & Volts* have featured articles that detailed the I2I Controls Spectrum-ACE family of products. (See the March and April Design Cycle columns.) This article builds on those earlier ones and demonstrates how simple it is to snap together a few devices and construct a relatively sophisticated — but simple — solar powered Data Acquisition System (DAS). This system can be used to monitor and log/record any signal that can be represented by an analog voltage, or digital pulses or pulse widths.

At the heart of this system is the Spectrum-ACE 2a product. This unit sports 128K of RAM, 32K of user programmable Flash, a one-wire four-channel 16-bit A/D converter, a real-time clock with 256 bytes of user programmable EEPROM, 20 general-purpose digital I/O lines, two UARTS, and six user programmable interrupts. Additionally, the I/O can be expanded via the external bus, 1-Wire devices, or SPI devices. Just enough options to get almost anyone in trouble!

As this project was in the early stages of development, two decisions were made: 1) The acquisition system should be able to function without connection to AC power; and 2) Cost was to be kept to a minimum. The first goal gives the user great flexibility as to where the device can be physically located, plus anything solar seems to be "in." The second goal was established mainly because it's always more fun to make a high quality device at the lowest possible cost rather than see how much money you can spend on something. After all, we're not the government here!

Okay, if we are acquiring measurable data (say temperature), where will the data be stored? We could either go wireless and log the data remotely or use some local storage device. In this case, we elected to use a storage device because it is a bit more universal, introduces fewer points of failure, is probably lower in overall cost, plus it makes the unit completely "self contained" in case you want to drop it off somewhere in the Outback.

Fortunately, the Spectrum-ACE 2a command set directly supports USB thumb drives and provides a mini DOS-like environment to create files and write or read data. Thus, the data can be stored on the USB drive and retrieved later on. To define "later on," if we store 100 bytes of data a minute, a lowly two gig thumb drive will take about 38 years to fill up. So, you'll probably want to check the battery or something else in the system before then.

Figure 1 shows the pin-out of the ACE 2a board, along with a schematic of the rest of the system. What's

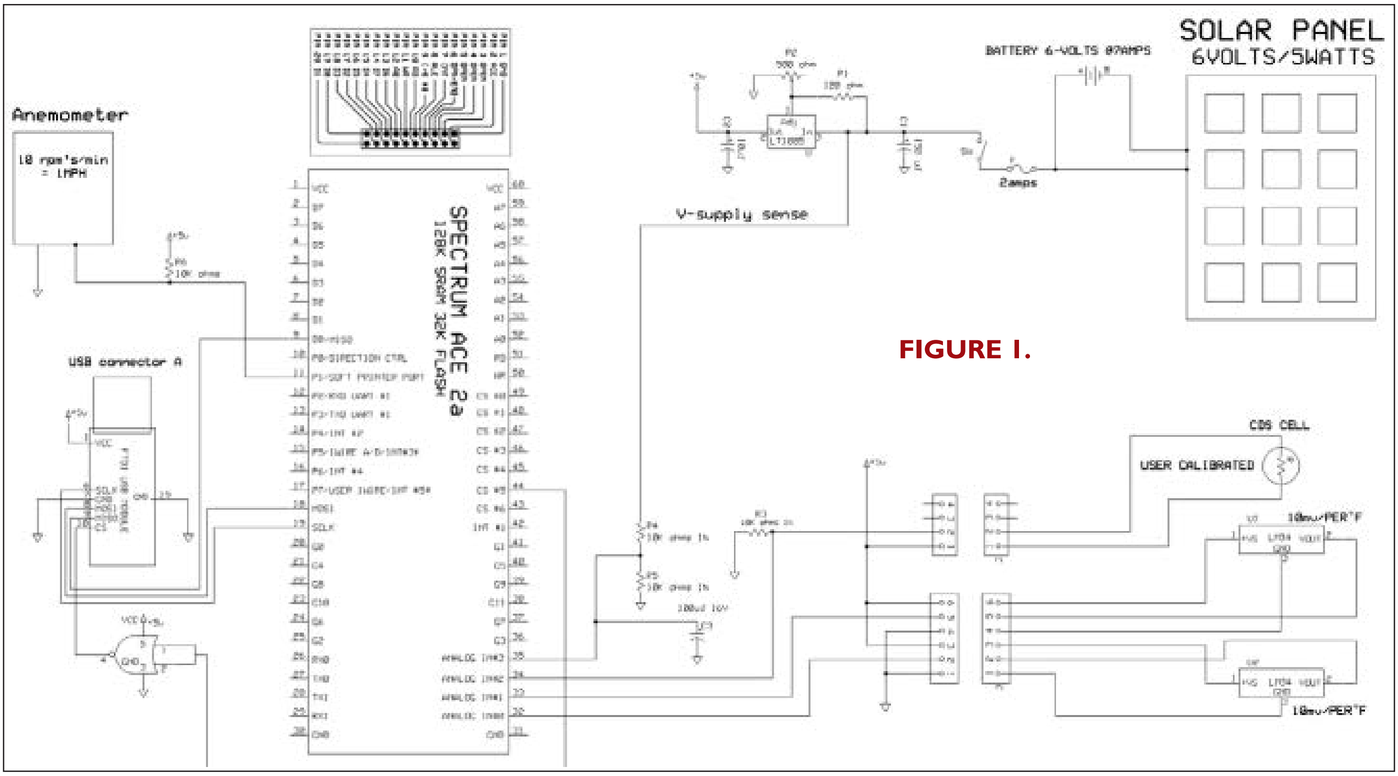


FIGURE 1.

striking is its simplicity, as there are only a few wires to connect. The solar panel is connected directly to the battery which feeds the LT1085 regulator on the small breadboard. The regulated five volts, along with the unregulated battery voltage, is then brought directly to the Spectrum-ACE board. This allows us to monitor the battery voltage to determine if the system has sufficient power to continue operation. The actual battery voltage is divided by two with two 10K ohm resistors. This is required because the maximum input on the A-to-D (analog-to-digital) converter is 5.11 volts, so we divide the battery voltage by two then have the software multiply the value by two.

Six wires are needed to connect the FTDI VDIP1 USB module: they are +5 volts, ground, Chip Select, SPI data in (MISO), SPI data out (MOSI), and SPI clock. The 74HC02 is required to invert the Chip Select to the VDIP1 module because the Chip Select is asserted high (go figure). Finally, a serial port is needed in order to communicate with the Spectrum-ACE board.

Photo 1 shows all of the components mounted on the back of the solar panel. The ACE 2a board and the USB interface module are mounted on I2I Controls 'E' prototype board on the right, the LT1085 voltage regulator including an on-off switch is on the small board in the center and the six volt battery is on the left. By the way, the five watt solar panel and the six volt battery were purchased from eBay for $32 and $20, respectively, including shipping!

I had a bit of personal interest in developing this project since I like to garden, and being able to monitor things like air temperature, soil temperature, wind velocity, sunlight, and rainfall is useful in tracking year-to-year consistency. It also can shed some light on issues if things aren't going well. As a result, for this project I decided to attach two LM34 temperature sensors to measure air

PHOTO 2.

temperature and soil temperature, one light — dependent resistor to monitor sun intensity, and one cool looking anemometer (which I borrowed from a local university) to measure wind velocity. **Photo 2** shows the unit out in the garden. If the mounting of the anemometer looks a bit funky, it's because I simply strapped it to an old microphone stand from my rock 'n roll days and removed the boom. The input connections are as follows:

- Analog Channel 0 - Air Temperature using an LM34 – input to Analog Channel 0.
- Analog Channel 1 - Soil temperature using an LM34 – input to Analog Channel 1.
- Analog Channel 2 - Battery voltage.
- Analog Channel 3 - Light-dependent resistor to measure relative brightness.
- Pulse input 1.1 - Anemometer input.

The LM34s produce 10 mV of output per degree Fahrenheit, so .7 volts of output would equal 70° Fahrenheit. Even though I live in Phoenix, I don't recall outdoor temperatures exceeding 250° F, so the range of the A-to-D converter was adjusted to 0 to 2.55 volts for the two LM34s. This gives a little better accuracy.

If things are working right, the battery voltage should be somewhere between three and 3.8 volts, so the range on Analog Channel 2 was set to 5.11 volts, as was input for the light-dependent resistor which is just one leg of a simple voltage divider with a 10K resistor.

I don't know anything about commercial anemometers, so I don't know if the one I obtained is typical or not, but two wires come out of the anemometer and they open and close contact twice for each full revolution of the anemometer vane. So, each pulse represents half a revolution. One wire from the anemometer is connected to ground and the other is connected to port 1 bit 1 on the Spectrum-ACE 2a board. That's something even a software guy can do!

Somewhere along the way, I was told that the anemometer rotates 10 times per minute for every mph of wind speed. Thus, 20 counts per minute would be 1 mph, 40 counts would be 2 mph, etc. The software makes this adjustment so the wind speed is stored as mph.

```
setio u,0xfa00                    ;Set USB address and Initialize
openw "data.txt"                  ;Open a file for writing
a1d(i)                            ;Initialize the 1-wire A-to-D
a1d(m,08) = 0                     ;Set channel 0 to 16 bits, 2.55 volts
a1d(m,09) = 0
a1d(m,10) = 0                     ;Set channel 1 to 16 bits, 2.55 volts
a1d(m,11) = 0
a1d(m,12) = 0                     ;Set channel 2 to 16 bits
anem1 = port1 & 0x02              ;read bit 1 which is the anemometer

do
while (!s != 1)

do                                ;loop while Battery > 5.9 volts
  t1 = 0                          ;initialize accumulation variables
  t2 = 0
  bat = 0
  light = 0
  anemom = 0
  acount = 0                      ;initialize the sample counter

  ; keep reading and averaging the sensors for one minute

  do
    if anem1 != (port1 & 0x02) then anemom++
    anemom = anemom + count(1,100)        ;count for .5 seconds
    anem1 = port1 & 0x02                  ;read bit 1 of the anemometer
    if !s = 0 break                       ;exit loop is !s = 0
    t1 = t1 + int(a1d(a,0)/25.5)/10       ;Temperatures, Battery,
    t2 = t2 + int(a1d(a,1)/25.5)/10       ;and light intensity
    bat = bat + int((a1d(a,2)&0xfff0)*10.22/655.35)/100
    light = light + a1d(a,3)
    acount++                              ;Increment the loop counter
  until (!s = 0)                          ;when !s = 0, output to USB

  ; done reading the sensors, now write the averaged data to USB

  output[s] using(###.#), t1/acount,    ",", t2/acount, ",",
  output[s] using(#.##) , bat/acount,   ",",
  output[s] using(#####), light/acount,",",
  output[s] using(h1)   , rdate,        ",", rtime, ",",
  output[s] using(##.##), anemom/20,    ",",
  output[s] using(#####), ++out_count
  write $o                                ;Write data to the thumb drive

  do                                      ;wait for !s to not equal zero
  while (!s = 0)
while (bat > 5.9)                         ;stop if Bat <= 5.9, else
                                          ;loop again
```

FIGURE 2.
This program reads two LM34 temperature sensors, the voltage from a CDS device, the anemometer, and the battery voltage. It then averages the data for one minute and finally writes the data to a USB thumb drive.

Yes, It Is That Easy!

The software environment on the Spectrum-ACE 2a board is called ALEC® which stands for "Advanced Language for Embedded Computing." It contains everything you need to easily read all of the sensors and store the data on a USB thumb drive. **Figure 2** is the entire base software that reads all of the sensors and stores the data in an easy to read formatted fashion on the thumb drive. This software must be transferred to the ACE 2a board via a program called Spectrum Port which must be in the "non-native" or programmer's mode.

The Spectrum Port software can be downloaded free of charge from **I2Icontrols.com**. This basic software will acquire and log data as long as the battery voltage is above 5.9 volts. If it falls below that point, execution is simply halted. The reason for terminating execution is to insure that any data on the thumb drive is not corrupted if the power supply voltage drops to an unsafe level. As shown, this software collects all the data, averages the data, and stores it on the thumb drive in an easy to read formatted fashion. Now, let's take a quick walk through the code just to explain what is going on.

The first instruction *setio u, 0xfa00* tells ALEC the I/O address (0xfa00) of the FTDI VDIP1 USB module and initializes the USB controller. The next instruction *openw "data.txt"* opens the file data.txt for writing. This is followed by six *a1d* instructions that initialize registers 8 through 11 on the DS2450 1-Wire A-to-D converter to 16-bit conversion and 2.55 volts full scale. The first *do-while* pair waits for the second value on the resident battery backed-up DS28DG02 real time clock to equal one. *!s* is a special internal register in ALEC. *!s* along with *!m*, *!h*, *!d*, *!mo*, and *!y* are used to read and write the seconds, minutes, hours, day, month, and year of the real time clock.

To write a value, you simply enter *!s* = 30; to read it, you would enter X = *!s* or Output *!s*. Thus, the instruction [*while (!s != 1)*] is looping and waiting for the second value to equal one. The variables (*T1 through acount*) are then initialized to zero. The instructions inside the *do-until(!s = 0)* loop continuously read, sum, and scale the anemometer and the analog inputs until the second count is equal to zero (*!s =0*). It should be noted that the *count(1,100)* operator reads the number of transitions on port 1.1. The value 1 that follows the count operator specifies that bit 1 of port 1 will be counted, and the 100 specifies that the port will be read for 100 * 5 milliseconds or half second. The variable *anem1* is used to store the last state of port 1.1 and adjust the anemometer count accordingly.

When *!s* = 0, one minute has gone by and a series of *output[s]* instructions are then used to write the averaged data to a special output string in a formatted manner. In ALEC, formatted outputs can be directed to the console, the auxiliary serial port, a serial printer port, a user defined driver, or a dedicated output string which is designated $o (the o is for output). As a general rule, it's a good idea to write to the output string before writing to the USB device because it gives you the option to easily display the output string to the console device with a simple *output $o* instruction. This is great for facilitating code debugging.

The *using(##.##)* directive determines how many digits to the left and to the right of the decimal point will be written. Finally, the [*write $o*] instruction writes the output string to the USB device. A test loop is then inserted to make sure that *!s* is no longer equal to zero, and then the last instruction [*while (bat > 5.9)*] repeats the entire process as long as the battery voltage remains above 5.9 volts. By the way, without comments the entire code is less than 720 bytes in length.

Figure 3 shows a couple of segments of the actual output of the data.txt file. The first segment was taken just as the sun was rising so the un-calibrated light value starts to increase. The next few samples were taken a few hours later when there was a very slight breeze. Note four things about this data: 1) The air temperature is not really the air temperature because while this segment was being measured, I had the LM34 directly exposed to the sun; 2) Because of thermal mass, the soil temperature is a little out of phase with air temperature (the LM34 was placed in a baggie and buried about four inches) and does not vary as much as the air temperature; 3) The battery voltage in the last segment is in full charge; 4) There is no calibration for brightness.

Also, note that the data.txt file is a pure ASCII text file and can be read by any text editor or other software that accepts CSV (comma separated values) formatted data. If

FIGURE 3.

```
Air      Soil    Battery Light     Date      Time      Wind     Sample
Temp     Temp    Voltage                                Speed    Count

56.7 ,   78.4 ,  6.17 ,   1787 ,  0x3EA3,  0x2660,   0.00 ,    745
56.7 ,   78.3 ,  6.17 ,   1859 ,  0x3EA3,  0x2680,   0.00 ,    746
56.7 ,   78.3 ,  6.17 ,   1947 ,  0x3EA3,  0x26A0,   0.00 ,    747
56.7 ,   78.3 ,  6.17 ,   2080 ,  0x3EA3,  0x26C0,   0.00 ,    748
56.7 ,   78.3 ,  6.17 ,   2205 ,  0x3EA3,  0x26E0,   0.00 ,    749
56.6 ,   78.2 ,  6.16 ,   2364 ,  0x3EA3,  0x2700,   0.00 ,    750
57.0 ,   78.2 ,  6.17 ,   2567 ,  0x3EA3,  0x2720,   0.00 ,    751
57.0 ,   78.2 ,  6.17 ,   2793 ,  0x3EA3,  0x2740,   0.00 ,    752
57.0 ,   78.2 ,  6.16 ,   3084 ,  0x3EA3,  0x2760,   0.00 ,    753
57.0 ,   78.2 ,  6.17 ,   3448 ,  0x3EA3,  0x2800,   0.00 ,    754
57.7 ,   78.2 ,  6.17 ,   3848 ,  0x3EA3,  0x2820,   0.00 ,    755
57.5 ,   78.1 ,  6.17 ,   4418 ,  0x3EA3,  0x2840,   0.00 ,    756
57.2 ,   78.1 ,  6.16 ,   5023 ,  0x3EA3,  0x2860,   0.00 ,    757
57.4 ,   78.1 ,  6.17 ,   5748 ,  0x3EA3,  0x2880,   0.00 ,    758
57.7 ,   78.1 ,  6.16 ,   6614 ,  0x3EA3,  0x28A0,   0.00 ,    759
57.9 ,   78.1 ,  6.16 ,   7582 ,  0x3EA3,  0x28C0,   0.00 ,    760
57.8 ,   78.1 ,  6.16 ,   8811 ,  0x3EA3,  0x28E0,   0.00 ,    761
57.5 ,   78.1 ,  6.16 ,  10120 ,  0x3EA3,  0x2900,   0.00 ,    762
57.3 ,   78.1 ,  6.16 ,  11636 ,  0x3EA3,  0x2920,   0.00 ,    763
57.8 ,   78.0 ,  6.16 ,  13312 ,  0x3EA3,  0x2940,   0.00 ,    764
57.9 ,   78.0 ,  6.16 ,  15124 ,  0x3EA3,  0x2960,   0.00 ,    765
;
;
88.7 ,   77.7 ,  7.74 ,  63694 ,  0x3EA3,  0x3E60,   1.55 ,    925
89.0 ,   77.7 ,  7.73 ,  63695 ,  0x3EA3,  0x3E80,   1.00 ,    926
89.1 ,   77.7 ,  7.72 ,  63697 ,  0x3EA3,  0x3EA0,   1.50 ,    927
```

RDATE:															
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Year MSB	Year LSB +5	Year LSB +4	Year LSB +3	Year LSB +2	Year LSB +1	Year LSB	Mon MSB	Mon LSB +2	Mon LSB +1	Mon LSB	Day MSB	Day LSB +3	Day LSB +2	Day LSB +1	Day LSB
RTIME:															
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Hour MSB	Hour LSB +3	Hour LSB +2	Hour LSB +1	Hour LSB	Min MSB	Min LSB +4	Min LSB +3	Min LSB +2	Min LSB +1	Min LSB	Sec MSB	Sec LSB +3	Sec LSB +2	Sec LSB +1	Sec LSB 2

The RDATE and RTIME registers integrated into the ALEC operating environment represent the date and time in the same format as the FAT32 file system. Because only five bits are allocated to seconds, the time resolution of the RTIME register is two seconds. Also, in this format, the year 1980 is assumed to be the year where all seven bits allocated to the year are zero. Thus, the next Y2K will be 2108, and if you're reading this, you won't have to worry about it.

FIGURE 4.

you examine the series of output[s] instructions, you will note that two internal system variables appear. They are *rdate* (real time clock date) and *rtime* (real time clock time). These 16-bit variables are the FAT32 file format representation of the date and time. **Figure 4** presents the details of this format. If one desires, the rdate and rtime variables can be used to create filenames that denote a specific date or time. For example, the following sequence:

```
output[s] using(s, h1), "d", rdate, ".txt"
openw $o
```

will create the filename d0xnnnn.txt, where nnnn is the hex FAT32 file format for date. The 0x is automatically inserted to designate a hex number. The *s* in the using directive suppresses all leading spaces and the *h1* forces the output of rdate to be four hex digits. This allows you to create a different filename for each day or specified time.

Load And Go

The Spectrum-ACE 2a hardware and ALEC make it a snap to load programs, modify them, and execute them when the hardware is powered up. After the software is loaded into the system RAM, the user simply enters the command PROG. What the PROG command does is take the current program that is in RAM and write it to the processor's internal Flash memory. After that, the user must enter BOOT 2.

ALEC has about a half dozen or so boot options and BOOT 2 saves the current serial port baud rate and directs the system to start executing the program in Flash memory after reset. Other boot options allow one to load programs from the thumb drive and execute them from reset. Anyway, it's easy to directly launch programs from reset without a user console device attached to the system.

Simple Power Savings

Running the software as shown, the unit draws about 145 milliamps, which is about .87 (six volts x .145 amps) watts from the battery. Thus, a few hours of sunlight a day on the five watt solar panel should be able to keep the seven amp-hour battery fully charged. In fact, a fully charged battery should be able to power the unit for about two days (seven amp-hrs/.145 amps = 48.2 hours) without any additional charging.

With one simple instruction (*OSC 1*), the current draw can be reduced to about 85 milliamps. What the *OSC 1* instruction does is reduce the operating frequency of the processor from 29.4912 MHz to 7.3728 MHz. In this application, reducing the frequency has virtually no effect except to reduce the power consumption. When operating in the *OSC 1* mode, a fully charged battery should be able to power the unit for over three days (seven amp-hrs/.085 amps = 82.3 hours). The *OSC 1* instruction should be placed early in the code before or after the *a1d* initialization. There are other oscillator options that could be explored to further reduce power consumption, but they are beyond the scope of this article.

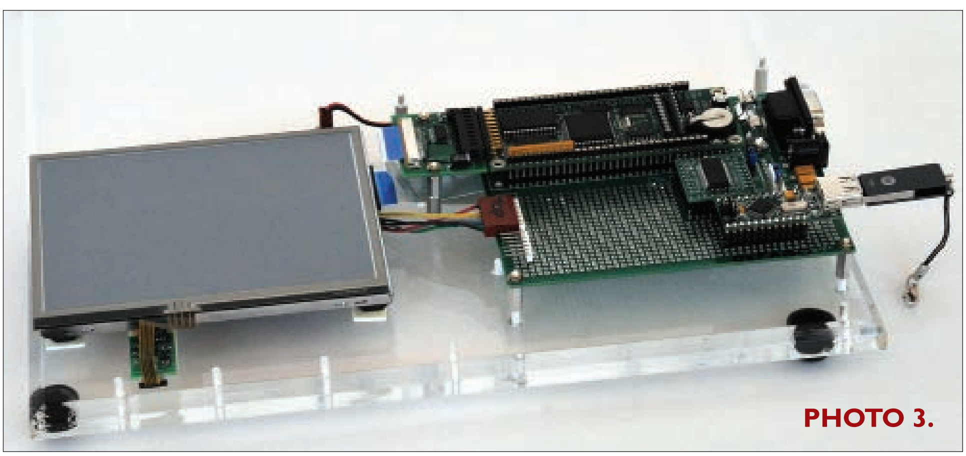


PHOTO 3.

But Wait ... There's More ...

Okay, in the end we have a

bunch of your favorite hard earned data on a USB thumb drive. We could take it over to a PC and read it into Notepad, Word, Excel, or whatever, and be done with it ... Boring! C'mon, don't you spend enough time looking at your monitor? This project is meant to be useful and fun! We don't want to turn our data over to the man in the PC! We gotta shoot for higher ground!

Fortunately, the Spectrum-ACE 2a system directly supports VGA graphics devices based on the Solomon Systech SSD1963 controller, as well as other display devices. The supported color displays can be either 640x480 or widescreen at 800x480. The one we used was from New Haven Displays International. ALEC also supports an optional touch screen controller for either of these displays. Unfortunately, we couldn't get an 800x480 display in time for this article, so we settled for the smaller one.

At one end of the ACE 2a board are two rows of 10 pads on 1/10 inch centers. These 20 pins provide control signals and buffered data lines that are designed to interface to the various displays supported by the system. **Photo 3** shows the display attached to a system.

The base software to open a file on the thumb drive and write data to the display is even simpler than reading the sensors and writing the data to the thumb drive. For the purpose of illustration, we will keep things as simple as possible and only display the two temperature values and only display raw data. No time averaging or scaling will be performed. The complete software is shown in **Figure 5**.

All instructions up to the *do* instruction are simply positioning the cursor (the P after *glcdout* denotes position) and writing the coordinate values (the *o* after *glcdout* denotes origin; the location where the dot will be placed). The instructions inside the *do-while* loop read the data from the thumb drive, calculate the appropriate position for the display, and place a red or green dot to graph the data point.

The instructions following the *while* close the open USB file and then position the cursor in the upper right-hand corner of the display. The *glcdout etime* instruction writes the internal variable *etime* to the display. This variable keeps tracks of the execution time of a program to the nearest five milliseconds. As you can see in **Photo 4**, it took about 1.84 seconds to execute the entire program.

```
setio u,0xfa00          ;Set USB address and Initialize
setio g,0xf000          ;Set Graphics address
setglcd i               ;initialize the graphics display
setglcd c               ;Clear the display
setglcd bf(63,63,63)    ;set base forground color to white
setglcd p(0,18)         ;Position Cursor (X, Y)
glcdout "0   -"         ;Then write the display markers
setglcd p(0,118)
glcdout "50  -"
setglcd p(0,218)
glcdout "100 -"
setglcd p(0,258)
glcdout "0   -"
setglcd p(0,358)
glcdout "50  -"
setglcd p(0,458)
glcdout "100 -"
setglcd p(60,18)
glcdout "0H"
setglcd p(180,18)
glcdout "2H"
setglcd p(300,18)
glcdout "4H"
setglcd p(420,18)
glcdout "6H"
setglcd p(540,18)
glcdout "8H"
setglcd p(240,50)
glcdout "Air Temperature"
setglcd p(240,290)
glcdout "Soil Temperature"
openr "data.txt"        ;Open the file for reading
i = 60                  ;start graph 60 pixels to the right

do                      ;loop & read the file
  readf t1, t2, bat, light, udate, utime, wind_speed,
out_count
  setglcd bg(63,0,0)    ;set graph color to red
  setglcd o(i, t1*2)    ;Place a dot at (x,Y)
  setglcd bg(0,63,0)    ;set graph color to green
  setglcd o(i, 240 + t2*2)  ;Place a dot at (x,Y)
  setglcd bg(0,0,63)    ;set graph color to blue
  setglcd o(i, 240)     ;Place a dot at (x,Y)
While (++i < 640)       ;loop

close
setglcd p(580,478)
glcdout etime
end
```

FIGURE 5. The entire program needed to read two data elements from a USB thumb drive and plot the data on a 640x480 LCD display.

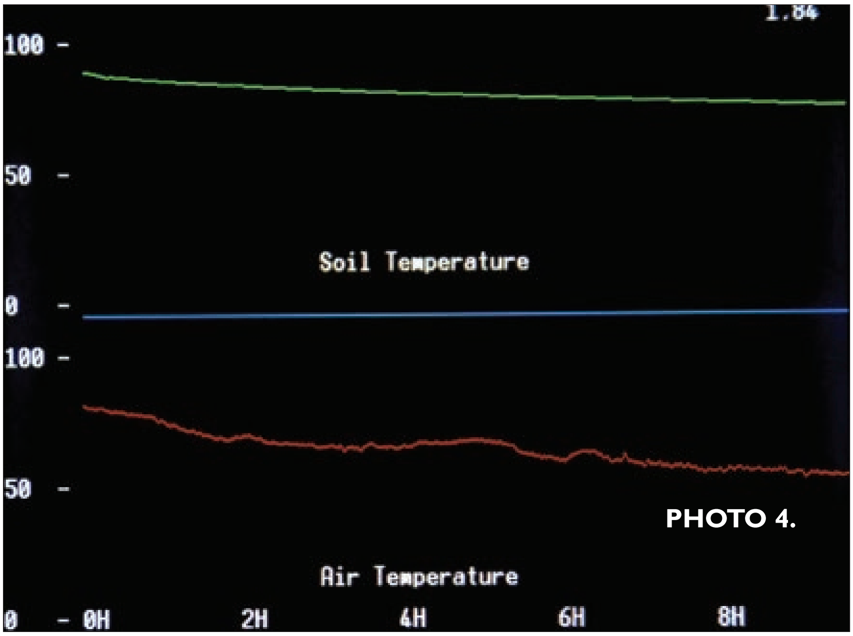


PHOTO 4.

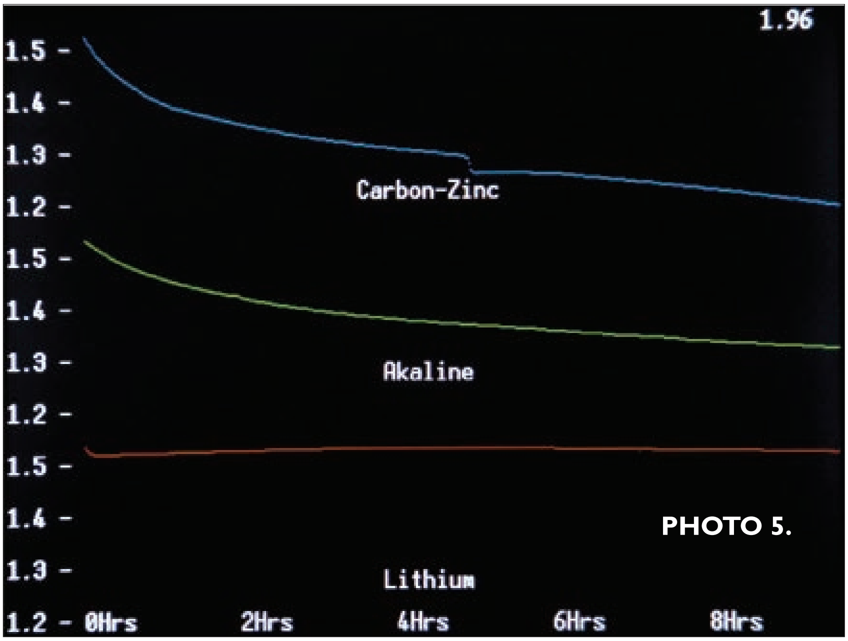


PHOTO 5.

PARTS LIST

ITEM	QTY	DESCRIPTION
Base Board	1	Spectrum Proto "E"
Battery	1	6 volt 7 amp Gel Cell
LDR Resistor	1	VT43NI
Processor Module	1	Spectrum-ACE 2a
Solar Panel	1	5 watt - 6 volt
Temperature Sensor	2	LM34
TFT Display	1	NHD-5.7640480WF-CTXL#-T (New Haven Displays)
Voltage Regulator	1	LT1085CT
USB Module	1	FTDI VDIP1

Conclusion

The Spectrum-ACE 2a board coupled with whatever collection of sensors you need makes a cost-effective and versatile data acquisition/monitoring system. The software presented here was indeed rudimentary and designed to demonstrate how easy it is to gather data and save it to a USB thumb drive. With the addition of a battery, a solar panel, and a voltage regulator, a completely self-contained unit can be located almost anywhere — where the sun shines for a few hours a day.

Any analog data with the appropriate ranging can be acquired, and if desired, displayed. As another example, **Photo 5** shows the voltage over time of a lithium, alkaline, and carbon zinc AA battery when loaded with a 24 ohm resistor for 10 hours.

We realize that numerous hardware and software enhancements would most likely need to be employed in many designs. Hardware refinements such as a more sophisticated battery charger circuit, faster and more accurate A-to-D converters, and front-end amplifiers for some sensors would probably be required. The software possibilities are nearly limitless. Data averaging, data integration, data correlation with least squares fitting, variable sampling times, and the logging of local minimums and maximums could be implemented to ultimately present more refined data to the user.

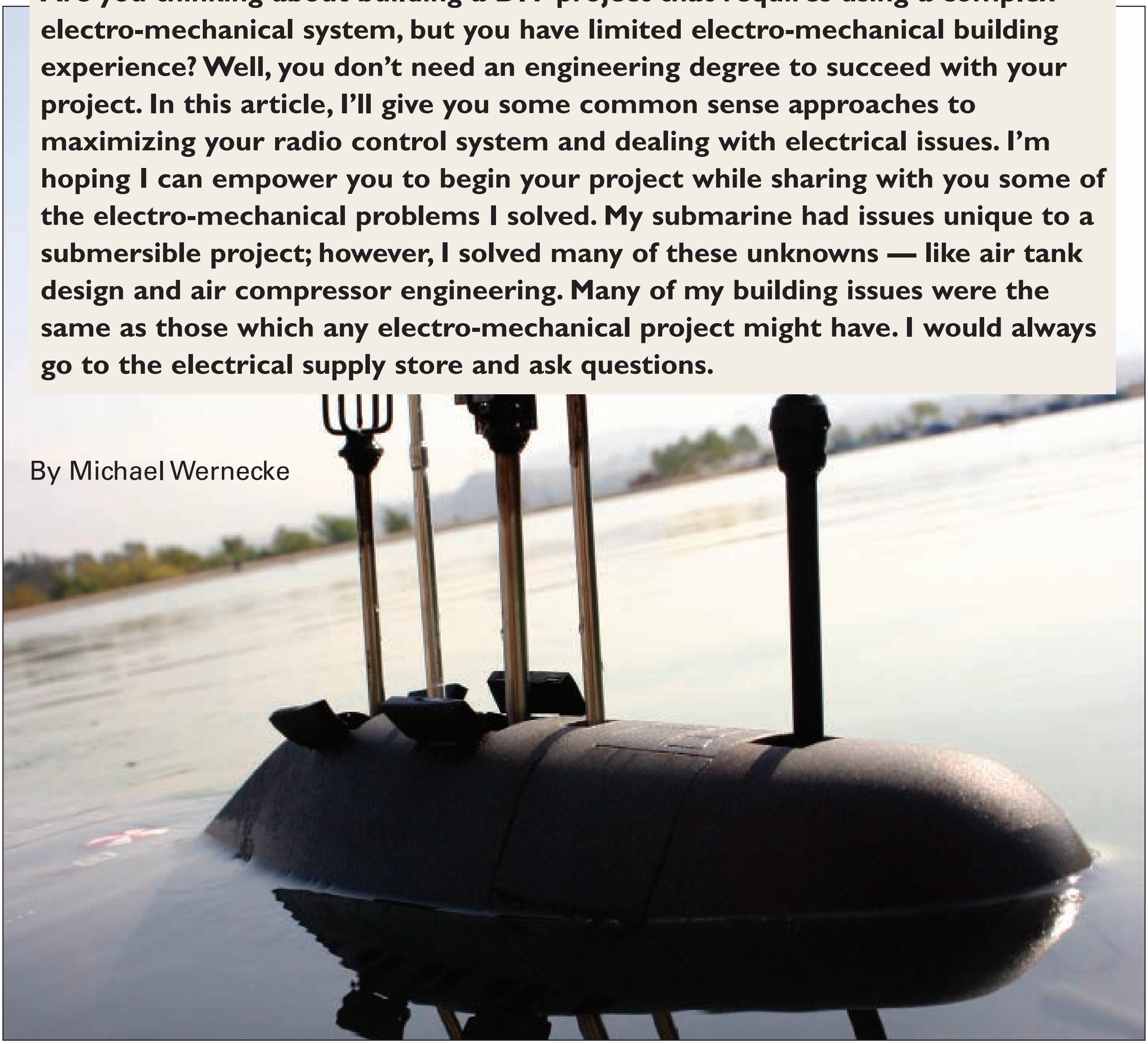
In the end, you have a very sophisticated electronic strip-chart recorder at a fraction of the price, and no paper to buy! **NV**

HOW I SCRATCH-BUILT A FIVE FOOT LONG RADIO-CONTROLLED SUBMARINE

Part 3

Are you thinking about building a DIY project that requires using a complex electro-mechanical system, but you have limited electro-mechanical building experience? Well, you don't need an engineering degree to succeed with your project. In this article, I'll give you some common sense approaches to maximizing your radio control system and dealing with electrical issues. I'm hoping I can empower you to begin your project while sharing with you some of the electro-mechanical problems I solved. My submarine had issues unique to a submersible project; however, I solved many of these unknowns — like air tank design and air compressor engineering. Many of my building issues were the same as those which any electro-mechanical project might have. I would always go to the electrical supply store and ask questions.

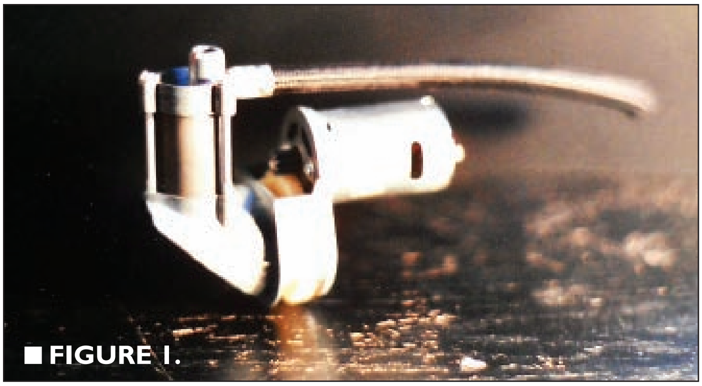
By Michael Wernecke



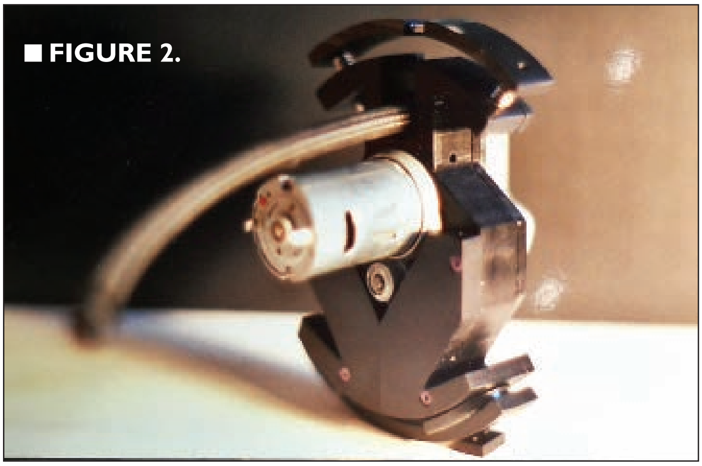
The Air Compressor

The air compressor in **Figure 1** is the key feature of this system. Using an onboard air compressor allows the submarine to surface, add compressed air to the holding tank, and submerge again. I removed this little air compressor from a 12 volt tire inflator system. This compressor was designed to plug into your automobile cigarette lighter which should be connected to your car tire to inflate a flat tire. I cut the connecting line to the tire to make it fit into the small work space within the seven inch PVC tube. The compressor was rated at 250 PSI. It compresses to about 90 PSI in my holding tank.

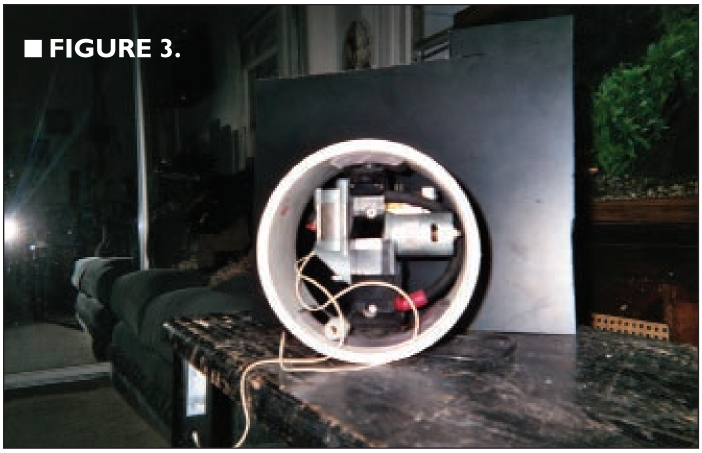
This 12 volt air compressor was the basis for my using the same voltage system on my submarine, although there are other compressors of this nature which would work, as well. **Figure 2** shows the compressor installed in the holding bracket. I built up this bracket/stabilizer as a cardboard and wood prototype. Later, I made the parts out of aluminum and had them anodized to protect them from rust. **Figure 3** shows the compressor in its location in the PVC tube. **Figure 4** shows the copper tank which holds the compressed air, and a side view of the completed compressor system.



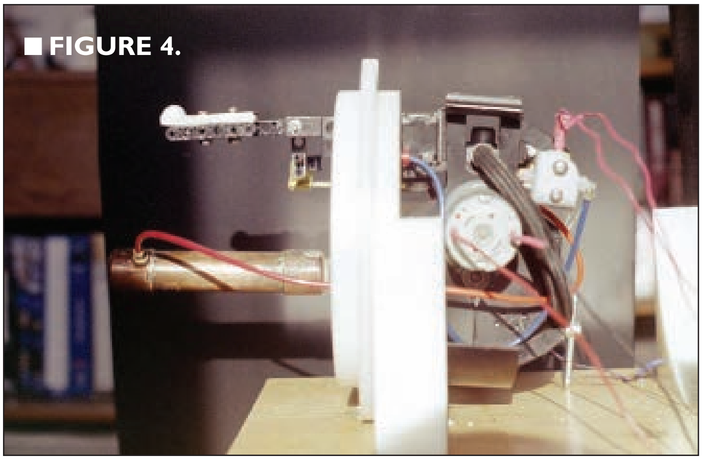
■ FIGURE 1.



■ FIGURE 2.



■ FIGURE 3.



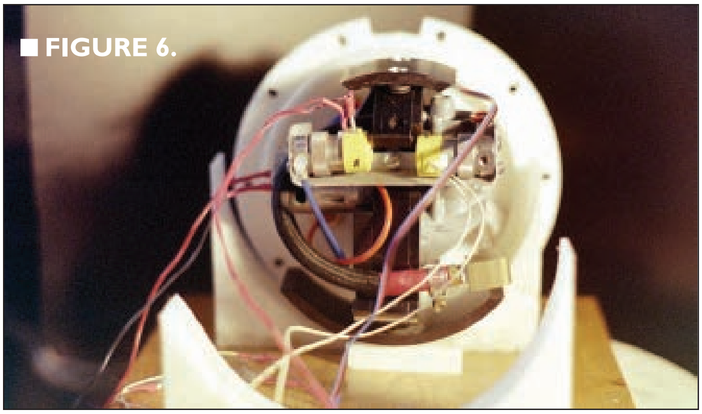
■ FIGURE 4.

Compressed Air-Holding Tank

The purpose of the holding tank is to keep the compressed air in a pressurized state until it is needed to blow water out of the ballast tank to surface the submarine. The holding tank is made from off-the-shelf, one inch copper plumbing tubing. The copper tube is made up of four things. There are two end-caps soldered in place and a small brass barb fitting. The fourth is the one inch copper tube to which the latter is attached to connect air-tubing passing to a Clippard valve inside the compressor chamber to release the compressed air when needed. The ballast tank and the compressor compartment are back-to-back with holes to allow the passage of a pushrod to operate the ballast tank and an air release port. The input end of the holding tank holds air due to the presence of a Schrader valve in the brass-fitting input. The input in **Figure 4** is the end of the copper tank connecting to the white PVC pipe.

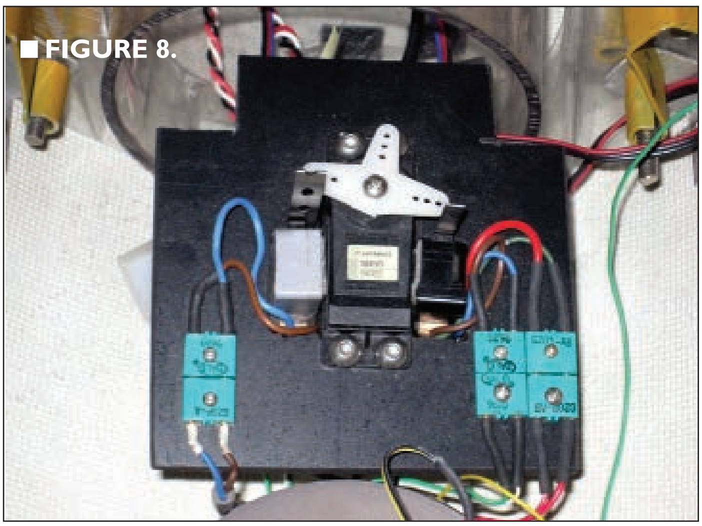
The Schrader valve is the valve in a bicycle or car tire. I removed a Schrader valve from a bicycle tire and burned the rubber off of it. I threaded a brass fitting to fit the Schrader valve and valve stem. The valve required silver soldering with MAPP gas to seal the brass fittings into the copper tube. Care must be taken when doing this type of silver soldering. Also, the Schrader valve must be unscrewed and removed before the soldering, as it has a rubber seal built into it. The rubber seal on the valve cannot be damaged by the heat of the soldering procedure. If the rubber seal is damaged, it won't seal completely. (The MAPP gas procedure was covered in Part 1 of this series.)

To test the copper tank, I used a great little device with the strange name of "manometer." The manometer is

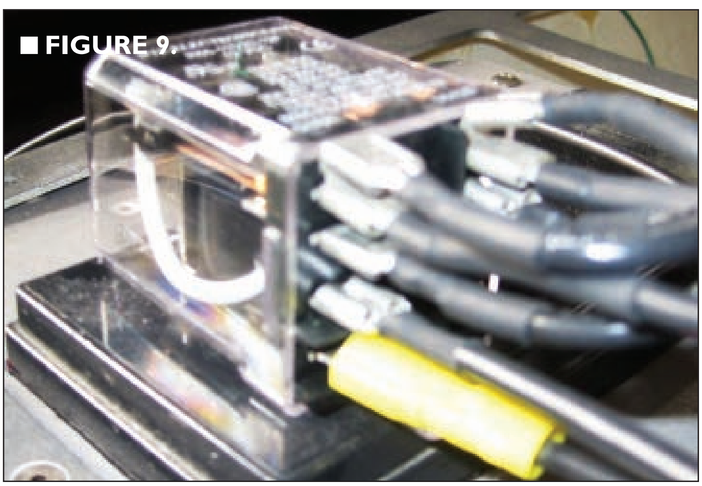


■ FIGURE 6.

■ FIGURE 7.



■ FIGURE 8.



■ FIGURE 9.

■ FIGURE 5.

a battery-operated device that tests air pressure. I used a compact version and connected it to the tank as shown in **Figure 5**. The air compressor is turned on and fills the tank while the manometer indicates the pressure accumulating in the tank. When the maximum pressure is reached, the compressor is turned off; this is when I would watch the manometer. If the pressure holding tank holds its pressure, the manometer would not change its pressure reading.

I encountered problems with this simple little tank. One issue was having to learn to use the MAPP gas system which had some backward type functions. Also, I unknowingly damaged the seat of the Schrader valve by overheating the seat area. This was while I was silver soldering it, and thus, I had to re-make the tank. The new tank turned out to be a good thing because I made it larger. The second tank worked fine. **Figure 4** actually shows the completed air-compressor system with the air-release valve to the upper left. (Yes, those are LEGO pieces.) This device became a prototype in itself, and I left it at that. That valve tip is made of the mold compound I used to cast the rudders and hatches. There is a servo connected to the air-compressor bracket which activates the LEGO arm via a bulkhead seal. This valve will open a small hole in the top of the ballast tank to allow air to escape, and permit water to enter at the bottom of the tank and submerge the sub.

Figure 6 shows the rear view of the air-compressor chamber with the two yellow Clippard valves. The Clippard valve on the right allows air to enter the chamber when the air-compressor is activated. The Clippard valve on the left holds back the compressed air in the compressed air holding tank, and releases the air to blow water from the ballast tank, allowing the submarine to surface. Here, I learned a lesson regarding wire gauge. During my testing of the compressed holding tank, I found that the air compressor would stop running before the tank had reached full capacity. The problem was that the thickness (gauge) of the wire going from bulkhead to bulkhead was too thin. The compressor worked until it had too much built-up pressure for the air-compressor to handle. The air-compressor motor couldn't draw enough amps through the thin wire to continue operating. Adding thicker wires solved the problem of the motor stalling. **Figure 7** shows the completed PVC tanks, while **Figure 8** shows the servo/micro switch connections that activate the air-compressor and Clippard ballast blow valve.

Speed Control

The speed control presented a unique dilemma and caused issues that were difficult to figure out. I have used a very nice Msonik reversible speed control in the past and had great plans for it on this new project. The ol' reliable Msonik 15 amp 12 volt speed control burned out. Here's where the large and the beautiful 12 volt Pittman motor came into play. I had another speed control from a former project and decided to try it. I figured out that the large Pittman motor was drawing too much amperage and would slowly burn out the low amperage Msonic speed control. A speed control, after all, is a form of radio-controlled variable resistor and will not allow an unlimited amount of amperage to pass through it. The large Pittman motor drew too much amperage. The larger speed control was rated at 33 amps and worked fine. The larger speed control didn't have a reverse function, however, I needed to create one. I had no budget for this, so I figured I could use a relay to reverse the motor.

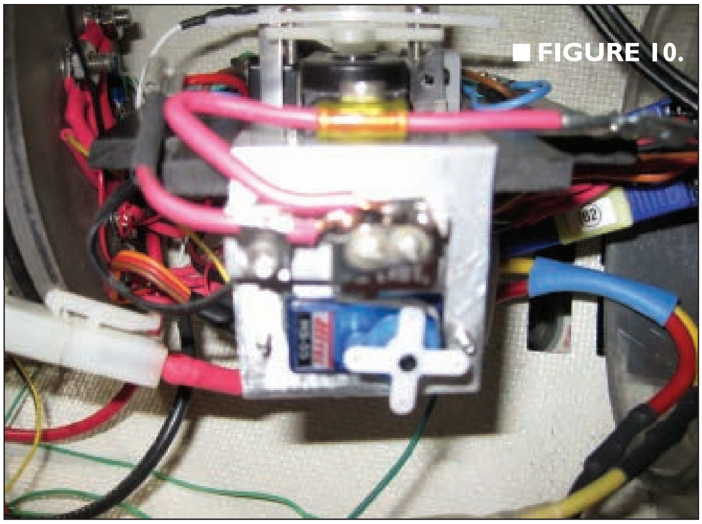
I bought a 10-pin heavy-duty spade terminal relay known as the "ice cube" (see **Figure 9**) from the local electronics supply store. I crossed the leads to the movable relay flipper so when the relay is switched, it would reverse the polarity leading to the motor, thus reversing the motor rotation direction. The motor reversing servo is depicted in **Figure 10**. This works so well that in operation it can be switched, and instantly the motor reverses. The voltage was still 12 volts but the amperage push needed was much greater than the small electric motors I used before. The speed control — as well as the receiver and compressor switches — is located in the small electrical chamber in **Figure 11**. The motor reversing relay is located in the ship's bow due to lack of space in the central electrical box. **Figure 12** shows the relay's water-tight chamber in the bow; **Figure 13** displays some work in progress details.

Potting Procedure

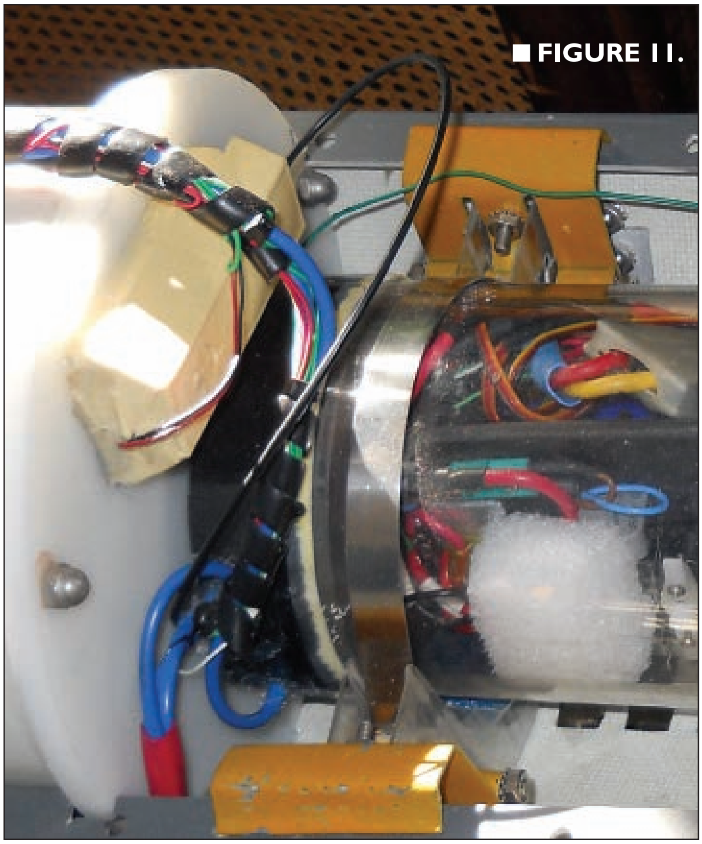
Anytime someone constructs an electrical device or electrical wiring into a system where it will be exposed to a lot of water or wetness, the electrical components need to be sealed. This process is called potting. There are a lot of potting compounds. To seal off the ends of the bulkheads (which are the connecting points of my electrical wiring), I used a potting compound recommended by and obtained from a company called Epoxies, Etc. The black liquid seen in **Figure 14** is the first step in the potting procedure of the electrical box at the hull center which contains the speed control and receiver. I poured in a small amount first to see if my protective fencing leaked or not. **Figure 15** shows the completed potting process.

Radio Transmitter Power Pack

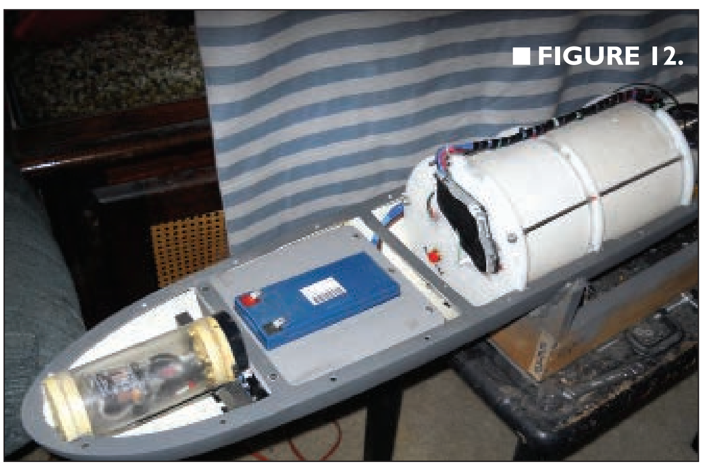
My submarine has a very nice 12 volt battery similar to a small motorcycle battery. This can run the low wattage components for a long time. The transmitter, however, has a very small nine volt battery in it and has a short life span.



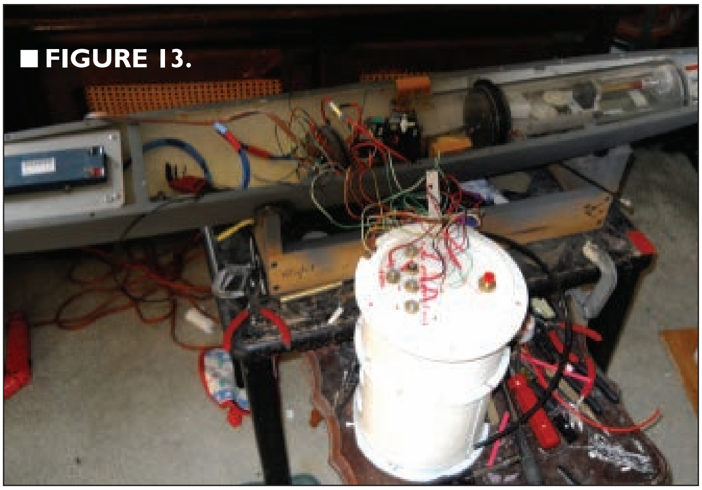
■ FIGURE 10.

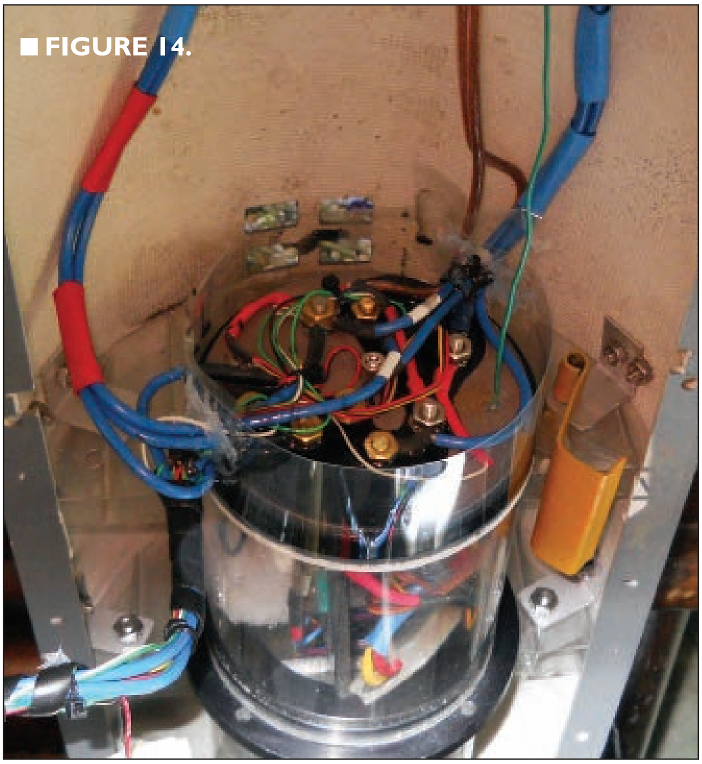


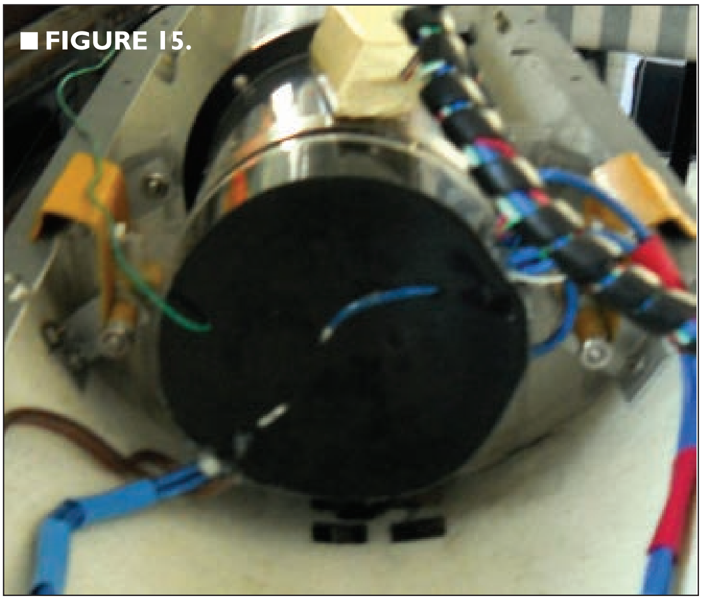
■ FIGURE 11.



■ FIGURE 12.


■ FIGURE 13.


■ FIGURE 14.


■ FIGURE 15.

However, I had a revelation one day to use a 12 volt battery to also power my transmitter. I wired the 12 volt battery into my transmitter with a transformer to step down the voltage to match the nine volt system in the transmitter.

On a visit to my local electrical supply store, I discovered they had a power pack with an adjustable regulator on it that was just what I needed. I hacked my radio transmitter by cutting off the electrical cord to the battery and constructed a plug which connected to the power pack. **Figure 16** shows my solution to the transmitter problem and the rechargeable power pack.

The funny little plugs that connect the transmitter to the power pack were cast in hard urethane plastic like the rudders. My estimate is that this system upgrades the transmitter reserve power to 1,000%. Another feature you might like is the fiber optic onboard battery capacity indicator.

Fiber Optic Indicator

I had to know the charge level in the submarine battery. I found a printed circuit board designed to indicate with three colored LEDS (light emitting diodes) the charge level in a 12 volt battery. This small board has a red, yellow, and green LED which I connected to some fiber optic lines to the sail top to enable me to see the charge level by bringing the sub close by to check it.

Figure 17 shows the underside of the sail and the encapsulated indicator chip super-glued to the underside of the sail. The chip itself is at the left for reference only. The fiber optic lines exit the top of the sail as seen in **Figure 18**. I cast the chip into hard urethane plastic to seal it from moisture. (Had I known about the potting compound I talked about earlier, I would have used it in this application.)

Water Sensor

To detect the presence of water in the air compressor chamber, I made a very basic water sensor. This is simply two electric lines held at an established distance from one another, then connected to the 12 volt battery. This sensor sits near the bottom of the water-tight chamber housing


■ FIGURE 16.

the air compressor. The water sensor LED leads to another fiber optic line to the sail exterior.

Electrical Schematic

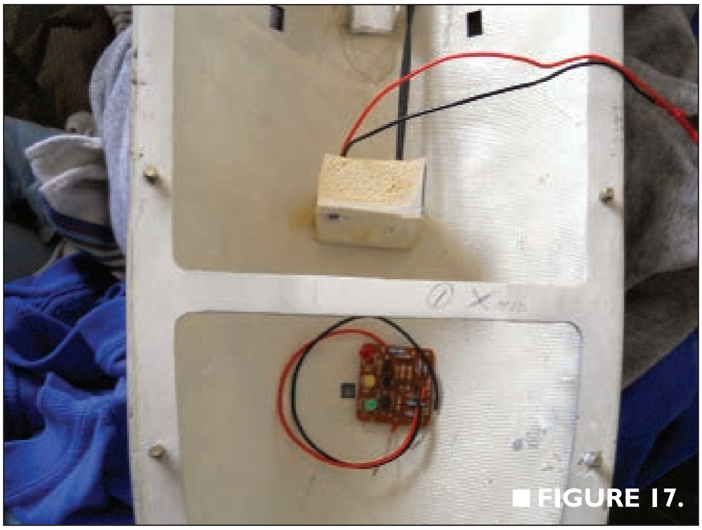
The electrical schematic in **Figure 19** gives you an idea of the real over-all complexity of the system, and what I had to deal with when one function or another wasn't working. This overall electrical configuration followed a simple rule: "If it works, it works." I designed this system on-the-fly and drew it up later.

Conclusion

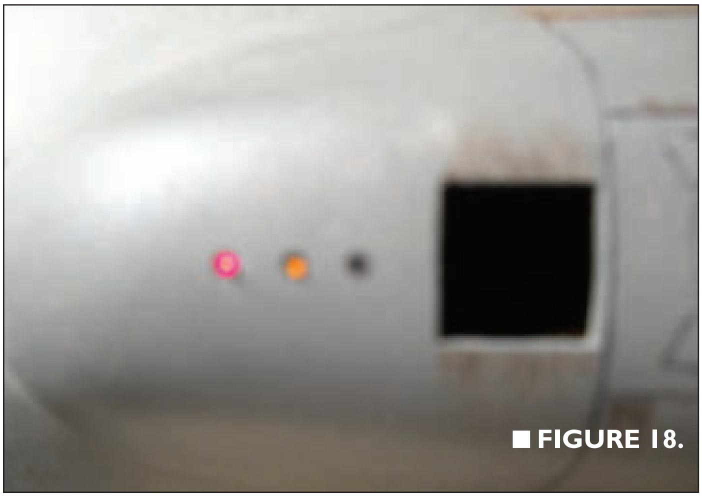
The sub went through final setup in a home-built test tank located in the basement. This required many hours balancing the final configuration with lead and closed-cell foam. Eventually, I perfected the submarine's balance by forward and reverse movement until the lower rudder wouldn't touch the bottom of the shallow test tank.

For 10 years I worked and moved forward each day with this project. There are times I look at it and wonder whether I should attempt to make some improvements or do some changes here or there. However, I look at it with pride. My submarine now maneuvers on the clear waters of Japan, England, and France. How much further it will travel, only time and my imagination will tell. **NV**

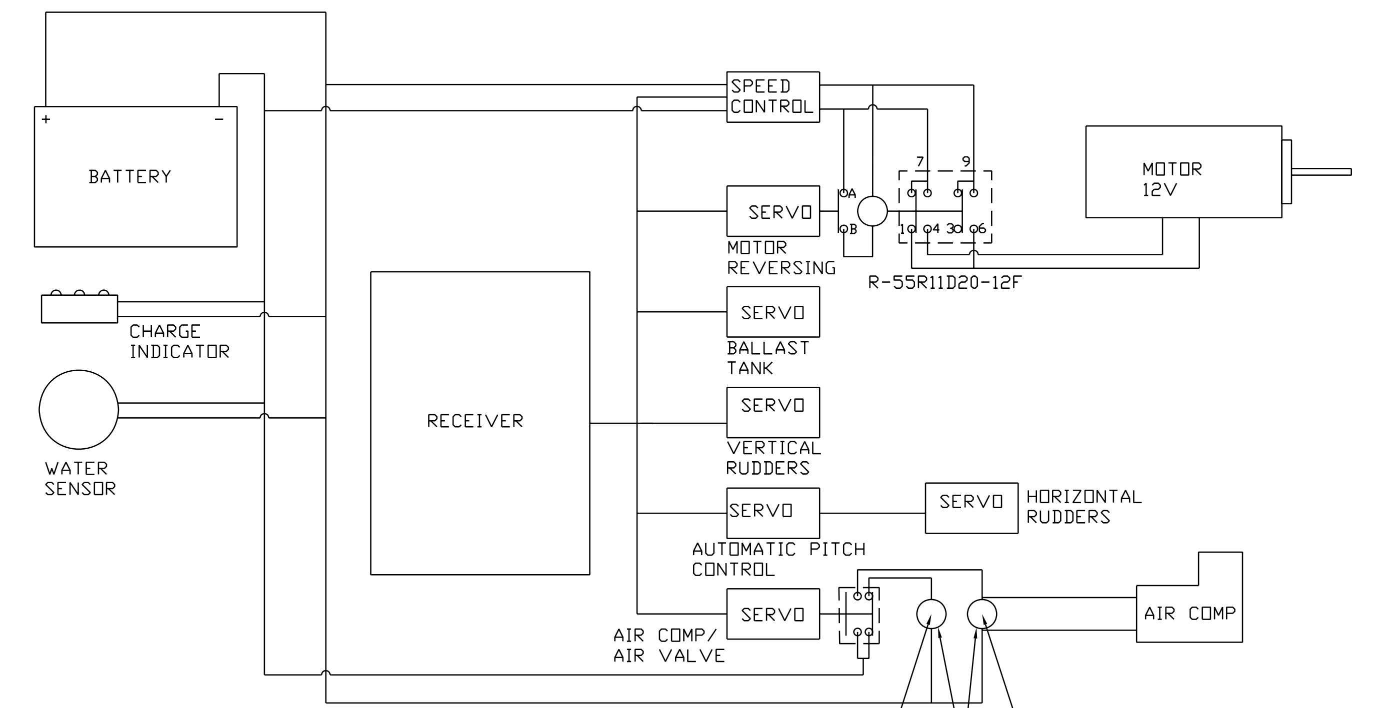
If you would like to correspond with me regarding this submarine build, you can contact me at ocean_tech04@yahoo.com.



■ FIGURE 17.



■ FIGURE 18.

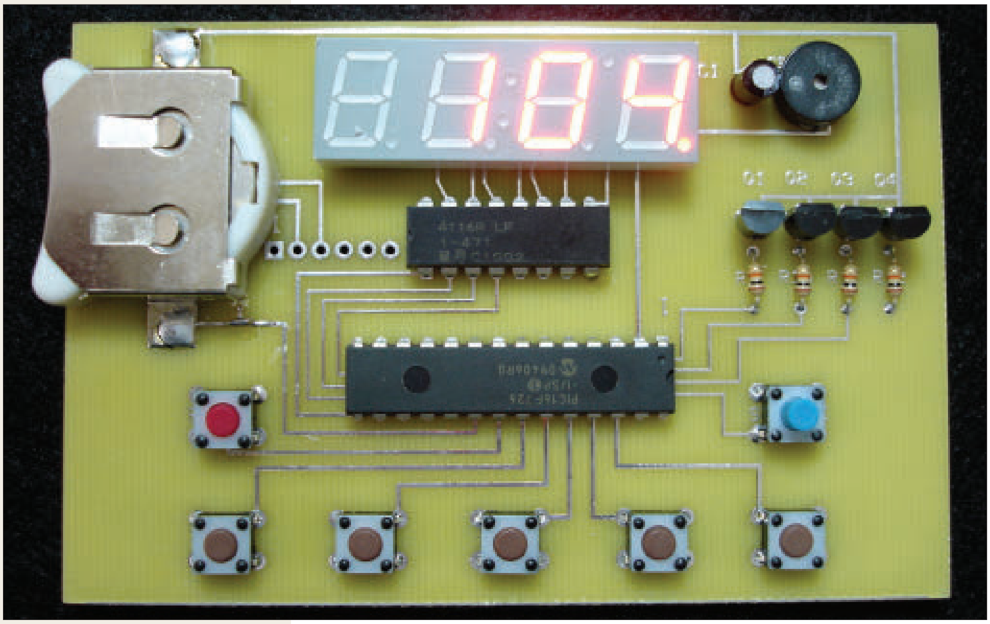


■ FIGURE 19.

BUILD A SORTING COUNTER

By Ron Newton

If you ever visited a medical laboratory 25 years ago, you would have probably found a med tech looking through a microscope, using a hand tally counter calculating white cells, red cells, or platelets. Or, they might have been using a sorting counter for differentiating white cells. Nowadays in America, most of this work is done using automated equipment. In developing third world countries, they still use the old method. Hand tally counters cost $40 and sorting counters run about $600.



I combined both devices with a parts cost of $15 plus the printed circuit board (PCB). This is a great project for a beginner or student because it will get you started in doing soldering and interested in doing programming. There is one surface-mount item (battery holder), then everything else is through hole. The nice thing is that it will fit in your shirt pocket.

Sorting counters have many uses: keeping score; counting parts; counting people, e.g., classifying their sex, age, etc. It is just a handy gadget to have on hand. Hand tally counters are often used for counting people at events or even cars on the road. Instead of using a sheet of paper and marking four lines and a slash showing a count of five, you just push the button (or buttons). The sorting counter allows you to keep a total, plus keep track of specifics. For example, if you are counting VWs on the road and want to know the percentage of red, blue, yellow, green, and black ones, you would use the differential counter.

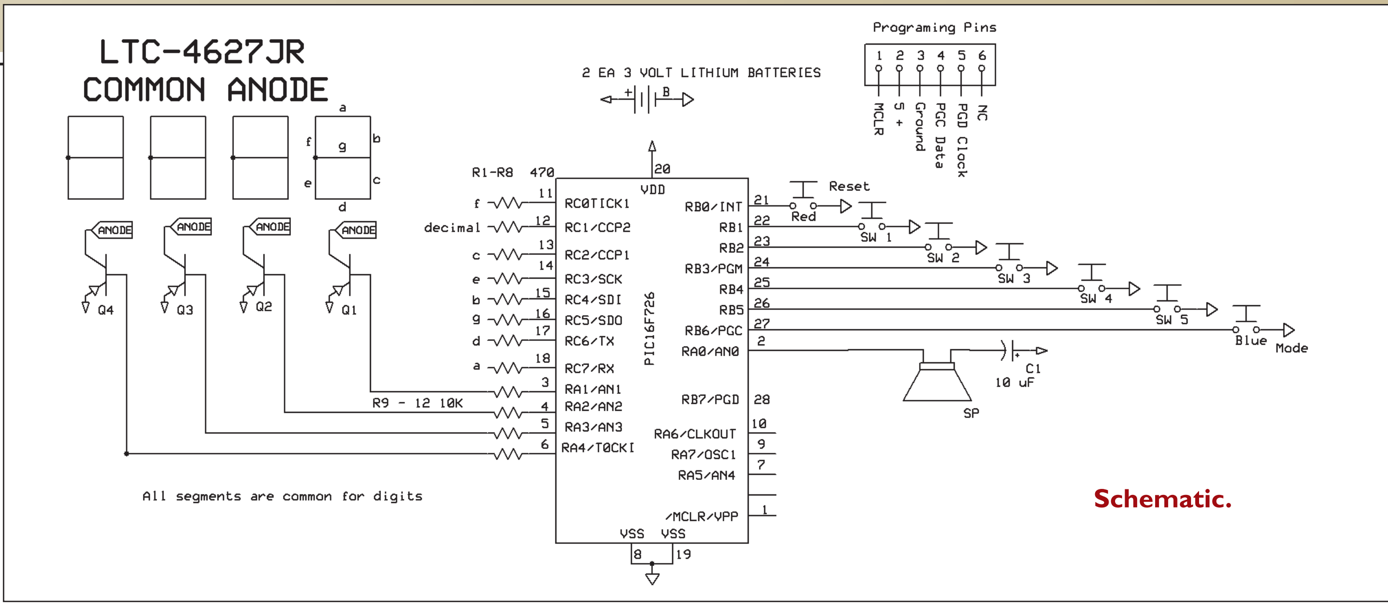
As I mentioned, this is a very simple project for those who want to learn to solder or are interested in using microprocessors and how they function. No special tools are needed except for a small tip soldering iron. It has no box as it stands alone, therefore there is no drilling. If you want to change the programming, you will need a Microchip PIC II programmer ($34.95; **www.microchip.com**). Better yet, go to the *Nuts & Volts* store and purchase their PICkit 2 starter kit for $49.95. It comes with a board that will teach you additional programming techniques (**www.nutsvolts.com**).

The main point of this article is to teach the novice about displays and multiplexing.

What It Does

This project has five counting buttons for sorting and tallying. One mode button (blue) is for changing from differential to hand tallies and one button (red) is for clearing the results. When using the sorting function, it will count 100 items displaying the numbers, sound an alarm at 100, and then it will display the percentage of each button when you push the sorting buttons.

When using the hand tally, it has three buttons which will tally the counts. The first button advances the count by one. The second button will count in batches of three.



Schematic.

The third button will count continuously with a pulse rate of five counts per second as long as the button is held down. Pushing the reset button sets the counts back to zero. The LEDs will display up to 9,999 counts.

If no input is detected for three minutes, the LEDs shut down and the micro will go to sleep. Pushing the reset button (red) will wake it up. No data is lost. It runs on two three volt CR2035 batteries.

Construction

Place four rubber feet on each corner of the bottom side of the board to prevent scratching the traces. Mount the PIC16F726 with its pin 1 in the square pad labeled 1. You can program the micro yourself or you can order a pre-programmed one from the *Nuts & Volts* store. (The micro is mounted upside down with pin 1 to the right.) Solder all the pins of the PIC. Next, solder the four PNP transistors with their flat sides pointing toward the top of the board. Solder the 470 ohm, eight inline resistors above the PIC. Bend the leads of the four 10K resistors at right angles, place them in their respective holes, and solder.

Solder the transducer and C1 noting the + going to the square pads. Solder the seven switches into their holes. The five brown switches are inline on the bottom. The red switch goes on the left and the blue switch goes on the right above the brown switches. (Take a look at the **photo**.)

Flood solder onto the round circle on the battery holder to make a contact for the negative terminal of the battery. Solder the battery holder with its opening toward the edge of the board. Solder the four digit LED. The six pads will remain empty, as these are the programming pads. Clean any remaining flux and solder with alcohol.

Using the Unit

Slide two CR2032 Lithium three volt batteries into the holder. The positive should be up. Press the mode button; the decimal of the one digit will turn on and off indicating if the unit is in the tally mode or differential mode. With the differential mode, the decimal is off. A decimal indicates the tally mode.

Tally Mode

Make sure the decimal is on.

1. Press the first button (far left key); the counter will count once for each push.
2. Press the second button; the counter will count three counts for each push
3. Press the third button; the counter will continue at five counts per second as long as the key is pushed.

The counter can be cleared at any time by pressing the reset button.

Differential Mode

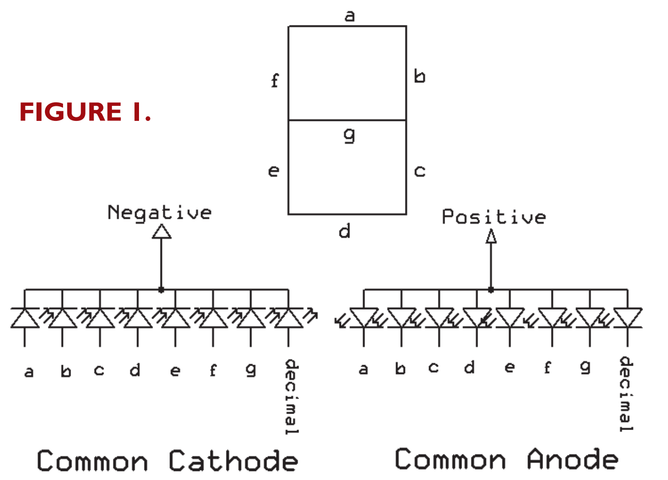
Turn off the decimal by pushing the mode switch.

1. Assign the buttons to what you want to sort.
2. Press any button. The counter should increase.
3. Press any other button and the counter should increase.
4. When the counter reaches 100, the alarm will sound. Pressing the buttons will no longer increase the count.
5. Hold down any button and it will display that button's percentage.

Electronics

The PIC16F726 has many attributes. It has a voltage range of 1.8-5.5 volts (can go to 6.5V) and when put to sleep, it only draws 20 nano-amps (.00000002 amps). It does not need an external crystal and each pin can sink or source 25 milliamps. It even has 14 analog-to-digital converters (not used in this application), 12 interrupt

FIGURE 1.



capabilities, plus many other features.

The best thing I like about the PIC F series is that they can be programmed over and over, even when soldered in a circuit. To program the chip, use a PICkit 2 and plug in a six-pin header into the programmer. Using the header, contact the six programming pads next to the battery and program." (These are the pads next to the battery.)

The switches go to separate pins of the micro which have internal pull-up resistors. This eliminates having to place external pull-resistors (which I had to do a few years back). When pressed, the switches take the inputs to ground. The reset pin is placed on a special pin that is called an interrupt pin.

Multiplexing

Let's take one display at a time. Displays come as common anode and common cathode. Take a look at **Figure 1**. With a digital display, it has eight segments and sometimes a decimal or colon. If you are using a common anode, all the segment anodes are tied together. If you place the positive of a battery to the common terminal and touch the segment cathode to negative (via a resistor to limit the current), it will light that segment. With a common cathode, all the segment cathodes are connected together. You just reverse the polarity of the power to the chip. With the sorting unit, I chose to use a common anode. No particular reason; it just happened to be available. Connect the positive terminal to the common anode to display an "8" ground to all the segments. To display a "1," ground cathodes B and C.

There are four digits in the display I used. You could use a micro or several micros to provide eight pins for each of the digits and tie all the anodes together, but this would mean you would need 64 pins for the display alone! What if we tied all the segments as, bs, cs, ds, es, fs, gs, and decimals together, and separate the common anodes from each digit? This would only require eight pins for the segments, and if we connected the four anodes to the pins to the micro (via a PNP transistor going to VCC), we would only need 12 pins instead of 64.

The human eye cannot detect a flicker above 50 cycles per second (50 Hz). This is why the US went to 60 Hz in the 1940s from 50 Hz. Europe often still uses 50 Hz and you can see the flicker in fluorescent lights. (Incandescent lights don't flicker due to the filament staying hot.) If you ground a, b, c, d, and g segments, and turn on the transistor, it will display a "3." Turn off digit 1 and ground a, b, and c, turn on its transistor, and it will display a "7", and so on. If this is done at a frequency above 50 Hz, they will all appear to be on at the same time. The PIC runs a 4 MHz, so this is not a problem.

Software

Download the free software called MPLAB from Microchip. Go to the article link page and open the Sorting.ASM in MPLAB. Make sure you turn on the line numbers. You always have to keep in mind that most micros count in hexadecimal (base of 16) 0, 1, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f, and that the displays display in decimal (base of 10) 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. This means that the hexadecimal needs to be converted to decimal, e.g., F = 15. This is done by a canned program I picked up on Microchip's website. (Why re-invent the wheel?)

Line 595 starts the Display section. All the digits are turned off.

I used a look-up table for the display to show the numbers. Lines 602 to 607 insure that a jump to the look-up table does not end up in oblivion.

PARTS LIST

ITEM	QTY	SOURCE
Battery holder 20 mm coin two stack	1 ea	Memory Protect Devices
C1 10 µf 16V	1 ea	
Feet self sticking 1/2"	4 ea	
IC1 PIC1726-I/SP	1 ea	
Opto 4-digit common anode	1 ea	Light On, Inc.
Q1-Q4 PNP PN2907	4 ea	
R1-R8 470 ohm resistor network isolated	1 ea	
R9-R12 10K 1/8 watt carbon	4 ea	
Speaker buzzer 2.73 kHz	1 ea	Soberton, Inc.
S1-S5 brown momentary NO 6 mm tact	5 ea	
S6 blue momentary NO 6 mm tact	1 ea	
S7 red momentary NO 6 mm tact	1 ea	

IC1 preprogrammed
Board

See the *N&V* website for Sorting Parts and Source.xls.

This can be a problem with look-up tables. Let's say there is a 3 in the ones register and we want to display it. Three is loaded into the "W" register (working register) and then a call is made to the look-up table called "PATTERN." Take a look at starting line 733 — Pattern is the name of the look-up table. The ADDWF tells the PIC to add the number in the W register to the Program counter. The remaining 10 lines provide the inputs and outputs for turning on the segments; 0 = ground and 1 = Vcc to the pins going to the LEDs. W was loaded with a 3; 3 + the program counter = line 739. The RETLW returns the binary code (B'01001011') via the W register and places the binary code into PORTC which controls the LEDs. Digit 1 is then turned on. A delay is called so that it will display for a period of time, then digit 1 is turned off.

The program does the same thing for the tens, hundreds, and thousands, looking up each number that needs to be displayed.

Switch Bounce

If you are not familiar with microprocessors, you probably didn't know that when most switches and relays are turned on, their contacts bounce on and off several times. This is normally not a problem. However, with the PIC running at four million times a second, it will count the bounces. Fortunately, the switches in this project give very little bounce. However, even if they didn't bounce, you would have trouble releasing the switch to the off position in that amount of time and would probably get a count of several thousand before it turned off. If you take a look at the five lines after the label "START," you will see that the program calls for a "DEBOUNCE" which is a timer delay. The program will hold until the switch is back in the off position.

Call Versus GOTO

A call is a routine that is used quite often. Instead of writing the "DEBOUNCE" each time, you just call it, it does its function, and returns to the next step after the call. 'GOTO" causes the program to jump to a section of the program but will not return. It is often used after a BTFSS (Bit Test File and Skip If Set) or a BTFSC (Bit Test File and Skip if Clear) to perform another function. The $-1 after a GOTO causes the program to go back one step. You can use $-5 to go back five steps. Be careful though. Sometimes it won't jump back to the right place if you are at a page break.

For more information on labels and how the program works see "Hints and Tips" on the *N&V* website. You know you can count on that. **NV**

Programming CHIPINO with SimpleC

By The CHIPAXE Team

In previous articles, we introduced our CHIPINO module with a pin-compatible layout to the popular Arduino module (but ours is based on the Microchip PIC). We also showed previously how to create your own shield. Now, we want to demonstrate a C programming option that is targeted at the beginner using the CHIPINO module. For this demonstration, we'll show how easy it can be to control a 2x16 LCD character module with a single command line using the SimpleC library Chuck Hellebuyck created for his book *Beginner's Guide to Embedded C Programming – Volume 3*. With Chuck's permission, we've included the SimpleC files with the CHIPINO documentation.

To demonstrate the simplicity of SimpleC, we'll do an LCD project. Any SimpleC project requires you to include the simplec.c library file and the simplec.h header file, plus your main.c file which are all based on the Microchip HI-TECH C compiler you can download for free in lite mode. Because all the heavy lifting is done in the simplec.c library file, the main.c file is very short.

Hardware

The hardware connections for the LCD are defined in the simplec1.1.h file using the PORTB pins which are pins 8 through 13 on the CHIPINO. These six pins control the E, RS, and DB4-DB7 pins of the LCD module which is all you need for four-bit mode operation — the most common LCD control. The schematic in **Figure 1** shows the connections, and the breadboard layout using a CHIPINO module is in **Figure 2**.

The Vo pin of the LCD is grounded, which gives maximum contrast. On some LCDs, this makes it tough to read so you may want to add a resistor divider or potentiometer output on that pin so you can adjust the voltage and thus the contrast.

Software

Writing ASCII characters to the LCD is useful but more often you'll probably want to display a full message of text. Sending each individual ASCII character could do this or you could use the lcd_text function in SimpleC. This project uses that function to display a message on the first and second line of the 2x16 LCD.

```
/*
This project creates a message on a 2x16 LCD
module using the lcd_text() function.

LCD
PIN 1 - Gnd
PIN 2 - 5v
```

```
PIN 3 - Gnd
PIN 4 - RB4/CHIPINO Pin 12 (RS)
PIN 5 - Gnd
PIN 6 - RB5/CHIPINO Pin 13 (EN)
PIN 7 - NC
PIN 8 - NC
PIN 9 - NC
PIN 10 - NC
PIN 11 - RB0/CHIPINO Pin 8 (DB4)
PIN 12 - RB1/CHIPINO Pin 9 (DB5)
PIN 13 - RB2/CHIPINO Pin10 (DB6)
PIN 14 - RB3/CHIPINO Pin11 (DB7)

 */

#include "simplec1.1.h"

void main(void)
{
init_micro(); // Initialize I/O
lcd_init();   // Initialize LCD Display
lcd_clear();  // Clear LCD screen

while (1==1)
   {

   lcd_goto(0);       // Select first line
   lcd_text("Simple C Makes");
                      // Display Hello World

   lcd_goto(0x40);    // Select second line
   lcd_text("Programming Easy");

   pause (1000);      // Delay for 1 second to
                      // read display

   } //End While

} //End Main
```

How it Works

The software header describes the connections and the description of the project. Anything placed between the /* and */ is considered a comment.

```
/*
This project creates a message on a 2x16 LCD
module using the lcd_text() function.

LCD
PIN 1 - Gnd
PIN 2 - 5v
PIN 3 - Gnd
PIN 4 - RB4/CHIPINO Pin 12 (RS)
PIN 5 - Gnd
PIN 6 - RB5/CHIPINO Pin 13 (EN)
PIN 7 - NC
PIN 8 - NC
PIN 9 - NC
PIN 10 - NC
PIN 11 - RB0/CHIPINO Pin 8 (DB4)
PIN 12 - RB1/CHIPINO Pin 9 (DB5)
PIN 13 - RB2/CHIPINO Pin10 (DB6)
PIN 14 - RB3/CHIPINO Pin11 (DB7)

 */
```

The simplec1.1.h file is included, followed by the main function.

```
#include "simplec1.1.h"

void main(void)
{
```

The init_micro, lcd_init, and lcd_clear SimpleC functions are next. They set up the LCD for proper communication.

```
init_micro();        // Initialize I/O
lcd_init();          // Initialize LCD Display
lcd_clear();         // Clear LCD screen
```

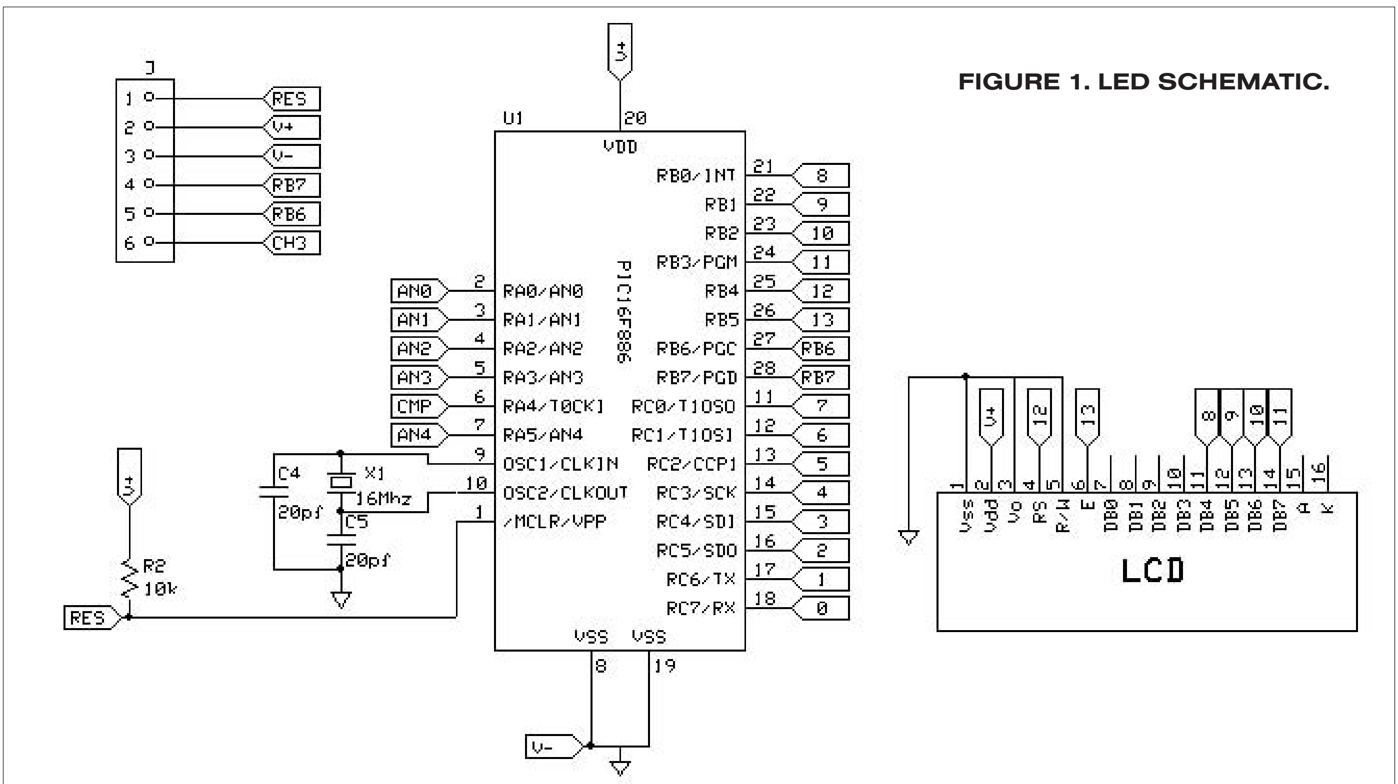


FIGURE 1. LED SCHEMATIC.

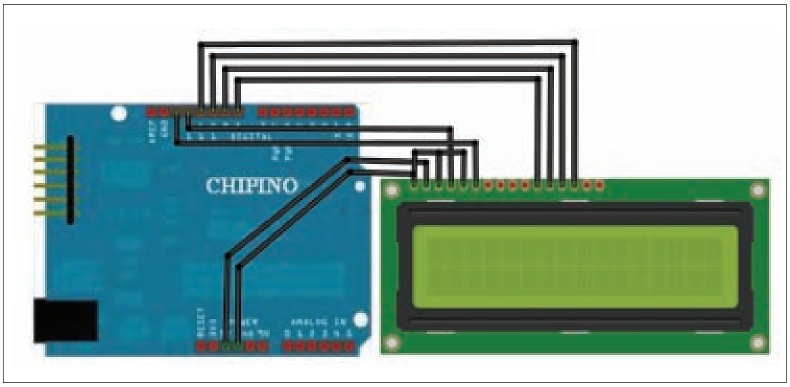


FIGURE 2. CHIPINO MODULE WITH LCD.

The while-loop contains the main code. It starts off by setting the LCD to position zero.

```
while (1==1)
      {

      lcd_goto(0);          // Select first line
```

The SimpleC lcd_text function does the work for us. The parameters of this function are placed between quotes so it knows this is a string. Each letter is then sent as an ASCII value to the LCD module. This displays the message "Simple C Makes" on the first line of the LCD.

```
lcd_text("Simple C Makes"); // Display Hello
                            // orld
```

Now, the LCD cursor is positioned on the second line with a hex value of 40 as the parameter. This is the value for the beginning of the second line. The lcd_goto handles the code that indicates this is a command character. After this function runs, the cursor will be at the beginning of the second line.

```
lcd_goto(0x40);         // Select second
                        // line
```

Now, the lcd_text function is used to write the second message, which is "Programming Easy."

```
lcd_text("Programming Easy");
```

We pause a second and then loop back to write the message again.

```
pause (1000);           // Delay for 1
                        // second to read
                        // display

      } //End While

} //End Main
```

Conclusion

This was just a short example of what SimpleC can do to make C programming easier for the beginner. If you are coming from the Basic compiler world and moving to C, then you should feel right at home with this method of programming. The whole point of this was to show the options you have to use the CHIPINO module to get something running in a very short amount of time.

We've also had many CHIPINO users tell us they like using the CHIPINO with their own choice of compiler. The CCS C compiler has a lot of the pre-written functions in it that make programming quite easy, as well. The CHIPINO can work with any compiler that produces a .hex file for the PIC16F886. This includes the following compilers: CCS C, mikroBasic, mikroC , mikroPascal, Great Cow BASIC, PICBASIC PRO, PROTON Basic, SourceBoost C, and SourceBoost Basic, just to name a few. Some CHIPINO users have changed the PIC16F886 to a PIC18F25K22 and used Microchips C18, Swordfish Basic, Amicus BASIC, and more.

If you have any other unique uses for the CHIPINO, please forward it on to us at support@chipaxe.com. It's designed to be an open source platform so you can use any compiler you want with a common hardware setup. People are figuring this out, so keep the ideas rolling in. **NV**

 Continued from page 9

but the letter R is commonly used instead. It has exactly the same meaning. So, a 470R resistor is 470 ohms. In fact, a range of capital letters is widely used for component values. The reason is to ensure that the values are stated unambiguously and without using special symbols.

Another way in which the letters are used is to represent the decimal point in a value. A capital letter is much easier to see and less likely to be accidentally inserted in text. So, for example, a 4.7 kilohm (4,700 ohm) resistor may be shown as 4K7 with the K indicating that the unit is Kilohms and its position in the value between the 4 and the 7 marking the decimal point. In the same way, a 1.5 ohm resistor may be represented as 1R5. This notation is used worldwide; it is not a British peculiarity.

Capacitance values are widely stated in microfarads, nanofarads, and picofarads. One nanofarad (nF) is a thousandth of a microfarad. One picofarad (pF) is one thousandth of a nanofarad. In the same way as for resistance, capacitance is often shown using the letter as a decimal point. Thus, a 0.1 microfarad capacitor may be shown as 100n, meaning 100 nanofarads. Likewise, a 2,200 pF one may appear as 2n2, meaning 2.2 nanofarads or indeed 0.0022 microfarads.

Headphones with an impedance of 300R were

Continued on page 77

THE DESIGN CYCLE

ADVANCED TECHNIQUES FOR DESIGN ENGINEERS

■ BY FRED EADY

FLASHFLY SYSTEM GETS STAMP OF APPROVAL

Never underestimate the power of a BASIC Stamp. The first Stamp I ever saw was in charge of a small CNC machine's main stepper motor, among other things. When it comes to proof of concept, the Stamp excels. I've personally seen Stamps used in the initial production of scientific instruments that supported ground and flight hardware used in the spaceflight program.

The BASIC Stamp appeals to both machinist and scientist because it is easy to use. The Stamp is yet another proof that can be applied to *Fred Eady's First Rule of Embedded Computing*. The Stamp is easy to use because all of the embedded firmware and hardware work has already been done for you. Thus, as my first embedded computing rule states, "Nothing is free." However, in the case of the Stamp, you didn't have to pay.

In this month's Design Cycle, we are going to expand the power of a BASIC Stamp 2 using a pair of XBee radios and an extremely clever RF system. The XBee radios are the heart of a system that enables a Stamp-based computing platform to operate beyond the wires. This wireless layer of a Stamp application is called FlashFly.

FLASHFLY 101

A typical FlashFly system consists of a BASIC Stamp module, a FlashFly base module, and a FlashFly remote module. If the FlashFly remote module is not in the form of a FlashFly USB Stamp adapter module, a FlashFly RS-232 adapter board may be part of the FlashFly system.

FlashFly modules can be had as factory assembled units or semi-kits. In my opinion, the only way to become and remain a good soldering technician is to practice. So, all of the FlashFly units used in this discussion arrived on the Design Cycle bench in kit form.

■ PHOTO 1. The FlashFly XBee radio modules operate in peer-to-peer mode under the rules of 802.15.4. This particular XBee radio module has a maximum range of 100 feet indoors and 300 feet outdoors.

Regardless of the FlashFly system configuration, the base module and remote module both require the presence of an XBee radio module like the one under the lens in **Photo 1**. When the FlashFly USB Stamp adapter is acting as the remote application module, the XBee radio module is physically carried by the adapter.

THE FLASHFLY BASE MODULE

Photo 2 is a fly's eye view of a FlashFly base module in its out-of-the-box preassembled form. If you take a moment to closely examine the hardware in **Photo 2**, you'll see that an FTDI FT232RL USB-to-UART bridge IC is the personal computer-to-XBee radio interface.

The XBee radio module you see in **Photo 1** is accommodated by the pair of 2 mm female headers that will be soldered into the base module's J1 and J2 header positions. The FT232RL USB-to-UART IC is configured to drive its I/O subsystem at 3.3 volt logic levels which are compatible with the XBee radio module's 3.3 volt I/O engine. Power for the base module electronics is derived from the USB portal's +5.0 VDC power supply. The USB-to-UART IC performs the 5.0 VDC-to-3.3 VDC power conversion internally while the XBee radio module receives its +3.3 VDC power via the output of a Microchip TC1262-3.3 LDO voltage regulator. Since everything electronic that is riding on the FlashFly base module is referenced to a 3.3 volt voltage rail, there is no need for any voltage translation circuitry between the FT232RL and the XBee radio module serial and I/O interfaces.

The XBee radio modules are very popular and I'm sure you've seen them used in other wireless applications. If you wish to utilize the FlashFly system for something other than Stamp interfacing, you may do so by cutting bridge traces on the opposite side of the base module PCB. The set of 0.1 inch pitch 11-pin headers that lie inside of the XBee radio module 2 mm header pair can be used at your discretion and are labeled on the other side of the base module PCB. The 11-pin header pair shares the same footprint as a Stamp 2. So, you can plug the FlashFly base module into any socket or breadboard area that will accept a Stamp 2 footprint.

Modifications you may make to the FlashFly modules may inhibit their ability to operate correctly with a Stamp 2 module. So, for the sake of this discussion we will stick to interfacing our unmodified FlashFly system to a BASIC Stamp 2. With that said, the only FlashFly base module HDR-1 signals necessary to interface to our Stamp 2 include the TX, RXA, DTR, GND, and +3.3 VDC. The TX, RXA, and DTR signals presented at HDR-1 adhere to 3.3 volt logic levels. As you can see in **Photo 2**, the FlashFly base module is adorned with "blinkers" that indicate the status of the TX and RXA signals, as well as the presence of power and RF signaling (RSSI). The RSSI indicator will glow green when an RF signal of sufficient strength is detected.

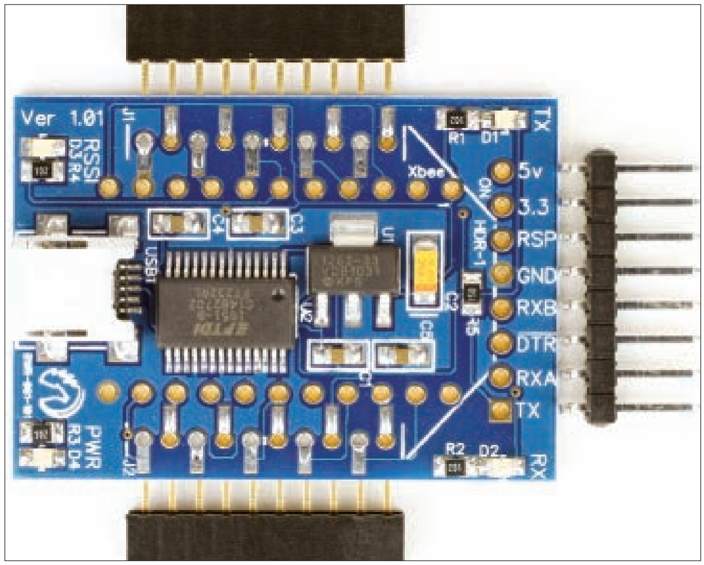
Soldering the pins at the FlashFly base module's HDR-1 position is optional. If you do decide to attach the pins, you can remove the base module XBee radio module and attach a FlashFly RS-232 adapter board. The radio-less base module/RS-232 adapter board combination can then be used as a PC USB-to-RS-232 converter.

THE FLASHFLY REMOTE MODULE

The freshly unboxed FlashFly remote module spread out in **Photo 3** is responsible for passing the incoming program data to its associated Stamp 2. The remote module also has the capability of acting as a remote application serial port. That is, it can be used to accept and return application-related serial data to the FlashFly base module.

Note that the remote module does not contain any RS-232 voltage translation circuitry. That means that you can directly connect the remote module to any other device that operates with 3.3 volt logic levels. However, the Stamp 2 is a 5.0 volt device and exposing the FlashFly remote module to 5.0 volt logic levels could be fatal to the XBee radio module. Mounting the eight-pin male header at the HDR-1 position of the remote module permits the joining of a FlashFly RS-232 adapter board which acts as an RS-232-to-3.3 volt logic level converter. The HDR-1 pins also allow the FlashFly remote module to ride on the edge of the USB Stamp adapter.

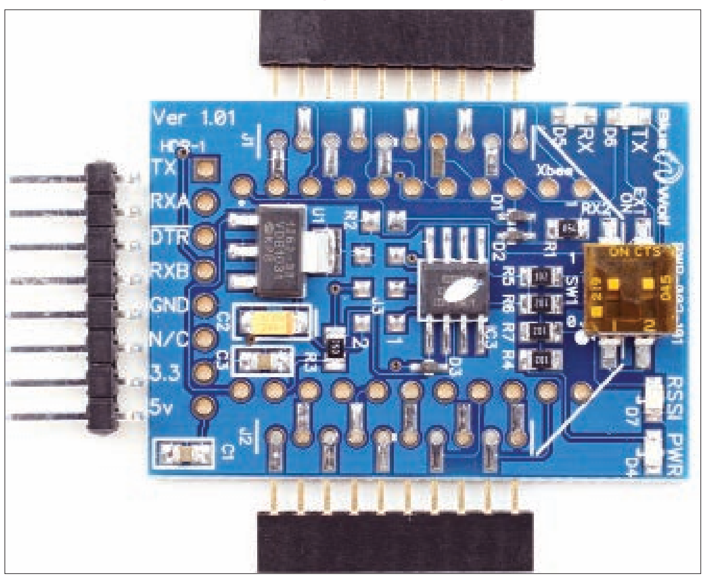
Just like its partner, the remote module beds down the XBee radio module with 2 mm female headers at header positions J1 and J2. To keep your head from exploding, a quartet of blinkers provides instant visual indication of the status of the module's power and RF link. The only other thing you really need to know about the remote module is that the two-position DIP switch must have both switches in the ON position for Stamp 2 transfers.



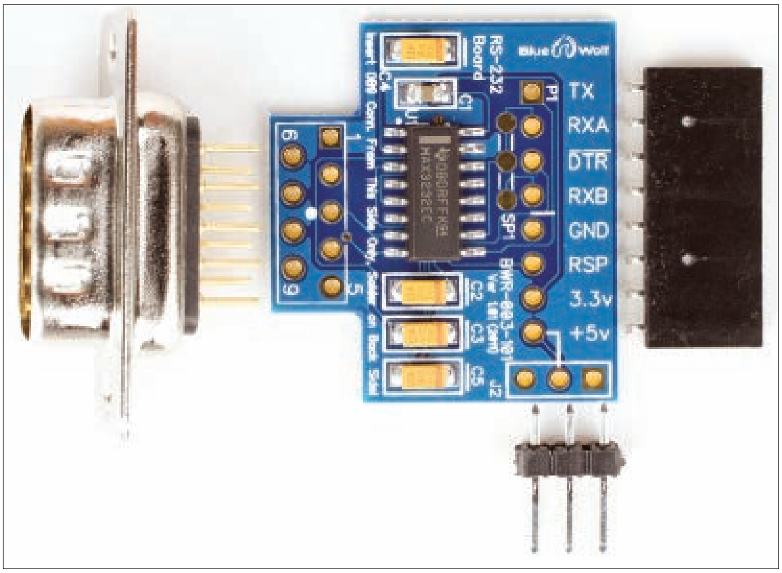
■ PHOTO 2. Mounting the pins at HDR-1 is optional. However, attaching the pins allows you to use the FlashFly base module in tandem with the FlashFly RS-232 adapter board to form a USB-to-RS-232 converter.

THE FLASHFLY RS-232 ADAPTER BOARD

If you've ever worked with microcontrollers and RS-232, there is absolutely nothing I can tell you about the RS-232 adapter board that you don't already know. On



■ PHOTO 3. Only 28 solder joints and you have a ready-to-run FlashFly remote module.



■ PHOTO 4. The folks at FlashFly tell me that this hardware rendition of the RS-232 standard is so portable and true to form that customers order the RS-232 adapter board alone for use in things that are not FlashFly.

that note, swivel your eyeballs over to focus on **Photo 4**. All of the adapter board's RS-232 voltage levels can be found at the nine-pin D-shell connector, and all of the XBee radio module 3.3 volt logic levels reside at the eight-pin P1 header.

The MAX3232 RS-232 transceiver can operate with power rails of +5.0 VDC or +3.3 VDC. In the FlashFly world, the MAX3232 is powered with +3.3 VDC by way of the FlashFly remote module's TC1262 3.3 volt LDO voltage regulator. The RS-232 adapter board's +5V header pin directs its +5.0 VDC power source out to the remote module and has no other connection on the RS-232 adapter board. The output of the TC1262-3.3 LDO voltage regulator mounted on the remote module is returned to the adapter board via the 3.3V header pin.

Powered by +3.3 VDC, the MAX3232 produces RS-232 voltage levels that swing between -5.4 VDC and +5.4 VDC. The MAX3232's RS-232 transceivers are inverters. So, a logical 1 on the 3.3 volt logic side of a transceiver results in a -5.4 VDC on the RS-232 side of the transceiver. In old timer's RS-232 vernacular, the negative RS-232 voltage is a MARK. A SPACE is represented on the RS-232 side as a positive voltage which, in this case, is +5.4 VDC.

I remember the difference between a MARK and SPACE voltage levels by visualizing a SPACE as "towards the sky" or upwards and positive. Most of us pen a 1 from top to bottom. Thus, a MARK is a "negative" stroke of the pen towards the ground.

If you fail to read the freaking manual before assembling your FlashFly RS-232 adapter board, please read the adapter board's silkscreen. It will save you from reworking a backwards-mounted nine-pin D-shell connector.

THE FLASHFLY USB STAMP ADAPTER

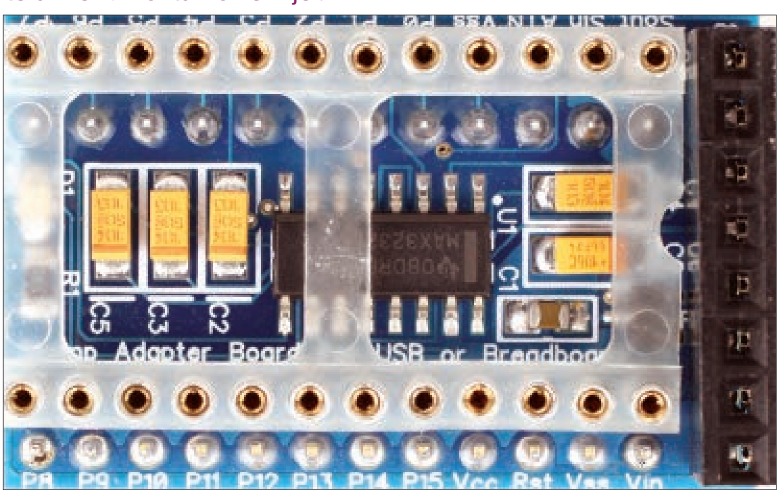
The Stamp 2 is designed to interface directly to a regulation PC RS-232 portal. Most Stamp 2 carriers (such as the Parallax BASIC Stamp 2 carrier board) include a nine-pin D-shell connector to allow the easy connection to a PC's serial port. However, you can't count on every Stamp 2 carrier board to accommodate the host Stamp 2 with a convenient nine-pin PC interface.

As you can see in **Photo 5**, the FlashFly USB Stamp adapter is a Stamp 2 carrier, RS-232 interface, and remote module carrier all in one unit. The Stamp 2 rests in the pins of the clear 24-pin socket, while the remote module plugs into the eight-pin female header. A pair of headers underneath the board allows the Stamp 2 to make contact with the outside embedded world.

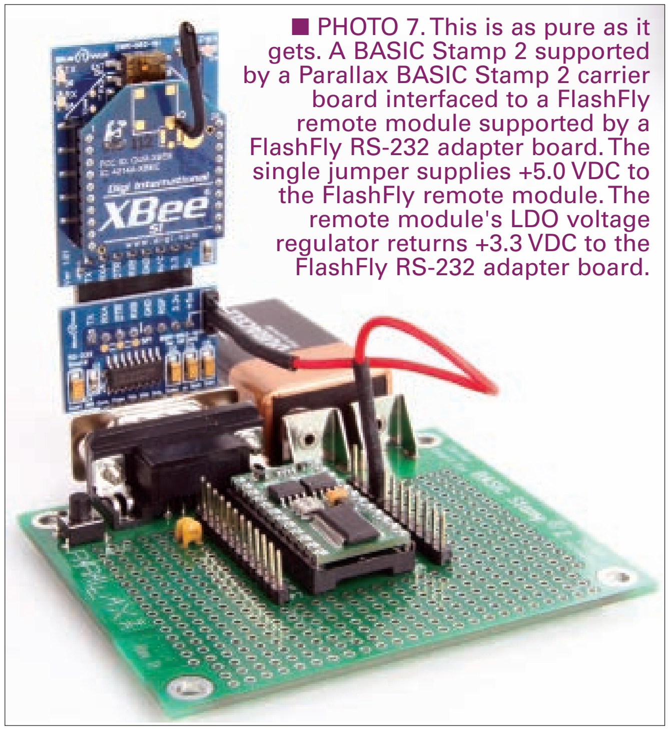
The USB Stamp adapter was designed with failure in mind. Your failure, that is. The USB Stamp adapter must be assembled in a particular order. If you get excited with the clear wash-away socket and install it before you install the upper set of headers, you're in for some header/socket rework action. The wash-away socket is included by design for those of us that may rush through the assembly process without direction. The wash-away socket is water soluble and can literally be washed away to leave its pins standing tall. With the wash-away socket obliterated, you can then solder in that top row of headers you should have mounted first while retaining the Stamp 2's bed of nails.

There is yet another way to fail and I invented it. I was so careful that I soldered the bottom row of headers into the wash-away socket's bottom row of PCB pads. Also, the wash-away socket can get sticky if you don't dry your fingers after drinking from that soda can. So, the word is pay particular attention to the USB adapter's construction details.

■ PHOTO 5. The wash-away socket allows you to recover from a severe case of Not Reading The Freaking Manual syndrome. As you can see, mounting the wash-away socket before soldering in the headers below it can lead to a monumental rework job.



■ PHOTO 6. Here's that assortment of base module parts in Photo 2 fully assembled and loaded with an XBee radio module.



■ PHOTO 7. This is as pure as it gets. A BASIC Stamp 2 supported by a Parallax BASIC Stamp 2 carrier board interfaced to a FlashFly remote module supported by a FlashFly RS-232 adapter board. The single jumper supplies +5.0 VDC to the FlashFly remote module. The remote module's LDO voltage regulator returns +3.3 VDC to the FlashFly RS-232 adapter board.

PREPARING THE FLASHFLY SYSTEM FOR USE

With the FlashFly base and remote modules assembled, the next thing to do is load the XBee radio module configuration profiles. If you're new to XBee radios, you'll need to download and install the X-CTU XBee configuration software. X-CTU is used to load the FlashFly base module and remote module XBee configuration profiles. The X-CTU application and XBee profiles are free and can be downloaded from the FlashFly website. It would be rare, but if you've never used an FTDI-based USB device you'll also need to download and install the USB FTDI drivers from the FlashFly site.

The XBee configuration profiles can be transferred to the XBee base module and remote module radio modules using the FlashFly base module and X-CTU. Our assembled FlashFly base module with XBee radio module is showing its teeth in **Photo 6**.

X-CTU is very intuitive and easy to use. So, you shouldn't have any problems loading the FlashFly XBee profiles. If you find yourself tangled up in X-CTU, the FlashFly website also offers a downloadable version of the X-CTU User's Guide.

After you've loaded the XBee configuration profiles, park the XBee radio modules on their respective FlashFly base and remote modules. If your Stamp 2 hardware complex provides a standard nine-pin D-shell connector, your remote setup will look similar to the FlashFly and Parallax equipment pictured in **Photo 7**. On the other hand, your FlashFly remote module may jettison the RS-232 adapter board and take on the look of **Photo 8**.

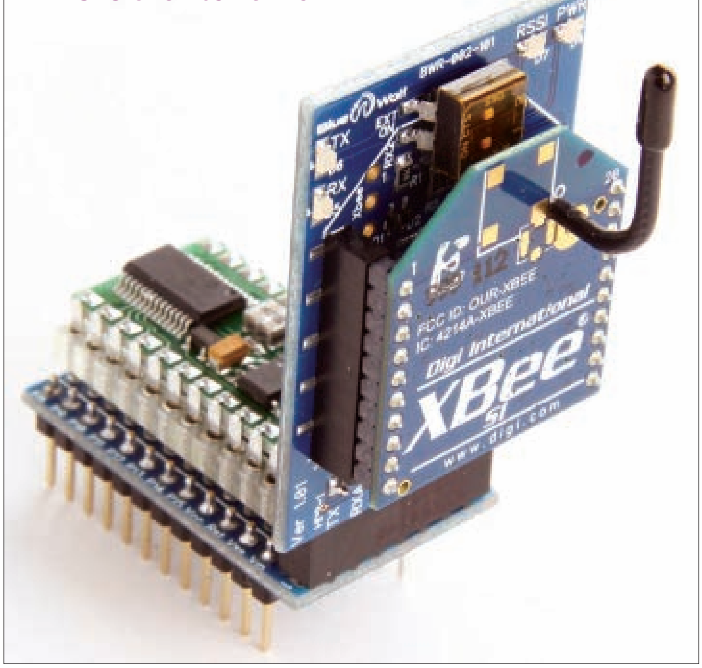
FLASHFLY DATA AND SIGNALS

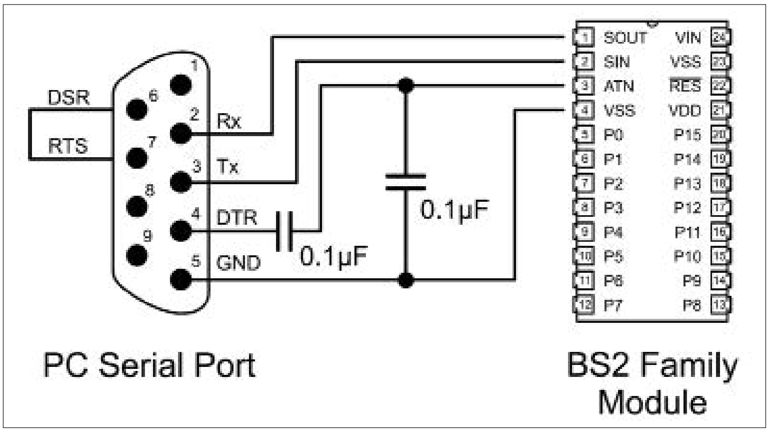
The XBee radio modules are configured to send data "in the clear" just as a wire would. That's totally understandable when applied to binary data. However, the active-low DTR signal used to reset the Stamp 2 is not a bit pattern. So, how does the FlashFly system reset the Stamp 2 remotely using the DTR signal? The answer lies in the understanding of the Stamp 2 circuitry and the XBee radio module's built-in I/O engines.

Take another look at **Photo 7**. Do you see the pair of 0.1 μF capacitors to the immediate left of the Stamp 2? That pair of capacitors is wired to the Stamp 2's ATN pin as shown in **Figure 1**.

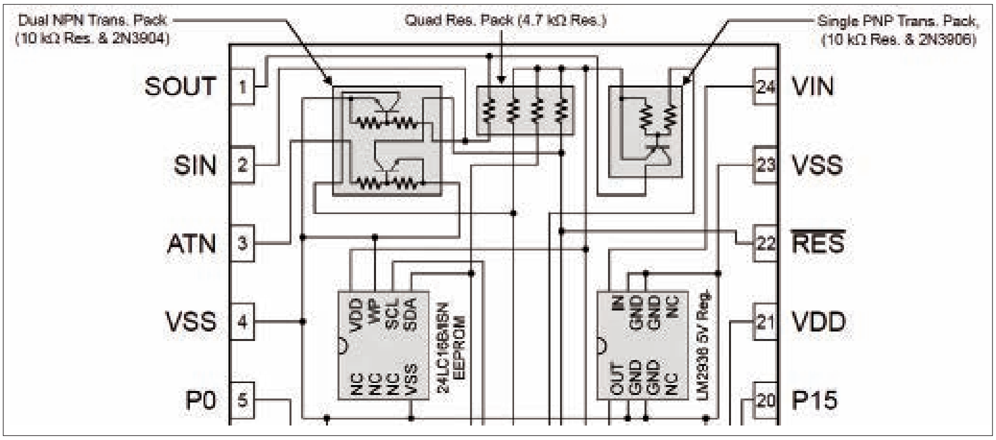
The role of the 0.1 μF capacitor that spans between the ATN and VSS pins is well known as far as digital circuitry is concerned. It's a noise bypass capacitor. To understand how the 0.1 μF capacitor in series with the DTR pin works for us, we have to examine the circuitry behind the ATN pin.

■ PHOTO 8. Unicorns live!





■ FIGURE 1. The arrangement of these capacitors can be confusing. To understand their missions, you must understand what stands behind the BASIC Stamp 2's ATN pin.



■ FIGURE 2. The BASIC Stamp 2's ATN and RS-232 duties are performed by a single PNP transistor, a pair of NPN transistors, and a handful of resistors. Simple, effective, and elegant.

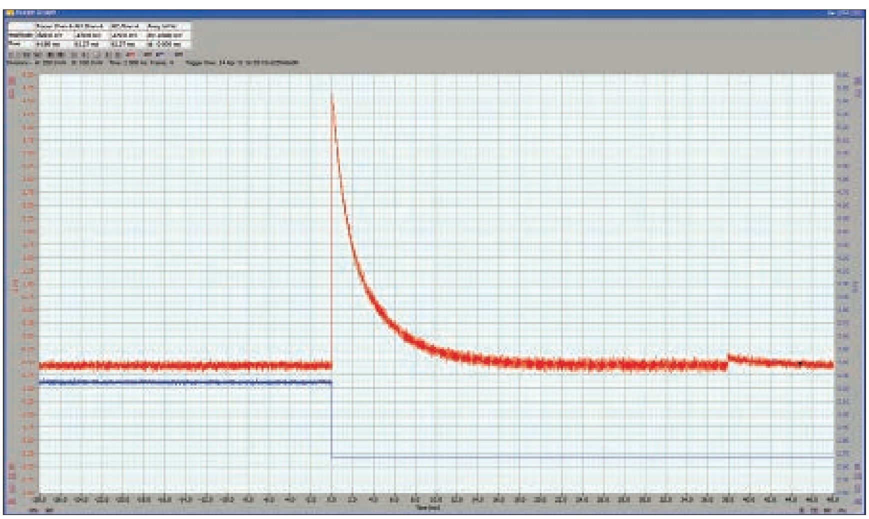
Figure 2 is a schematic view of the Stamp 2's RS-232 interface and ATN circuitry. If you trace the circuit from the SIN pin back into the Stamp 2, you'll see that the SIN RS-232 signal drives the base of an NPN transistor. The TTL equivalent of the RS-232 SIN signal is taken from that same NPN transistor's collector which is pulled high by a 4.7 KΩ resistor. Note also that the SIN signal is inverted by the NPN transistor. For instance, a SPACE (+5.4 VDC) presented at the SIN pin turns the NPN transistor ON and takes the NPN transistor's collector logically low. A MARK (-5.4 VDC) at the SIN pin holds the NPN transistor in an OFF state and allows the collector pullup resistor to present a logically high signal level at the NPN transistor's collector.

The Stamp 2's RS-232 level at the SOUT pin is controlled by a PNP transistor. A logical low applied to the base of the PNP transistor turns the transistor ON and +5.0 VDC (SPACE) is transferred to the SOUT pin. Since the Stamp 2 communicates on a half-duplex link, the SIN pin is externally held at a MARK level by the receiver while the Stamp 2 is transmitting (this is called MARKING). Thus, when the PNP transistor is turned OFF, a 4.7 KΩ resistor provides a path for the MARK on the SIN pin to be transmitted on the SOUT pin.

The operation behind the ATN pin is similar to that of the SIN pin. Without the DTR series capacitor, the ATN circuitry is identical to the SIN circuitry. With the DTR series capacitor absent, the application of a SPACE at the ATN pin would force the RES pin logically low and reset the Stamp 2. The DTR series capacitor and the bias resistors connected to the base of the NPN transistor form a differentiator. The function of this differentiator circuit is captured by a CleverScope in **Screenshot 1**.

The lower trace in **Screenshot 1** reflects the 3.3 volt logic level at the FlashFly remote module's active-low DTR pin. The upper trace represents the 5.0 volt logic level at the Stamp 2's ATN pin. As long as the remote module's DTR logic level is logically high, the voltage at the RS-232 DTR pin at the nine-pin connector is MARKING, or negative. The MARKING DTR pin does not allow the DTR-to-ATN series capacitor to charge as the ATN end of the capacitor is finding a path to ground through the NPN base bias resistors. A Stamp 2 reset will not occur as long as the ATN pin is held logically low.

As soon as the remote module's DTR pin is driven logically low, the RS-232 DTR signal at pin 4 of the nine-pin D-shell connector transitions from a negative MARKING state to a positive SPACING state. The signal inversion/conversion takes



■ SCREENSHOT 1. I used a CleverScope to capture this BASIC Stamp 2 reset pulse. The CleverScope was triggered on the falling edge of the FlashFly remote module's active low DTR pin.

place in the MAX3232 transceiver which lies between the remote module and the 9-pin D-shell connector. The 0.1 µF capacitor tied between the RS-232 DTR pin and Stamp 2's ATN pin sees a positive voltage at the DTR end and a ground path through the NPN transistor bias resistors at the ATN end. That allows the series capacitor to do what capacitors do ... CHARGE! As you can see in **Screenshot 1**, the capacitor in series with the RS-232 DTR pin charges toward +5.0 VDC. The series pair of 10 KΩ NPN bias resistors and the 0.1 µF capacitor create a 20 mS spike that drives the ATN pin logically high long enough to reset the Stamp 2.

Here's a view of the ATN action we just discussed from the FlashFly point-of-view. On the base module, the XBee-Pro module's DTR pin is electrically tied to the XBee radio module's DIO4 I/O pin and active-low DTR header pin. The remote module's DIO4 pin is tied to its active-low DTR header pin.

The remote module's DIO4 I/O pin is configured as a digital output that defaults to a logically high output state. The corresponding base module DIO4 I/O pin is configured as a digital input. So, as long as the base module's DIO4 input does not toggle from logically high to logically low, the remote module's DIO4 output pin presents a logical high to the MAX3232's DTR transceiver. This results in a MARK at pin 4 (DTR) of the RS-232 D-shell connector which prevents the DTR-to-ATN series capacitor from charging.

When the base module's DIO4 input is forced from a logical high to a logical low, the base module XBee radio module is configured to transmit the change in logic states of its DIO4 input to the remote module. The remote module receives the logic change event and proceeds to drive its DIO4 pin logically low. The active-low logic level at the remote module is presented on the DIO4 output pin. The MAX3232 transceiver servicing the DTR header pin on the remote module presents a SPACE to the DTR end of the series capacitor. The series capacitor charges and a 20 mS positive-going spike at the Stamp 2's ATN pin resets the Stamp 2. The remote module's DIO4 output stands at the logically low level for a predetermined amount of time before returning to its logically high default state.

The logic level transition on the base module's DIO4 digital input originates from the Stamp Editor during a RUN/DOWNLOAD event. You can also initiate a DTR reset operation from the debug terminal.

SOURCES

Special thanks to the Parallax Team for their BASIC Stamp 2 hardware and technical support.

Parallax – www.parallax.com
BASIC Stamp 2
BASIC Stamp 2 Carrier Board
BASIC Stamp Editor

Blue Wolf Robotics – www.bluewolfinc.com
FlashFly System

Digi – www.digi.com
XBee/XBee-Pro 802.15.4 Radio Modules

Saelig Company – www.saelig.com
CleverScope

WIRELESS WONDER

That's what the FlashFly system is. There is no better way to remotely program and exchange application data with a BASIC Stamp 2. If you need additional range, load your FlashFly base module and remote module with XBee-Pro radio modules. With the XBee-Pro radios, you can communicate at distances up to 300 feet indoors and one mile line-of-sight outdoors. Add a FlashFly system to your Stamp 2 Design Cycle and take your designs to places they've literally never been before. **NV**

Fred Eady can be reached at fred@edtp.com.

#36 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

avrtoolbox Ring Buffer

Recap

So far, in our briefly interrupted series on avrtoolbox, we've looked at some software engineering principles and applied them to creating the avrtoolbox project on Google Code [**http://code.google.com/p/avrtoolbox**/]. We've learned about creating an open source project using a consistent C programming style, documenting it with doxygen, putting our functions in libraries, and keeping track of the whole thing with a software versioning system. Last month, we learned a bit about two more software engineering tools: the FRS (Functional Requirements Specification) and the API (Applications Programmer Interface), and applied all that to an elementary serial communications library meant to mimic the kinds of novice-friendly functions we'd find in the Arduino or PBASIC.

The novice-friendly serial library was built on top of two other libraries: one for storing the data (ring buffer) and another for sending and receiving the data (USART). These libraries are not particularly novice-friendly and more like what you'd see in a professional software production environment. This month, we are going to look at ring buffers and next month we will look at the AVR USART. Also this month, we will look at another software engineering tool — the AVRStudio Simulator — that we will use to test the ring buffer functions.

What is a Ring Buffer?

A ring buffer algorithm turns a linear array into a circular array which as you will see in a moment, can be very useful for rapidly storing and retrieving data. A linear array is just a sequence of contiguous memory locations set aside to store data in such a way that you can access the data by using a number indicating its position in the array. For instance, if you had a 64-byte linear array named linArray and wanted to get the 32nd byte, you would use: myByte = linArray[31]. You use 31 instead of 32 because in arrays, we start numbering at 0 rather than 1, meaning we have bytes number 0 to 63 stored for a total of 64 bytes. A ring buffer is a linear array, but we use a special algorithm to make it behave as if it was a ring having neither a beginning nor an end.

Ring buffers are very useful in C programming where we often have a situation where we have two 'things' that are trying to deal with the same variable set of data, but are doing so at different rates. For instance, we may want to evaluate a stream of bytes that are coming in over a UART to see if we are receiving a command. However, we may be getting the bytes faster than it can analyze them; so incoming bytes begin to pile up. Another situation could be that we have some code generating data to be transmitted out over a UART but the data is being generated in short spurts faster than the UART can transmit them; so outgoing bytes begin to pile up.

In both cases, we need something analogous to a kind of pipe with a balloon in the middle that expands or contracts as the pressure differs on either end of the pipe. This is actually not such a bad analogy since we immediately see that the balloon must have properties of size and stretchiness that accommodate what comes in and goes out the pipes without overstretching and bursting. Obviously, if we connect a fire hose to one end and a soda straw to the other, that balloon better be large and the fire hose better not be left on too long.

Memory is linear, meaning it is addressed with an integer sequence beginning at 0 and ending at the largest address. We can create a subset of memory as an array that may be allocated anywhere in memory, but the array will keep track of the memory locations as if the first location is address 0. For example, we could allocate a 16-byte array that the compiler/linker would locate beginning at memory location 1000 and ending at memory location 1015. When we address the first element of the array, we use 0, but the underlying code substitutes the address of the first memory element: 1000. This abstraction from the real address means that we can reuse an array in other code on other processors and let the compiler/linker figure out where to put it — a detail that is of no interest to our application. Using our linArray[] example, the first byte at linArray[0] could be at 1000 or 2345 or 54321, but we never see that first address since we are using the linArray[0] as an alias.

We can use this 16-byte array to act as our balloon and handle the overflow. Let's say the input function is based on an Interrupt Service Routine (ISR) and our function that processes the input data can be interrupted at anytime for more data to be added to the array. Suppose that we have added 10 bytes to our 16-byte array, we start processing them, and are about to process the sixth of the 10 bytes when the ISR receives another 10 bytes to put in the array. Now we have a problem because we have received 20 bytes total and the array is only 16 bytes long. Notice, however, that we have already processed five of the first 10 bytes, so the first five spaces are now of no interest to us and can be considered 'empty.' We thus have five empty spaces at the start of the array and eight empty spaces at the end of the array for a total of 13 available spaces, but they are not contiguous. We could go ahead and do this the hard way and use our array as a linear array where the ISR copies the five oldest unprocessed bytes from their locations to the beginning of the array, then follows them with the newly received 10 bytes, leaving the total of 15 unprocessed bytes in the array in the proper order beginning at the start of the array.

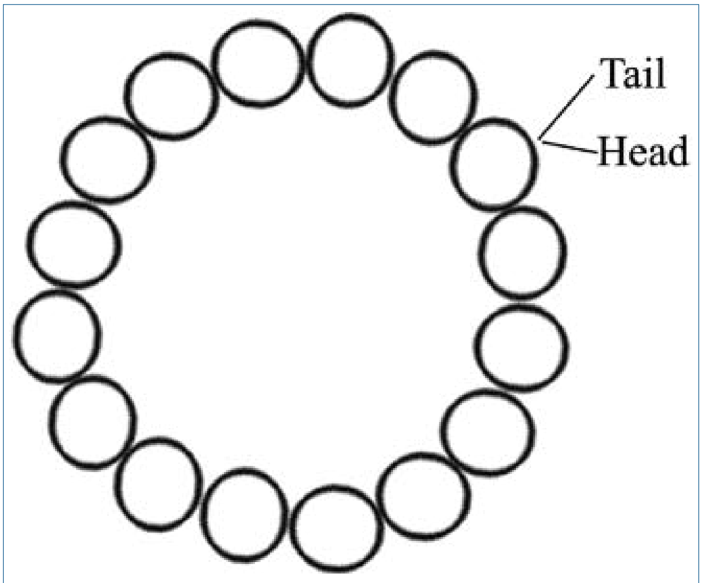
Using this 'hard way' technique, we will have to set some kind of message to inform any function using the array that the first unprocessed byte has been moved to 0. The user will have to read the message and (in the case above) know that the next byte to examine is not the sixth which it was about to work on, but the first. This shifting of byte and processing of flags is complex and time-consuming, but thankfully the ring buffer concept provides a much easier way to accomplish the task without having to move the data.

Instead of moving the data, we keep two indexes: one pointing to the next location to store data from (head index) and the other pointing to the next location to read data from (tail index). The ring algorithm is more difficult to understand, but it is much more efficient for the machine.

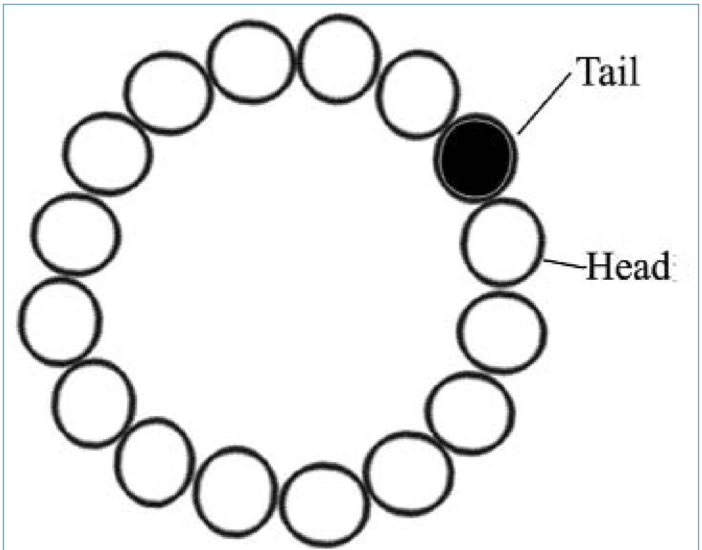
Let's visualize a circular array like a necklace with pearls where each pearl represents a location to store a byte of data. Let's say we have 16 pearls and we want one process to be storing data for another process to remove — each at its own rate. The process that does the storing will have the address of the 'first' input pearl and store data sequentially around the necklace. The storing process needs to remember the location of the first pearl and the number of pearls used to store data. Then, when we want to store a new byte, we can calculate the total number of already stored bytes (length) and get the next storage pearl by adding this length to the first location to get the location for the next empty pearl.

To extend the analogy, let's say that the pearls are chosen in a clockwise direction, and that storing data turns a pearl black. We can see in **Figures 0** through **6** that adding data causes pearls to turn black sequentially in the clockwise direction. For this analogy, we name the location of the next byte memory location to be written (stored) as the Head and the location of the next byte to be read (removed) as the Tail. We add data to the Head and remove data from the Tail.

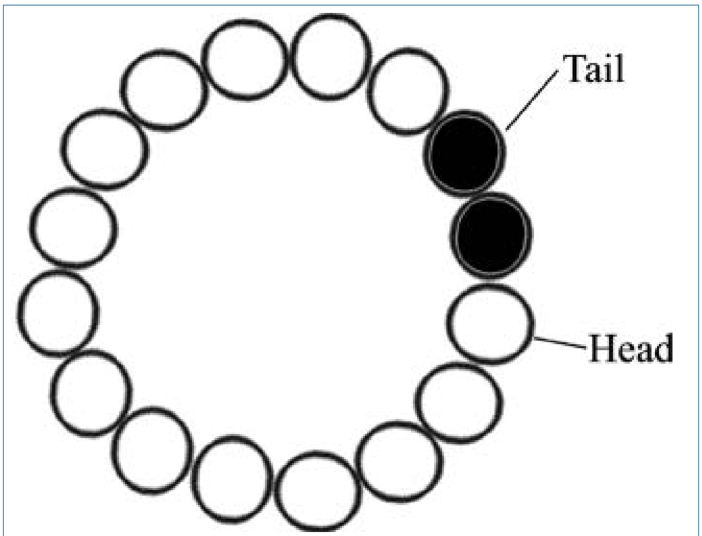
If the access process is slower than the storing process, then the Head location will grow more distant from the Tail around the circle with the Head and Tail changing as the data is added or withdrawn. However, the Head is equal to the



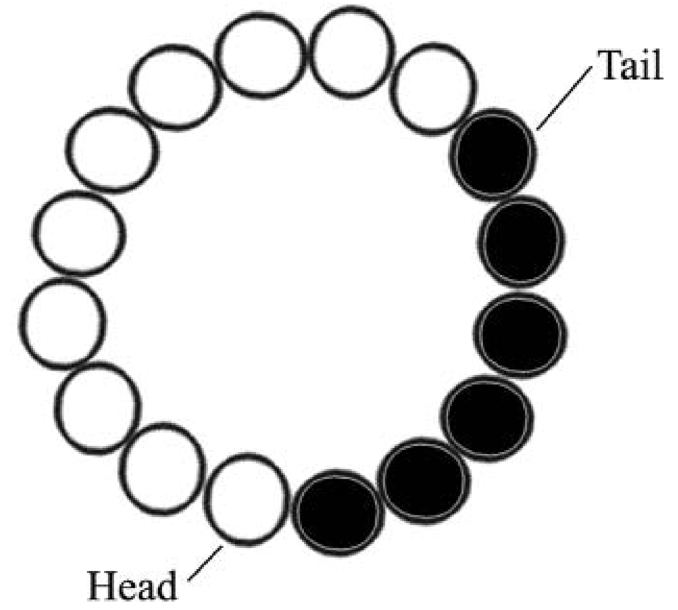
■ FIGURE 0. Empty.



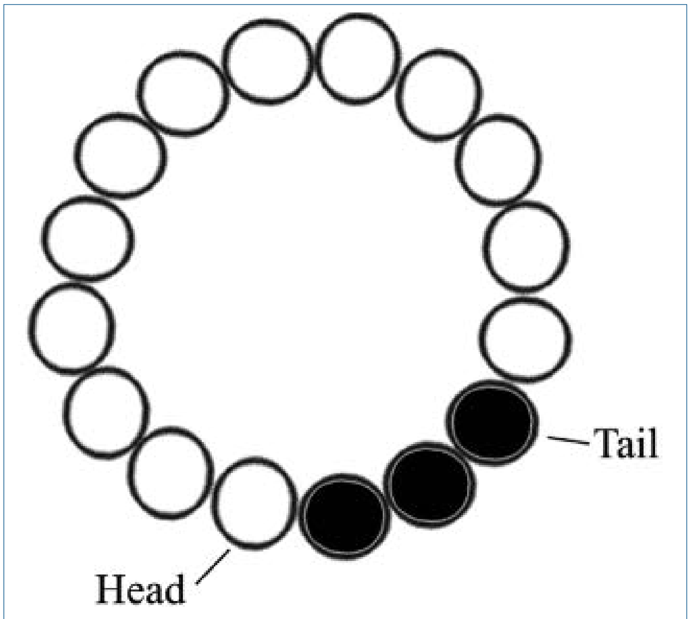
■ FIGURE 1. First byte stored.



■ FIGURE 2. Second byte stored.



■ FIGURE 3. Six bytes stored.



■ FIGURE 4. Three bytes removed.

Tail both when the buffer is empty or full, so we have to look at the count to see which is the case. If the buffer is empty, it's no problem since all that means is that you've caught up. However, if the buffer is full as shown in **Figure 6**, you may have a problem and you may start overwriting data that you haven't read yet. This is not something that you want to happen. Such a condition won't hurt so much if the streaming data is audio output and only happens occasionally, in which case the listener may hear a glitch, but if the data is for monitoring the core temperature of a nuclear reactor, well ...

To solve this problem, the storing function must monitor the indexes and the count, and be able to respond intelligently if things are getting out of hand. For instance, if you are receiving bytes from a PC via the UART and the buffer fills up, then you'll want to use a communication protocol allowing it to tell the PC to hold off for a while.

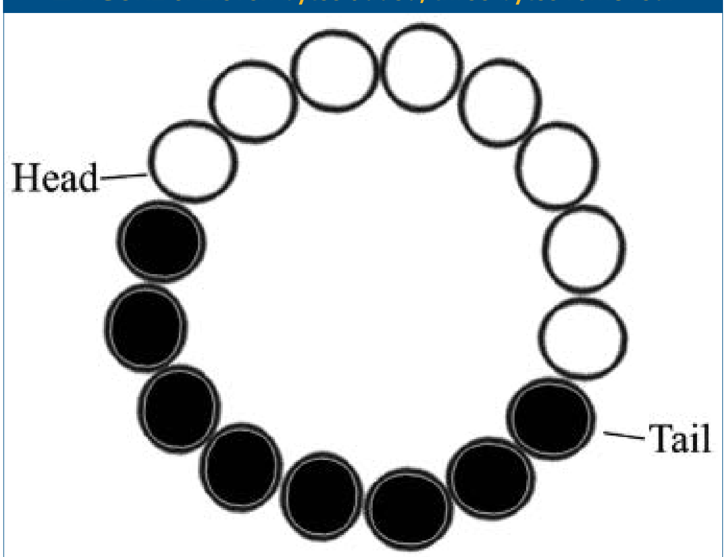
You can lessen the likelihood of this error occurring by increasing the amount of RAM available for the buffer. However, since RAM is precious on microcontrollers, we have to make a trade-off of costs and make a judgment call on how large to make a ring buffer.

Also note that while it is technically feasible to dynamically allocate buffers at run-time using the C malloc() function, eight-bit microcontroller developers aware of RAM limitations rarely do this. So, we will not. We will allocate the buffers when we design the code and make our size decision then.

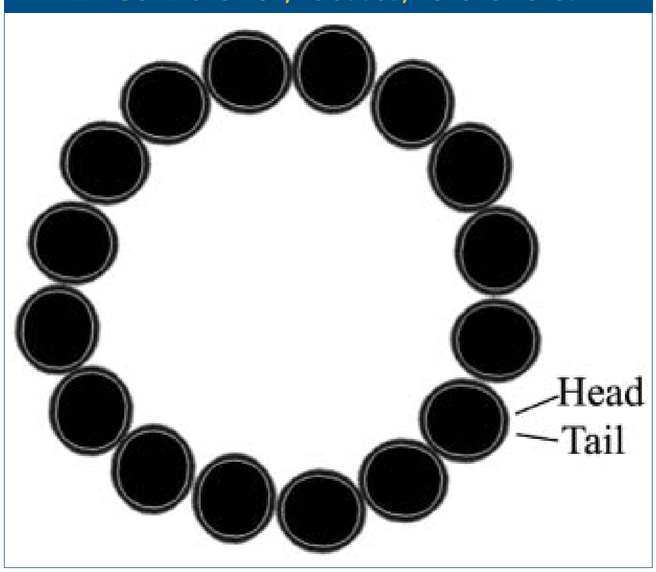
Ring Buffer Functional Requirements Specification

Ring buffer data type: ring_t will be a data type that will hold a pointer to the buffer, the size of the buffer, the Head index, the Tail index, and the data count.

■ FIGURE 5. Eleven bytes added; three bytes removed.



■ FIGURE 6. Uh oh, 16 added; none removed.



Ring buffer initialization function: ring_init() will initialize a ring buffer based on receiving a pointer to a ring_t structure — a pointer to a buffer created by the calling function that is of the size provided.

Ring add to buffer function: ring_add() will add a byte at the next available space in the buffer.

Ring remove from buffer function: ring_remove() will remove a byte from the oldest valid location in the buffer.

Ring peek at buffer function: ring_peek() will read an uint8_t 'count' number of bytes from the ring buffer into a new buffer provided as a parameter without removing any of the values read from the ring buffer. It will return the number of bytes actually read.

Ring clear function: ring_clear() will set the Tail equal to the Head and load 0 into all buffer positions.

Ring Buffer Applications Programming Interface

ring_t

Description: ring_t is a structure that holds data required to create and manage the ring buffer.

```
typedef uint16_t ring_index_t;
typedef uint8_t *ring_buffer_t;
typedef uint8_t ring_count_t;
typedef uint8_t ring_size_t;
typedef struct
{
    ring_buffer_t buffer;
    ring_size_t size;
    ring_index_t head_index;
    ring_index_t tail_index;
    ring_count_t count;
} ring_t;
```

ring_init()

Description: Sets up the ring buffer with ring_t parameters. The clear command is also called to set 0 values within the ring buffer functions.
Syntax: bool ring_init(ring_t *r, ring_buffer_t buffer, ring_size_t size)
Parameters:
ring_t *r: A pointer to a ring_t structure.
ring_buffer_t buffer: A pointer to buffer what you want to use for the ring buffer.
ring_size_t size: Size in bytes of the buffer; must be equal to or greater than two. The actual amount of storage available in the ring buffer is size -1.
Returns: Boolean true if the buffer was created; false otherwise.
Example:

```
void setup()
{
    // Initialize the ring buffer
    if(!ring_init(ring_t *r, ring_buffer_t
    buffer, ring_size_t size))
    {
        // Buffer not intitialized so
        // handle the error
    }

// Okay to use the buffer
}
```

ring_add()

Description: Adds a byte of data to the ring buffer.
Syntax: bool ring_add(ring_t *r, uint8_t data)
Parameters:
ring_t *r: A pointer to a ring_t structure.
Data: An eight-bit byte of data to add to the buffer.
Returns: Boolean true if the byte was added; false otherwise.
Example:

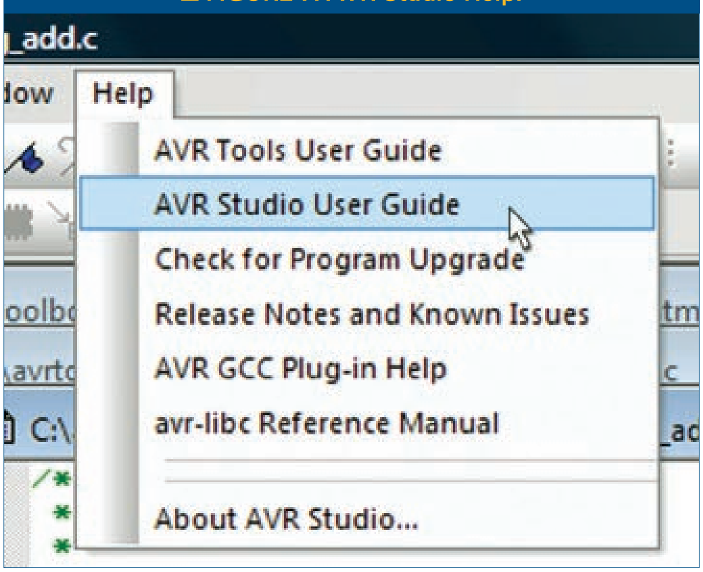
```
// receive_ring structure defined elsewhere
bool put_byte(uint8_t b)
{
    return(ring_add(&receive_ring, b));
}
```

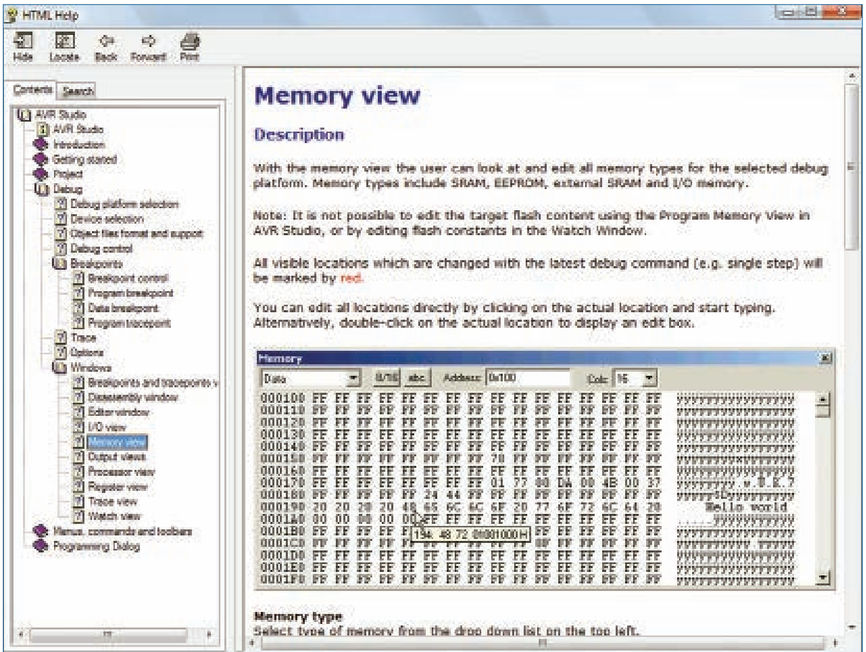
ring_remove()

Description: Removes a byte of data from the ring buffer.
Syntax: uint8_t ring_remove(ring_t *r))
Parameters:
ring_t *r: A pointer to a ring_t structure.
Returns: The byte of data removed.
Example:

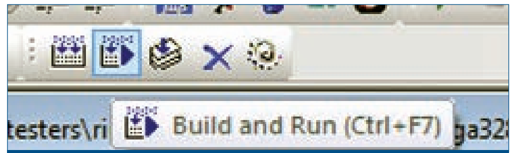
```
// receive_ring structure defined elsewhere
uint8_t get_byte()
{
    return(ring_remove(&receive_ring));
}
```

■ FIGURE 7. AVR Studio Help.





■ FIGURE 8. Debug Help.



■ FIGURE 9. Build and Run.

ring_peek()
Description: Reads uint8_t count bytes from the ring buffer into a new buffer provided as a parameter without removing any of the values read from the ring buffer. It returns the number of bytes read.
Syntax: uint8_t ring_peek(ring_t *r, uint8_t *buf, uint8_t count)
Parameters:
ring_t *r: A pointer to a ring_t structure.
uint8_t *buff: A pointer to a buffer to hold the data.
uint8_t count: The number of bytes to load from the ring buffer to buf.
Returns: The actual number of bytes read.
Example:

```
// receive_ring structure defined elsewhere
uint8_t get_bytes(uint8_t *buf, uint8_t
count)
{
    return(ring_peek(&receive_ring, buf,
    count));
}
```

ring_clear()
Description: Sets all data in the buffer to 0 and sets the Head and Tail indexes to 0.
Syntax: bool ring_clear(ring_t *r)
Parameters: ring_t *r : a pointer to a ring_t structure.
Returns: True if successful; false otherwise.
Example:

```
void end_this()
{
    ring_clear(&receive_ring);
}
```

Using AVR Studio Simulator

The AVR Studio Simulator is really great for testing how programs use the AVR memory, but it can be a bit of a pain to use at times. So, if you aren't already familiar with it, open the AVR Studio Help as shown in **Figure 7** and then in the HTML Help file open the Debug section and play around in it as shown in **Figure 8**.

We will mostly be using the Memory View and the Watch View, so read these sections before doing the testing. I found the Simulator to be a bit arcane and balky at times, but with persistence I was able to run all the memory tests in the Ring Buffer Tester. Note that in the following tests you must set the Project Options Optimization to -O0 meaning no optimization since the compiler will look at this code and think that some bits are stupid and remove them. They are stupid, but they are also needed for testing. So, kill the optimizer AND DON'T FORGET to reset the optimization to -Os before compiling any code that you intend to use on a real AVR. Note also that the memory window may not be set to show data when you open it. If anything I do in the tests isn't entirely clear, I suggest you read the help file. If that doesn't help, then put on your waders and ask a question on **www.avrfreaks.net** using 'Smiley's Workshop' in the title so I might see it.

Testing the Ring Buffer Library

Test 1

We will start out with a simple test just to show that we are initializing and setting the indexes and count correctly. Start with the following code:

```
#include "C:\avrtoolbox\libavr\source
\general\ring\ring.h"
#include "C:\avrtoolbox\libavr\source
\elementary\serial\serial.h"

#define BUFFER_SIZE 16

static uint8_t array1[BUFFER_SIZE];
static uint8_t array2[BUFFER_SIZE];
static uint8_t array3[BUFFER_SIZE];

int main(void)
{
```

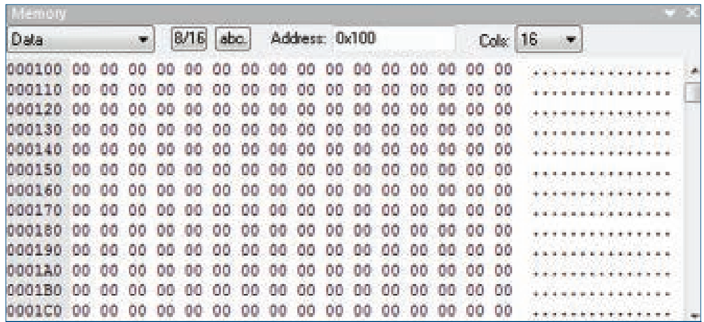
```
    // declare three ring buffer data structures
    ring_t ring1;
    ring_t ring2;
    ring_t ring3;

    // Create three ring buffers
    ring_init(&ring1, array1, BUFFER_SIZE);
    ring_init(&ring2, array2, BUFFER_SIZE);
    ring_init(&ring3, array3, BUFFER_SIZE);


    // Assign temporary variables so that we can
    // look at them in the Breakpoints and
    // Tracepoint window
    uint16_t volatile temp_head_index = 0;
    uint16_t volatile temp_tail_index = 0;
    uint8_t volatile temp_count = 0;


    // Test 1

    // Store six 0x01 bytes in ring 1
    for(uint8_t i = 0; i < 6; i++)
    {
           ring_add(&ring1, 0x01);
    }
    temp_head_index = ring1.head_index;
    temp_tail_index = ring1.tail_index;
    temp_count = ring1.count;

}
```

We declare three 16-byte arrays, then in the main() functions we declare three ring_t structures. We initialize these ring buffers with the ring_init() function. Next, we create three variables that we will use in our Watch window to observe the ring head_index, tail_index, and count parameters. Click on the 'Build and Run' button as shown in **Figure 9**. You will notice that the Memory window appears and has some bytes set to zero as shown in **Figure 10**. These are the locations we have reserved for our buffers.

You can find the starting location of each of the three arrays by putting your cursor on the array name in the code as shown in **Figure 11**.

We see that the arrays' start addresses are:

```
array1 - 0x0100
array2 - 0x0110
array3 - 0x0120
```



■ FIGURE 10. Initial Memory.

■ FIGURE 11. array1 size and location.

Place your cursor on the temp_head_index variable, click the right mouse button, and select 'Add Watch: "temp_head_index" as shown in **Figure 12**. Then add temp_tail_index and temp_count to the Watch window.

Place the cursor after the last line in the main function, then click on the 'Run to Cursor' button as shown in **Figure 13**.

We see in **Figure 14** that the six bytes beginning at 0x0100 (the start of array1) are changed to 0x01.

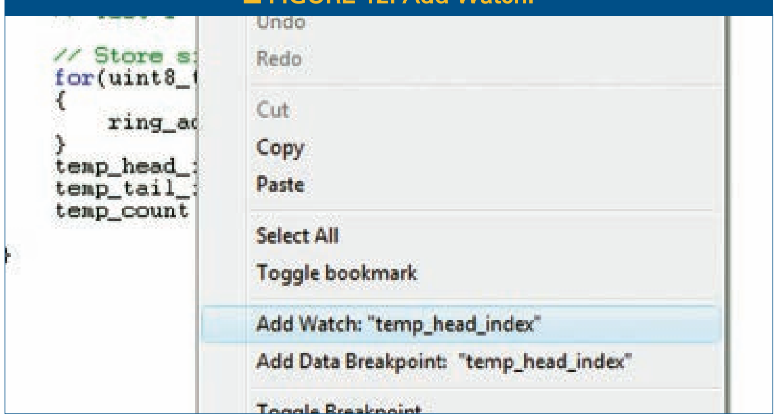
We then see in **Figure 15** that the Watch window variables have changed. The variable temp_head_index is 6, temp_tail_index is 0, and temp_count is 6 as we would expect. So, we have now validated that we can create and load one ring buffer.

Test 2

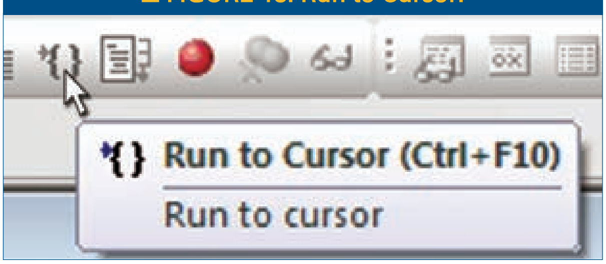
Next, we run the second test by adding the following code and repeating the preceding procedure:

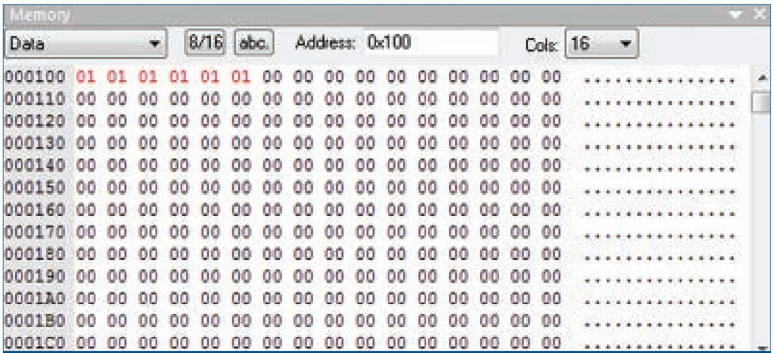
```
    // Test 2
    // First three bytes 'removed' to array3
    // Note that the value doesn't change
    // but the index does change
    for(uint8_t i = 0; i < 3; i++)
```

■ FIGURE 12. Add Watch.

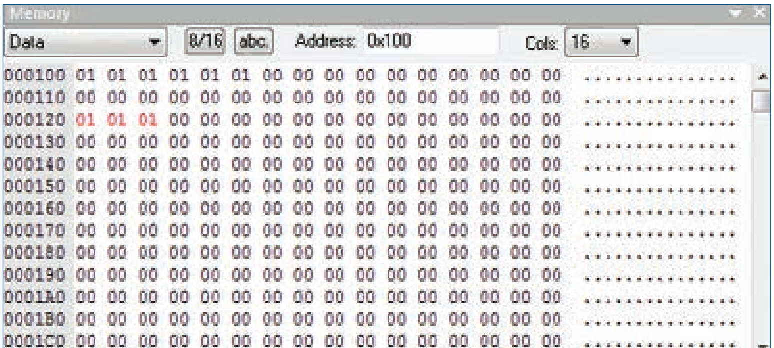


■ FIGURE 13. Run to Cursor.

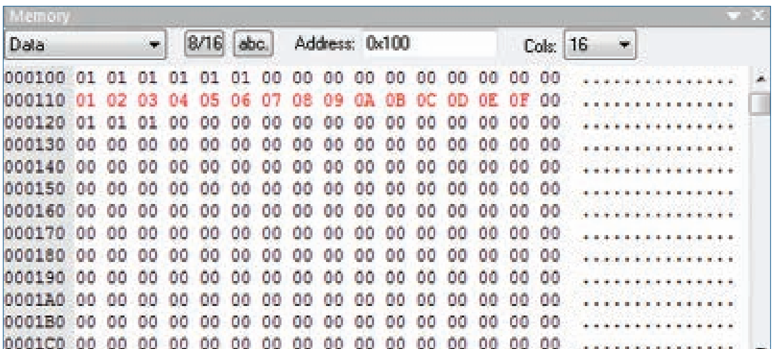




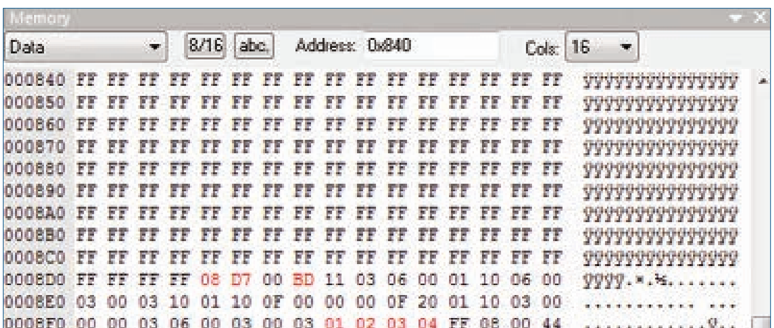
■ FIGURE 14. Test 1 puts 6 0x01 in array1.



■ FIGURE 16. Test 2 Memory.

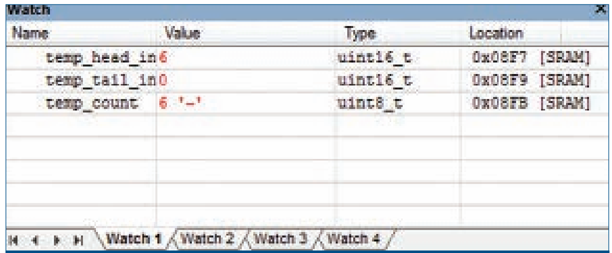


■ FIGURE 19. Test 3 Part 1.

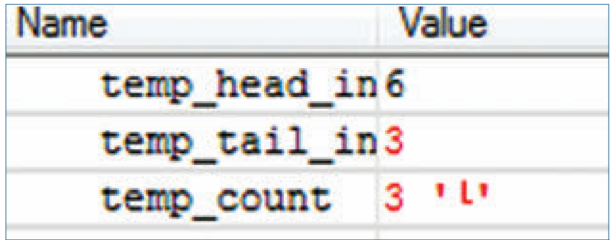


■ FIGURE 20. Test 3 Part 2.

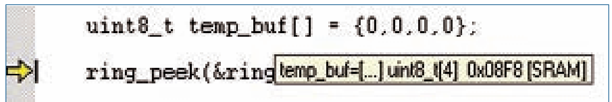
```
{
   ring_add(&ring3, ring_remove(&ring1));
}
temp_head_index = ring1.head_index;
temp_tail_index = ring1.tail_index;
temp_count = ring1.count;
```



■ FIGURE 15. Test 1 changes Watch variables.



■ FIGURE 17. Test 2 Watch.



■ FIGURE 18. temp_buf location.

In **Figure 16**, we see that the three bytes have been copied from the first array to the third one located at hex 120. Note also that even though those three bytes were 'removed' from the first array, they are still present. This is because only the indexes and counts are changed and the actual data isn't cleared.

Figure 17 shows the Watch window that now shows that the Head index is still 6, but now the Tail index is 3 since three bytes have been removed; the count is three which is how many bytes remain in the buffer.

Hey, this is looking like that weird pearl lecture at the beginning of this article, cool ...

Test 3

Let's test the ring_peek() function by filling the ring2 buffer with a sequence of 16 bytes (0x01 to 0x10), then read the eighth and nineth bytes to see if they really are 0x08 and 0x09:

```
// Test 3
// Fill ring2 with sequence of 16 bytes
// 0x01 to 0x10 and then read the 8th and
// 9th bytes to see if they really are
// 0x08 and 0x09
for(uint8_t i = 1; i <= 16; i++)
{
      ring_add(&ring2, i);
}
uint8_t temp_buf[2];
uint8_t temp_count;

ring_peek(&ring2, temp_buf, temp_count)
```

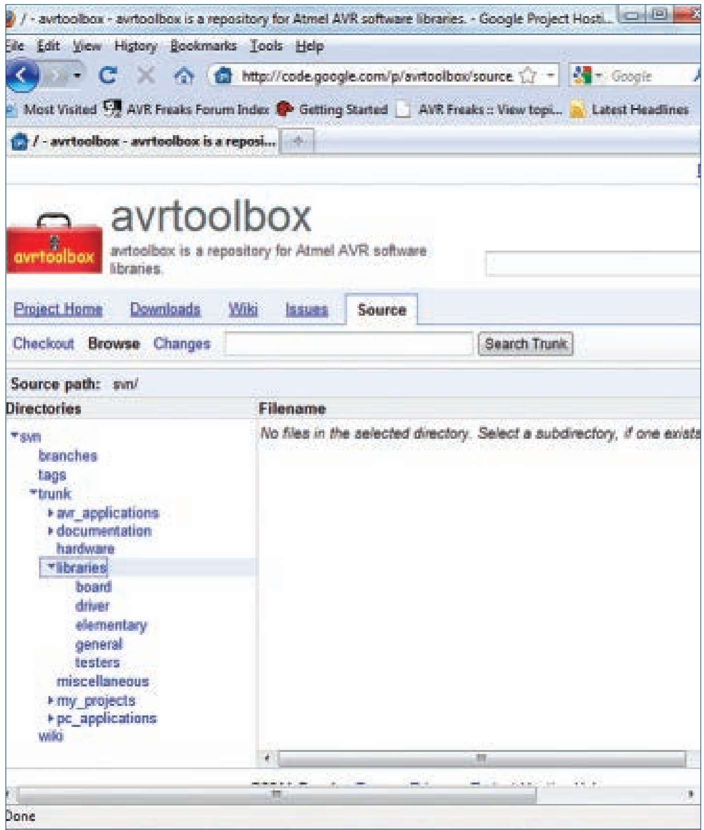
Placing your cursor over temp_buf as shown in **Figure 18** reveals that it is located at 0x08F8 in the SRAM — note, however, that it may be located somewhere else when you do this experiment.

Figure 19 shows the sequential bytes written in the second array; **Figure 20** shows the results of the ring_peek() that loaded the values of the first four into our temporary buffer that begins at 8F8.

And Then ...

We have a bunch more tests to run but no more space to show them. I think that if you got this far in the article, you won't mind finishing the testing without any more training wheels. I'm also sure at some point during all this testing you will scream "IS THIS REALLY NECESSARY!!!" And the answer I'd screamed back atcha is "OF COURSE NOT! YOU CAN TEST THESE FUNCTIONS WHILE DEBUGGING SOME CODE THAT IS ON A TIGHT DEADLINE MONTHS AFTER YOU'VE CREATED THE LIBRARY AND FORGOT HOW IT WORKED!!!" Or, in lowercase, "Nobody said software engineering was easy."

Since last we looked at avrtoolbox, I've redone the directory structure as shown in **Figure 21**. Now, the top directory is libavr followed by four sub-directories: doc, librarian, source, and testers. The libraries are kept in the librarian directory, one for each of our test platforms (Butterfly, Atmega328 {Arduino board [not IDE]}, and the Atmega644 {BeAVR}).



■ FIGURE 21. avrtoolbox.

The testers directory has sub-directories for each module; in this case, 'ring' and the code is written so that it references the libraries and header files as they are in the libavr directory tree. Yeah, it is a little complicated at first, but it seems to me the most logical way to keep all this in one place, so I'm sticking with it for a while.

If after all this good stuff, you just can't wait and want to get a leg up on real C programming and the AVR (while helping support your favorite magazine and technical writer), then buy my C Programming book and Butterfly projects kit from the *Nuts & Volts* website at **www.nutsvolts.com**.

Next month, if all goes well, we will continue with avrtoolbox using what we have learned about the ring buffer to apply it to creating an AVR USART library. **NV**

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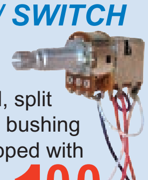

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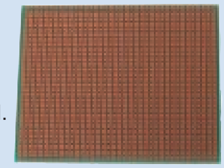

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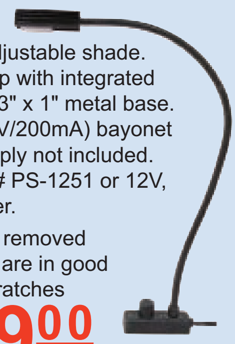

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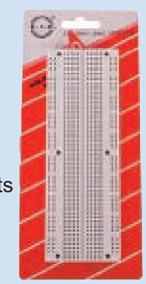

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The circuit in this experiment can act like an automatic security system. When the room gets dark, the LEDs light up.

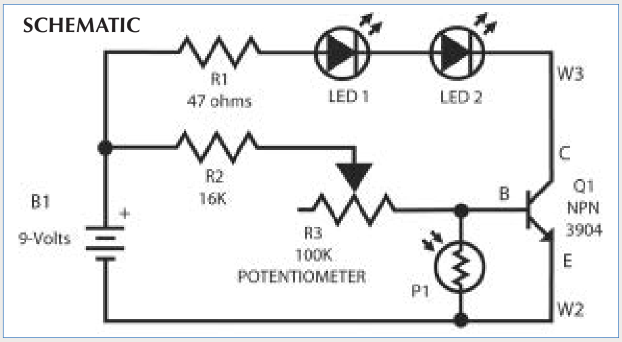
1. Build the Circuit.

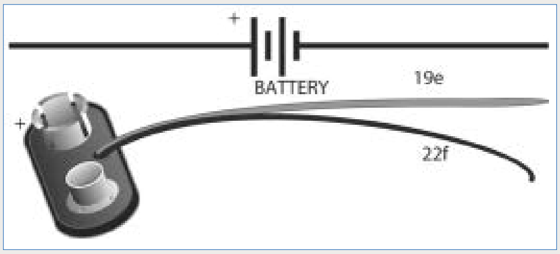
Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

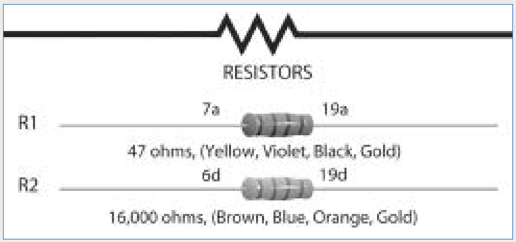
2. Do the Experiment.

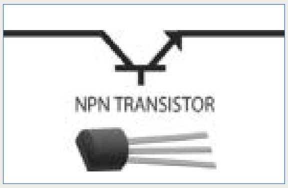
Theory: The photocell is in parallel with the base/emitter circuit of the transistor. Because the photocell and transistor act like two resistors in parallel, the amount of current through the transistor depends on the resistance of the photocell. The higher the resistance in the photocell, the greater the current through the transistor. So, the more current passing through the transistor, the more current running through the LEDs. The more current in the LEDs, the brighter they shine.

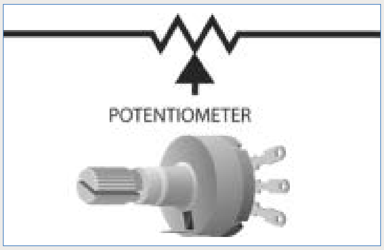
Procedure: Connect a nine-volt battery to the battery snap and observe the LEDs. This circuit causes the LEDs to be brightest during the night and dimmest during the day.

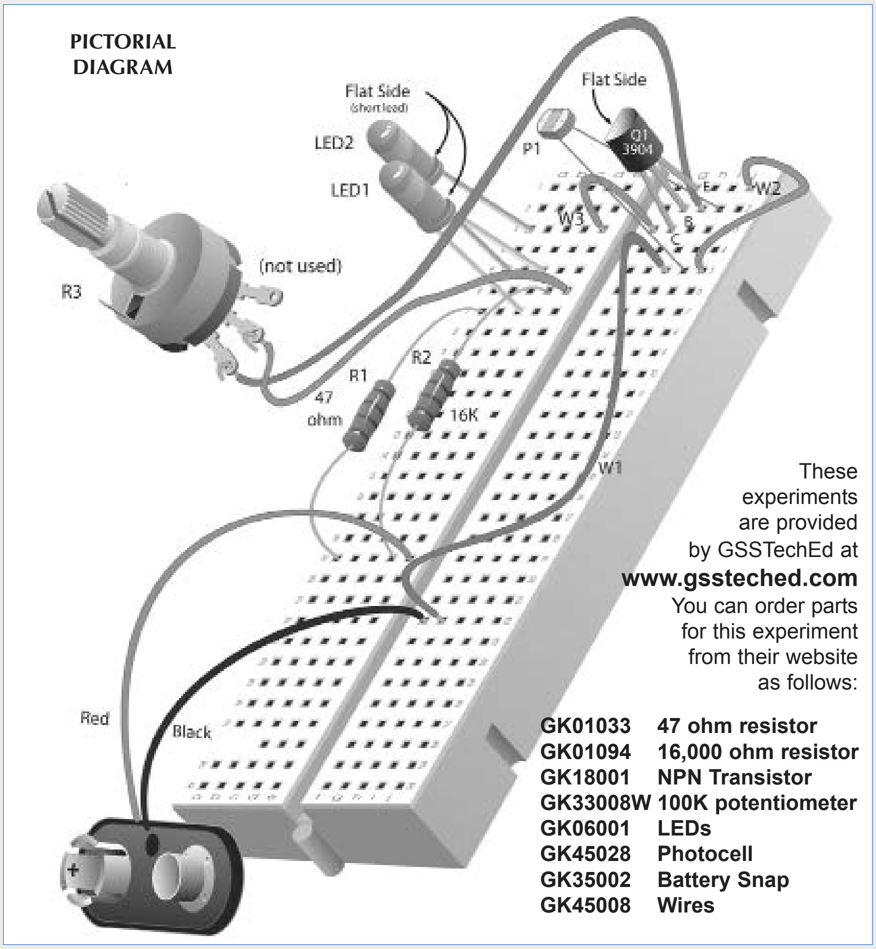






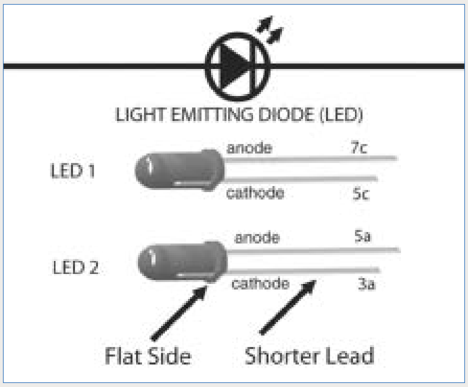


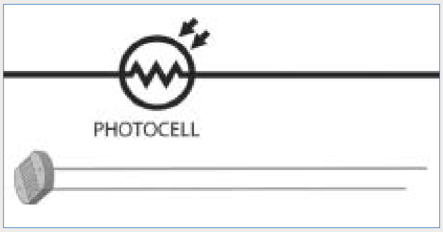


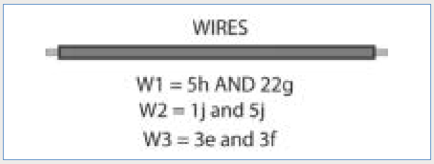


These experiments are provided by GSSTechEd at **www.gssteched.com** You can order parts for this experiment from their website as follows:

GK01033	47 ohm resistor
GK01094	16,000 ohm resistor
GK18001	NPN Transistor
GK33008W	100K potentiometer
GK06001	LEDs
GK45028	Photocell
GK35002	Battery Snap
GK45008	Wires







■ BY L. PAUL VERHAGE

PROGRAMMING THE NEARSPACE ULTRALIGHT

This month, we cover the programming of the UltraLight's Tiny Trak: the APRS system responsible for transmitting regular position reports of the near spacecraft. Unlike the PICAXE-28 (which you program for each mission), you program the Tiny Trak's parameters just once. These parameters — set by the Tiny Trak Configuration Editor — describe what position data the Tiny Trak is to transmit and how often.

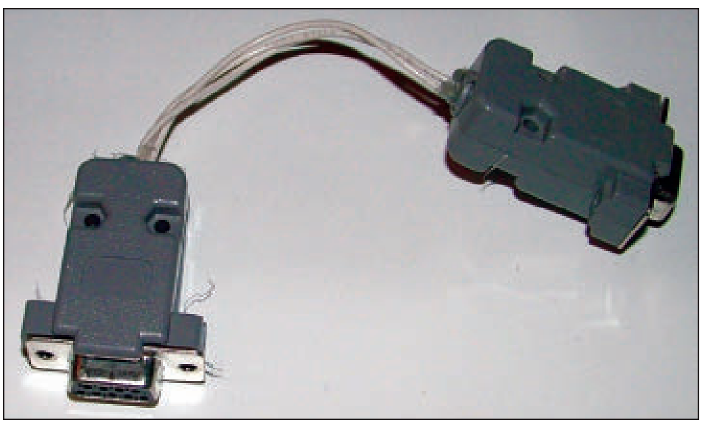
The Tiny Trak 3 used in the NearSpace UltraLight is an inexpensive Automatic Packet Reporting System (APRS) transmitter. It receives input from an attached GPS receiver and reformats the data into position reports that it sends through amateur radio. The position reports are essentially serial data transmitted as a series of two tones: 1,200 and 2,200 Hz. Over the radio, they sound like short bursts of scratchy noise. The two GPS sentences used as input to the Tiny Trak are the GPS receiver's GGA and RMC sentences. The position report transmitted by the Tiny Trak therefore includes the time, latitude, longitude, altitude, speed, and heading.

Byon Garrabrant N6BG developed the Byonics Tiny Trak 3 as a simple-to-use APRS tracker that's perfect for high altitude balloons. Unlike many APRS trackers, this one does not receive and decode APRS data; it only transmits position reports. Parameters loaded into the Tiny Trak by Byonic's free Tiny Trak 3 Configuration Editor describe to the tracker how it is to report its position and under what conditions. These parameter settings are stored in EEPROM so the Tiny Trak is ready to transmit position reports upon powering up. Therefore, before going any further, your first step is to download the Tiny Trak Configuration software from **www.byonics.com** and install it on your PC.

For your next step, you need to make a three-wire programming cable. This cable swaps pins 2 and 3 between two female DB-9 connectors and leaves pin 5 connected between both DB-9s. Since this cable is needed just once to program the Tiny Trak, don't go to elaborate lengths to make it; unless, of course, you plan to program several flight computers or change the settings of the Tiny Trak each time you fly a mission (**Figure 1**).

Now you're ready to program the Tiny Trak. Whenever you program the Tiny Trak, remove the transmitter from the UltraLight because we don't want the Tiny Trak transmitting without an antenna. In fact, **never** power-up the UltraLight before removing the transmitter or attaching an antenna. Letting the radio transmit when no antenna is attached is a sure way to damage the radio. When the Tiny Trak 3 Configuration Editor starts, the screen looks like **Figure 2**, sans the red circles and letters.

First, note that there are two tabs in the Editor: Primary and Secondary. These two tabs permit the Tiny Trak to operate under two different settings during a single near space mission. The Tiny Trak settings under the Primary tab are in effect while the PICAXE-28X output pin 5 is low; the Secondary settings are in effect when the



■ FIGURE 1. Since I make a lot of near space flight computers, I built this durable Tiny Trak programming cable. Its durability comes from the fact that the hollow space inside of each DB-9 jacket is filled with hot glue. Note that there are only three wires between the two female DB-9 connectors. Pin 2 of one DB-9 connects to pin 3 of the other DB-9 and pin 5 in each DB-9 connects together.

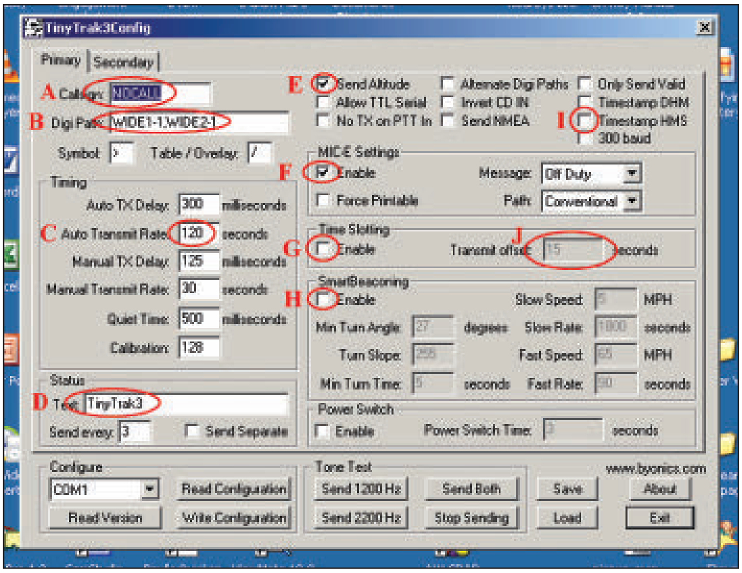


FIGURE 2. The Tiny Trak 3 Configuration Editor screen. The circled fields are the ones you will set for your UltraLight.

PICAXE's output pin 5 is high. An example of where you might want to implement Primary and Secondary settings is on ascent and descent. Since the descent takes place over a shorter length of time and is critical for the successful recovery of the near spacecraft, my UltraLight transmits position reports more frequently on descent than it does on ascent (once every 30 seconds as opposed to once every 60 seconds).

Now a word about APRS settings in near space applications. A near spacecraft at 100,000 feet sees a horizon roughly 400 miles away. Even though the Tiny Trak only has a 500 mW transmitter, that's still enough transmitting power to communicate with every APRS station within that 400 mile radius. Unlike a ground-based APRS station that has a much more limited horizon, a near spacecraft can swamp the APRS network if bad APRS parameters are set. Please consult you local amateur radio club to see what setting they recommend for your UltraLight flight computer. In this article, I'll recommend what should be good settings, but it still pays to double-check. Now, let's step through the circled fields in the Configuration Editor and explain what their settings should be for the UltraLight flight computer.

A. Callsign. In this field, enter the callsign assigned to you by the FCC after successfully passing your amateur radio test. Unlike other forms of amateur radio communication, APRS allows multiple stations to use the same callsign. Each station is still identified as a unique station because of the SSID attached to the callsign. SSIDs are numbers ranging from 0 to 15 that append to the end of the callsign. A dash (-) is used to separate the callsign from its SSID like this: KD4STH-11. Usually, "dash eleven" is the SSID given to high altitude balloons. If you have more than one UltraLight flight computer flying at the same time, then make sure each one has a different SSID (which can be different than -11). And don't forget, the SSID must also be different from the SSID for your chase vehicle.

B. Digi Path. This field tells ground stations how many times they are permitted to repeat position reports from the UltraLight. In the amateur radio community, we say this is the number of hops permitted for each position report. The digi-path is where you need to exercise some restraint. Retransmitting a single position report just barely received by a single APRS station makes sure everyone in the network is aware of your position. The problem occurs when lots of APRS stations receive your position report and the stations are permitted to retransmitt the reports lots of times.

This massive repeat can swamp the APRS network with multiple copies of a single position report. It gets worse when a high altitude near spacecraft transmits its position reports frequently. So, please consult with amateur radio operators in your neck of the woods to determine a good setting, but a setting of WIDE2-1 is probably fine. It will allow each UltraLight position report to be repeated twice.

C. Auto Transmit Rate. This field indicates how frequently the Tiny Trak will send position reports. The default is once every two minutes (120 seconds). I recommend changing this field to 60 seconds under the Primary tab. I believe a case can be made for more frequent auto transmit rates in the Secondary tab, perhaps once every 30 seconds if the Secondary settings are used during descent. A more frequent auto transmit rate is helpful to the recovery crew when the near spacecraft lands in a region without a lot of APRS stations to repeat its position reports. In that case, chase crews can only rely on direct reception of position reports by the UltraLight as they drive around. If the UltraLight transmits more frequently after landing, then recovery crews will most likely receive one of these reports and locate the near spacecraft.

D. Status Text. The text entered in this field is appended to the end of some position reports. How frequently the text is included in a transmission is indicated in the **Send Every** field. The status text is typically a short informative message about the flight computer or the mission — like their names. This field is one you might want to change on every mission.

E. Send Altitude. Make sure to check this box. The altitude is one of the most important fields in a position report of a near spacecraft.

F. MIC-E Settings Enabled. Uncheck this field. MIC-E is a way of appending digital position reports to the end of every audio transmission. The Tiny Trak on the UltraLight is not part of a handheld radio, so MIC-E is unnecessary.

G. Time Slotting Enable. Time slotting controls how many seconds after the minute that the UltraLight transmits its position report. You can check this box if you would like, however, you should check it if several near space flight computers are being launched together. By using time slotting, each near spacecraft's transmission occurs after different times so there is no collision between position reports. How long after each minute the position report is transmitted is indicated in field J.

H. Smart Beaconing Enable. Do not check this field. Smart beaconing is a way of reducing radio traffic by not transmitting as frequently when the APRS station is not changing its speed or heading. Chase crews need near spacecraft position reports reported at regular and dependable intervals, regardless of how the balloon is drifting. The regular position reports are also data from your mission.

I. Time Stamp HMS. When checked, Tiny Trak position reports contain a time stamp in the format of hours, minutes, and seconds. The alternative, days, hours, and minutes (DHM) is not useful, as a lot will happen to the near spacecraft over timespans of seconds. In addition, a typical near space mission spans a few hours at most. Including the day and not seconds in a position report is pointless.

J. Transmit Offset. If **Time Slotting** is enabled, this field indicates how many seconds after the minute position reports are transmitted. Set this field to a time that does not conflict with the time slotting of other flight computers.

TINY TRAK POSITION REPORTS

Here's what the position reports from the Tiny Trak look like. I downloaded this from **http://APRS.fi** as raw data.

```
KD4STH-12>APT311,WIDE2-1,qAR,K0KU:/
114933h3857.47N/09515.28W>289/000/A=000977

KD4STH-12>APT311,WIDE2-1,qAR,K0KU:/
115033h3857.48N/09515.28W>289/000/A=001000/
NearSys UltraLight Ascent
```

About half of each position report is not useful to us. What is useful begins after the colon-slash (:/). Each position report after the :/ follows this format:

time (UTC), h, latitude, N/, longitude, W>, heading (true north), /, speed (knots), /A=, altitude (feet), /, optional message.

SOME NOTES

Time is given in hours, minutes, and seconds with a colon separation.

Latitude and longitude are in degrees and minutes, without a separator between the degrees and minutes.

To convert knots (nautical miles per hour) into miles per hour, mutiply by 1.15.

That completes the programming of the Tiny Trak. The next column will briefly describe the programming of the PICAXE microcontroller and a suitable antenna design. Until then, try out the Tiny Trak 3 Configuration Editor.

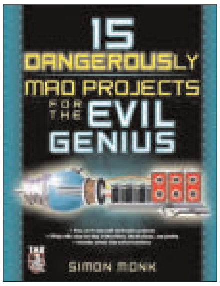
Onwards and Upwards,
Your near space guide **NV**

ELECTRONICS

15 Dangerously Mad Projects for the Evil Genius
by Simon Monk

NEW!

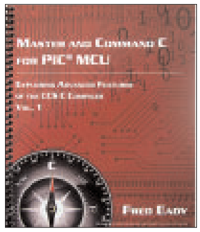
UNLEASH YOUR INNER MAD SCIENTIST!



This wickedly inventive guide explains how to design and build 15 fiendishly fun electronics projects. Filled with photos and illustrations, *15 Dangerously Mad Projects for the Evil Genius* includes step-by-step directions, as well as a construction primer for those who are new to electronics projects

$24.95

Master and Command C for PIC MCUs
by Fred Eady

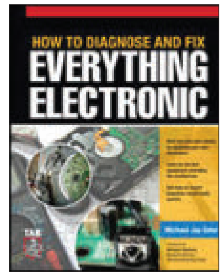


Master and Command C for PIC MCU, Volume 1 aims to help readers get the most out of the Custom Computer Services (CCS) C compiler for PIC microcontrollers. The author describes some basic compiler operations that will help programmers — particularly those new to the craft — create solid code that lends itself to easy debugging and testing. As Eady notes in his preface, a single built-in CCS compiler call (output_bit) can serve as a basic aid to let programmers know about the "health" of their PIC code.

$14.95

How to Diagnose and Fix Everything Electronic
by Michael Jay Geier

Master the Art of Electronics Repair!



In this hands-on guide, a lifelong electronics repair guru shares his tested techniques and invaluable insights. *How to Diagnose and Fix Everything Electronic* shows you how to repair and extend the life of all kinds of solid-state devices, from modern digital gadgetry to cherished analog products of yesteryear.

About the Author

Michael Jay Geier began operating a neighborhood electronics repair service at age eight that was profiled in *The Miami News*.

$24.95

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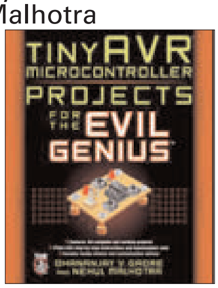
tinyAVR Microcontroller Projects for the Evil Genius
by Dhananjay Gadre and Nehul Malhotra

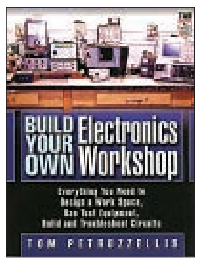


Using easy-to-find components and equipment, this hands-on guide helps you build a solid foundation in electronics and embedded programming while accomplishing useful — and slightly twisted — projects. Most of the projects have fascinating visual appeal in the form of large LED-based displays, and others feature a voice playback mechanism. Full source code and circuit files for each project are available for download.

$24.95

Build Your Own Electronics Workshop
by Thomas Petruzzellis

BUILD YOUR OWN DREAM ELECTRONICS LAB!



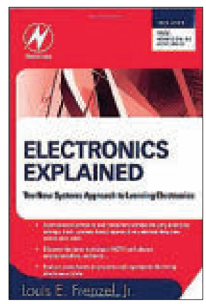
This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action -- building, testing, and troubleshooting systems. This great book has it all! And the best part is, it shows you how to build many pieces of equipment yourself and save money, big time!

Reg Price $29.95

Sale Price $24.95

Electronics Explained
by Louis Frenzel

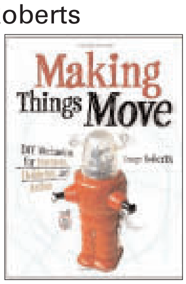
The New Systems Approach to Learning Electronics



Don't spend time reading about theory, components, and old ham radios - that's history! Industry veteran, Louis Frenzel, gives you the real scoop on electronic product fundamentals as they are today. Rather than tearing electronics apart and looking at every little piece, the author takes a systems-level view. For example, you will not learn how to make a circuit but how a signal flows from one integrated circuit (IC) to the next, and so on to the ultimate goal.

$29.95

Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists
by Dustyn Roberts

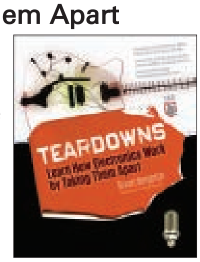


In *Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists*, you'll learn how to successfully build moving mechanisms through non-technical explanations, examples, and do-it-yourself projects — from kinetic art installations to creative toys to energy-harvesting devices. Photographs, illustrations, screenshots, and images of 3D models are included for each project.

$29.95*

TEARDOWNS
by Bryan Bergeron

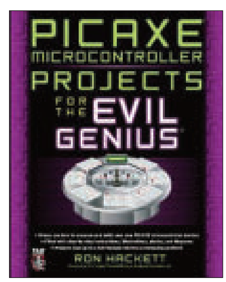
Learn How Electronics Work by Taking Them Apart



Amp up your knowledge of electronics by deconstructing common devices and analyzing the revealed components and circuitry. *Teardowns: Learn How Electronics Work by Taking Them Apart* contains 14 projects that expose the inner workings of household appliances, workbench measuring instruments, and musical equipment. Discover how resistors, capacitors, sensors, transducers, and transistors function in real circuitry.

Reg $24.95 **Sale Price $21.95**

PICAXE Microcontroller Projects for the Evil Genius
by Ron Hackett

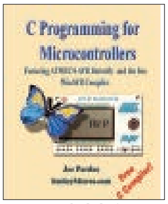


This wickedly inventive guide shows you how to program, build, and debug a variety of PICAXE microcontroller projects. *PICAXE Microcontroller Projects for the Evil Genius* gets you started with programming and I/O interfacing right away, and then shows you how to develop a master processor circuit.

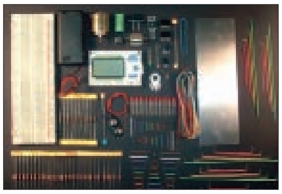
$24.95

Order online @ www.nutsvolts.com
Or CALL 1-800-783-4624 today!

BOOK & KIT COMBOS



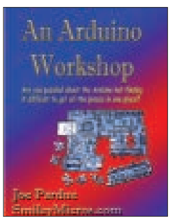
From the
Smiley Workshop
C Programming for
Microcontrollers
by Joe Pardue



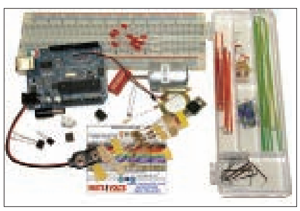
Book **$44.95** Kit **$66.95**

Do you want a low cost way to learn C programming for microcontrollers? This 300 page book and software CD show you how to use ATMEL's AVR Butterfly board and the FREE WinAVR C compiler to make a very inexpensive system for using C to develop microcontroller projects.

Combo Price $99.95 Plus S/H



From the
Smiley Workshop
An Arduino
Workshop
by Joe Pardue

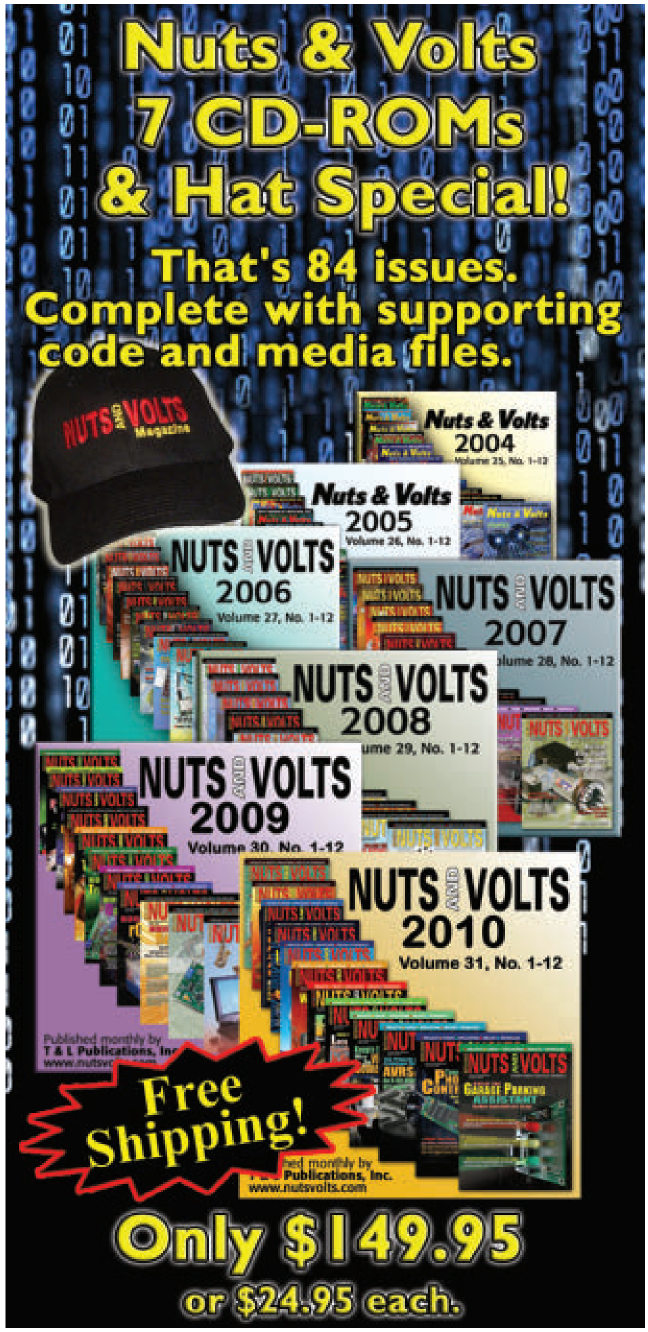


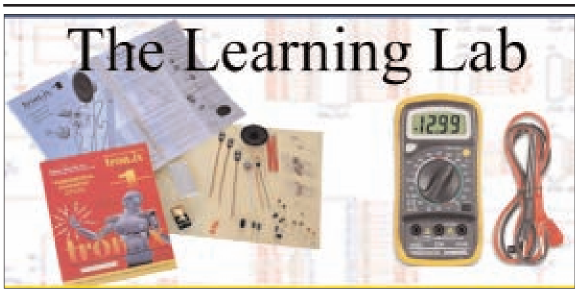
The book *An Arduino Workshop* and the associated hardware projects kit bring all the pieces of the puzzle together in one place. With this, you will learn to: blink eight LEDs (Cylon Eyes); read a pushbutton and 8-bit DIP switch; sense voltage, light, and temperature; make music on a piezo element; sense edges and gray levels; optically isolate voltages; fade an LED with PWM; control motor speed; and more!

An Arduino Workshop Combo

Reg Price $ 124.95 **Subscriber's Price $119.95 Plus S/H**

CD-ROM SPECIALS





This lab — from the good people at GSS Tech Ed — will show you 40 of the most simple and interesting experiments and lessons you have ever seen on a solderless circuit board. As you do each experiment, you learn how basic components work in a circuit. Along with the purchase of the lab, you will receive a special password to access the fantastic online interactive software to help you fully understand all the electronic principles. For a complete product description and sample software, please visit our webstore.

Reg Price $79.95 **Subscriber's Price $75.95**

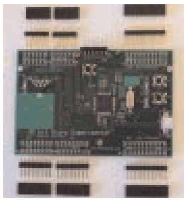
This great little book is a concise all-purpose reference featuring hundreds of tables, maps, formulas, constants, and conversions. AND it still fits in your shirt pocket!

CALL 1-800-783-4624 today!

Or Order online @ www.nutsvolts.com

PROJECTS

32-Bit Micro Experimenter Board



The new 32-Bit Micro Experimenter is the fastest way to learn 32-bit microcontrollers.

The kit includes onboard 46 programmable I/O and USB, free software, carefully documented step-by-step experiments for USB, embedded web server, graphics & audio, wireless, RTOS, and file I/O. User pushbuttons, LEDs, and 32 kHz clock crystal. Can be used in solderless breadboard environment or stand-alone. Also supports Arduino compatible interface.

Subscriber's Price **$89.95**

Non-Subscriber's Price **$93.95**

Piezoelectric Film Speaker Kit

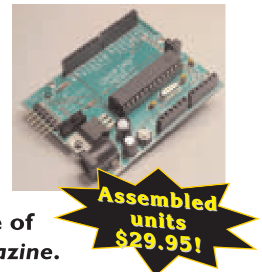
As seen in the November 2010 issue, here is a great project to amaze your friends and to demonstrate a unique way of producing sound. Kit contains one piece of piezoelectric film, speaker film stand, PCB, components, audio input cable, and construction manual. All you'll need to add is a battery and a sound source. For more info, please visit our website.

Subscriber's Price **$69.95**

Non-Subscriber's Price **$74.95**

CHIPINO Kit

The CHIPINO module is an electronic prototyping platform that is used in a series of articles starting with the March 2011 issue of *Nuts & Volts Magazine.*



Developed by the CHIPAXE Team as a bridge between PICs and Arduinos. The module was designed specifically to match the board outline, mounting holes, connector spacing, and most of the microcontroller I/O functions found on the popular Arduino module.

Subscriber's Price **$18.95**

Non-Subscriber's Price **$19.95**

128x64 Graphic Display Kit

New application for the 16-Bit Micro Experimenter

LCD displays ... they have been around for quite some time, but what if you could have both characters, as well as graphic displays at the same time? With this kit, we will show you how easy and inexpensive this technology can be using the 16-Bit Micro Experimenter.

Sale Price $29.95

Mini-Bench Supply Complete Kit

A small power supply with +5V, +12V, and -12V outputs is a handy thing to have around when you're breadboarding circuits with both op-amps and digital ICs.

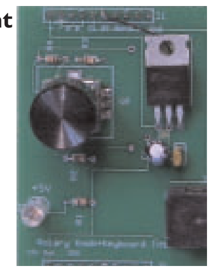
Kit includes: Enclosure box, accessories, DC-to-DC converter kit, switching regulator kit, and article reprint. For more information, please see the "feature article section" on the of the *Nuts & Volts* website.

Subscriber's Price **$76.95**

Non-Subscriber's Price **$83.95**

The Mini Kit

The best experiment yet for the 16-Bit Experimenter Board.



Adding this Mini Kit to your Experimenter Board will enhance the Experimenter. The Mini Kit is a user interface with a rotary encoder using the PIC24F timer peripheral set and its interrupt capability. For more information, see the December 2010 issue. Assembled units also available.

Subscriber's Price **$36.95**

Non-Subscriber's Price **$39.95**

16-Bit Experimenter Handbook

From the series of articles by Tom Kibalo, The Complete 16-Bit Experimenter Handbook on CD-ROM!

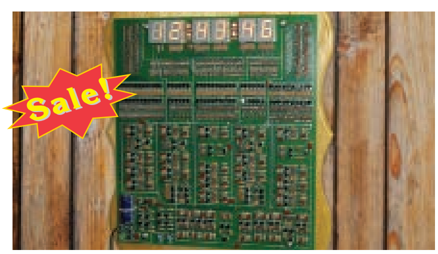
This CD-ROM handbook contains: 200 pages of detailed instructions and 41 experiments with 'C' software examples. Also includes the experiments for the dsPIC33.

For a complete list of kits and combos, please visit our webstore.

Subscriber's Price **$64.95**

Non-Subscriber's Price **$69.95**

Transistor Clock Kit



If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

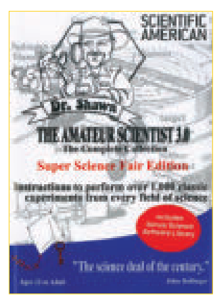
Reg $225.95

Sale Price $199.95

PCBs can be bought separately.

The Amateur Scientist 4.0 The Complete Collection

by Bright Science, LLC



There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of your friends busy for a lifetime!

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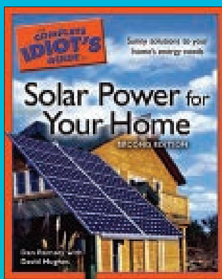
ALTERNATIVE ENERGY SECTION

The Complete Idiot's Guide to Solar Power for Your Home
by Dan Ramsey / David Hughes



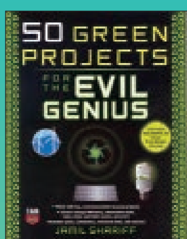
The perfect source for solar power — fully illustrated. This book helps readers understand the basics of solar power and other renewable energy sources, explore whether solar power makes sense for them, what their options are, and what's involved with installing various on- and off-grid systems.
$19.95

Green Lighting
by Brian Clark Howard, Seth Leitman, William Brinsky

Flip the switch to energy-efficient lighting!

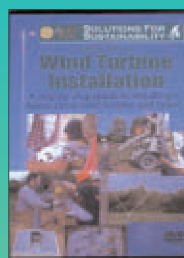
This do-it-yourself guide makes it easy to upgrade residential and commercial lighting to reduce costs and environmental impact while maintaining or even improving the quality of the lighting. Filled with step-by-step instructions and methods for calculating return on investment, plus recommended sources for energy-efficient products.
$24.95

50 Green Projects for the Evil Genius
by Jamil Shariff



Using easy-to-find parts and tools, this do-it-yourself guide offers a wide variety of environmentally focused projects you can accomplish on your own. Topics covered include transportation, alternative fuels, solar, wind, and hydro power, home insulation, construction, and more. The projects in this unique guide range from easy to more complex and are designed to optimize your time and simplify your life!
$24.95

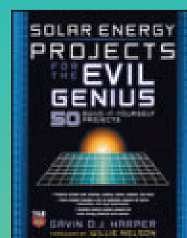
Wind Turbine Installation DVD



Manuals can be confusing, especially for people who learn by seeing how things work. So, this DVD takes the viewer step-by-step through the entire installation process, from choosing a site, to running wire, assembling the tower, and finally using a winch for the final lift. This is a must-watch for anyone planning on installing a wind turbine who wants to learn the process and the proper techniques for a safe and successful installation.

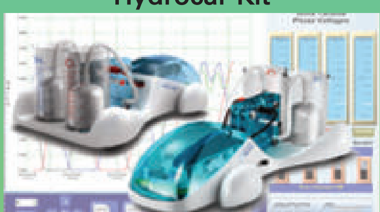
$19.95*

Solar Energy Projects for the Evil Genius
by Gavin D J Harper



Let the sun shine on your evil side — and have a wicked amount of fun on your way to becoming a solar energy master! In *Solar Energy Projects for the Evil Genius*, high-tech guru Gavin Harper gives you everything you need to build more than 30 thrilling solar energy projects. You'll find complete, easy-to-follow plans, with clear diagrams and schematics, so you know exactly what's involved before you begin. **$24.95**

Hydrocar Kit



The Hydrocar is used in a couple of great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 10 and 11, he teaches you the operation of the Polymer Electrolyte Membrane "reversible" fuel cell.
For kit details and a demo video, please visit our webstore.

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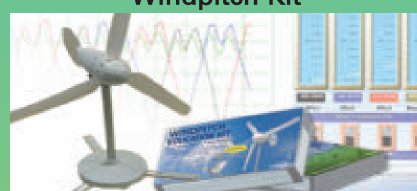
Windpitch Kit



The WindPitch Wind Turbine Kit is a miniature real-working wind turbine and is one of the great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 8 and 9, he teaches you how to produce the most power by evaluating the pitch (setting angle) of the profiled blades. For kit details, please visit our webstore.
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 Continued from page 51

suggested as that would best match the relatively high output impedance of the device; 32R ones would still be satisfactory, although a little less loud. Lower impedances such as 8R are probably best avoided.

Jonathan Berber

WITHOUT A TRACE

The bat detector article in the June '11 issue is a very interesting project; one that I might give a try. Two points/questions, though.

In Figure 5 (board layout), it looks like there should be a cut in the Vero board trace underneath capacitor C4. Also, there is no connection to the battery negative. There should be a connection between the trace in the lower left corner and the trace to its left.

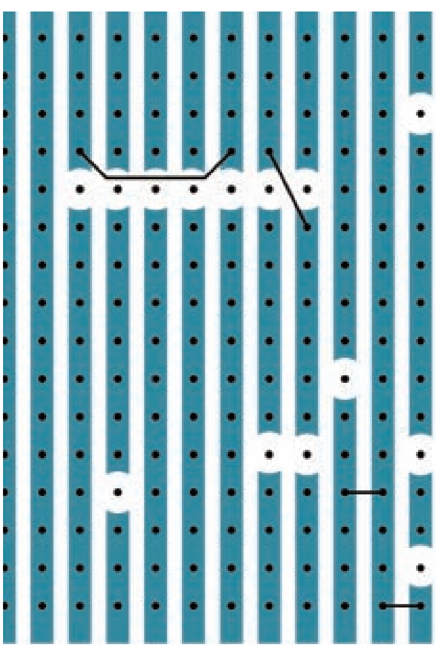
Jimmy 101

Response:

Michael is correct. There should be a link between the battery negative (black) wire in the lower left-hand corner and the adjacent trace.

The drawing here shows all of the track cuts, and just as importantly it also shows the four wire links that are required on the copper side of the board. Without these links the circuit will not, of course, work. (This file is available on the NV website.)

Jonathan Berber



GO FIGURE

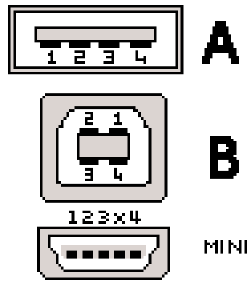


Figure 3 in my June '11 Q & A column does not show the pinout for the USB battery charger. I had two Figure 3s in the write-up, but only one in the list of figures. The missing Figure 3 is shown here.

Russ Kincaid

SOURCE MIA

Ron Hackett's PICAXE column for June was very interesting but lacked a source for the AXE401 shield base.

A search of the Internet at Revolution Education and their listed distributers gave no information. Can you help?

Allen Baker

Response:

I thought for sure I had given a specific reference for the AXE401 board, but I just re-read the column, and all I said was that it's available from Revolution Education. (Sorry about that!)

*You can find it by going to the PICAXE website (**www.rev-ed.co.uk/picaxe/**), clicking on the "Buy Online - Prices" link on the left edge of the page, entering the store, and choosing the PICAXE-28X2 Shield Base.*

*If you prefer, here's the direct link: **www.techsupplies.co.uk/PICAXE**.*

Ron Hackett

LOOSE IDEA

In making the breadboard shield from the June PICAXE column, instead of using loose straight pins with the acknowledged alignment headaches, why not just use the male headers Ron rejected (Ron installed them with the black plastic touching the board) and install them like you would the pins (wood block, etc.) with the black plastic floating at the end of the pins off the board, then snip off the "black plastic" after soldering? The pins are then essentially prealigned; the only source of misalignment being the "snipping" process.

Steve Bepko

Response:

I did consider that approach, but I was concerned that it might not hold up over time. On page 17 of the Primer article in the first column, see the paragraph that begins with "The simplest solution..." for the explanation of why I decided against it. I hope this information is helpful.

Ron Hackett

MISSED THE FUN

The FUNdamentals in the June issue has a serious mis-statement in the Theory section: "opening the normally closed switch S2, capacitor C1 will discharge." This is not correct. Opening S2 will have the same effect as closing S1 — it will charge C1 and apply a positive voltage to the gate of the SCR.

Also, with S1 open and S2 closed, there is no way that C1 can have a charge on it.

Larry Cicchinelli K3PTO

Response:

Larry is correct. Opening S2 will charge C1 through D1, applying voltage to the gate of the SCR.

Bryan Bergeron

DRIVES POINT HOME

Bryan Bergeron's April '11 column is spot-on, with excellent examples. I think the take-away can be boiled down to the presenter's rule (whether the presenter is making a presentation to an audience or providing a product): Who is the audience? Fellow Arduino hackers would never reverse a 9V battery ... but an eight year old?

As more and more complex DIY projects become "productized," we must heed this basic rule in everything we build.

Thanks for a great column.

Mike Peterson

TECHFORUM
READER-TO-READER

>>> QUESTIONS

Nine Sec Video

I want to extract nine seconds' worth of video from a disc, put it into a digital device and display it on a video screen. This will all be mounted on an award plaque. How can I do it very reasonably?

#7111 **Rich Monday**
Rincon, PR

Hacking A Driveway Alert System

I want to extend the range of a Bunker Hill driveway alert system (wireless) model 93068 (Harbor Freight) to a 1,000 feet, and install a relay (or other device) to turn on some flood lights (up to 1,500 watts) for day or night use. These units appear to be 6 and 9 VDC. I would like to extend the time to four to six hours. The existing time is about five seconds.

I also have a series 7120 motion sensor (Hampton Products International Corp.) from Foothill Ranch, CA. I would like to extend the on time to about 4-6 hours for day or night use; to turn on up to 1,500 watts of power. The existing time is only about 10 minutes. Both units could be reset manually if need be. As always, cost is the crucial factor.

#7112 **PK**
San Antonio, TX

Resistance Amplifier

I was wondering if someone knows how to design a circuit to measure resistance. I would like to jumper select the input range, run it through a zero and span circuit, and output a 0-10 VDC signal inversly proportional to the selected resistance range.

As the resistance goes down to the bottom of the range, the output would increase to the maximum (10 volts). As the resistance increases to the maximum of the range, the voltage on the output would go down to zero. As with all analog designs, linearity is important. I have seen circuit boards that do this. They have two eight-pin chips on them, two trimmers, and a small assortment of misc. parts. Simple is good.

Producing a suitable power supply for this circuit is the easy part, so I can come up with that on my own.

#7113 **Brian Prigge**
St. Cloud, MN

Energy For Future

Is nuclear energy the only available source for our future? Is there another source except solar?

#7114 **Rohit Shinde**
Kolhapur, Maharashtra

Circuit Design

I am looking for a simple circuit that would allow two CC cameras to be displayed on one monitor with a split screen. Cameras have composite outputs and the monitor has composite inputs. The circuit needs to be simple, produce a half and half split screen, and have just an on/off switch with no other controls.

#7115 **Dennis Brotman**
Pasadena, CA

Utility Meter Receiver

I need a receiver that can read the utility meters currently being used.

I should feature an RS-232 control so it could easily be used in connection with a micro data logger or a PC/MAC using a USB/RS-232 adapter.

Being able to see electricity and/or water usage on a daily basis would let people know which activities are causing high utility bills.

#7116 **Larry Dvorsky**
via email

>>> ANSWERS

[#5113 - May 2011]
Timing Circuit Needed

I need a resistor-capacitor-transistor timing circuit that is powered by 6 VDC, started with a momentary contact switch, and will pass a 4 to 5 VDC, less than 0.1A current for 30 seconds.

Look at page 70, May '11, Fundamentals. Use the 555 in MONOSTABLE mode. The connections change as follows: Move pin 6 to connect with pin 7. Use one resistor from the positive to pins 6 and 7. The capacitor connects from pins 6 and 7 to ground or negative. Pin 2 is used for the input. When using a contact trigger, you need to add a resistor (10K works) from pin 2 to positive to prevent false triggering. A low input pulse triggers a high output pulse. The output stays high for a duration using the formula 1.1RC = time; 1.1 * 1,000,000 ohms * .000010 farad (10 mfd) = 11 seconds. A three meg resistor calculates to 33 seconds.

Dennis Hewett
via email

[#5116 - May 2011]
Circuit Design - Audio Oscillator

Can someone provide me with an audio oscillator design in the frequency range of 1,500-3,500 Hz that has the ability to:

- *Vary the frequency through the range.*
- *Adjust the output amplitude.*
- *Change the phase of the output.*

I am trying to use this device to

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reduce tinnitus (ringing in ears) by cancelling it with an out-of-phase audio signal.

#1 Your proposal is a round-about attempt to correct the effect of an annoyance rather than correcting the cause. Fifty years ago, I had a serious attack of tinnitus. I went to see an ORL suggested by a co-worker who had had the same problem. The treatment consisted of one week of a massive intake of vitamins. Unfortunately, I forget what it consisted of. All I recall is that I purchased quite a number of over-the-counter vitamins. I have never been bothered since. I strongly suggest that you visit an ORL.

F.A. Leclaire,
Monbtrel, QC

#2 I think you are unlikely to experience an improvement in tinnitus symptoms via this technique. An out-of-phase cancellation will work only if there is an actual incoming signal to cancel, but by definition, tinnitus is a spurious electrical signal transmitted from your ear to your brain caused by damaged or bent hairs in the inner ear corresponding to a particular frequency — there is no actual "input" signal to cancel.

An online article from the Mayo clinic discussing treatments for tinnitus (**www.mayoclinic.com/health/tinnitus/DS00365/DSECTION=treatments-and-drugs**) mentions white noise machines, hearing aids, masking devices (basically an in-ear white noise machine), and tinnitus retraining devices — all of which focus on masking your perception of the frequencies via psychological perception masking techniques rather than a physical elimination of the problem. The problem lies in a faulty sensor (the hairs in your inner ear) rather than an actual sensor "input" that can be modified via phase cancellation. I would, of course, strongly suggest consulting your doctor and an auditory specialist if you haven't already.

Andy
Redmond, WA

[#5117 - May 2011]
Need To Transmit From Laptop To FM

I use my laptop to play MP3s through my stereo. I have plenty of cigarette lighter type FM MP3 transmitters. Unfortunately, they all run on 12 VDC. I need either a similar style (cheap) FM transmitter that will run off a laptop's 5 VDC USB port or a way to convert the USB's 5 VDC to 12 VDC.

#1 What you want is the Belkin TuneCast II FM Transmitter (model # F8V3080-APL) which, in my case, I think I bought from Fry's Electronics, and which I remember coming with three power cables: one for 12V auto, one for USB, and I forget what the other one was (in addition to being able to be powered by two AA batteries). If you don't live near a Fry's Electronics, try Best Buy or a Google search, but I'd recommend going to the store to verify it has the power cables you need, as there is a newer version that looks much different (mine is the white one, and in the worst case, you could use the AA battery option).

Rusty Carruth
Tempe, AZ

#2 There are several battery operated wireless FM transmitters available that would allow you to transmit your laptop audio to an FM receiver. They are available from **Amazon.com**.

Following are the links with the information on each:

www.amazon.com/Soundfly-Player-Transmitter-Stickplayers/dp/B0018P7WZ2/ref=pd_sim_sbs_e_3

www.amazon.com/Sonic-Impact-Wireless-Music-Adapter/dp/B00017WXVG/ref=pd_sim_sbs_e_1

www.amazon.com/irock-Beamit-Wireless-Music-Adapter/dp/B0000DK6II

They all use two AAA batteries, so you could use either rechargeables or the Eveready Platinum series disposables.

Ralph J. Kurtz
Old Forge, PA

#3 You need a DC to DC 5V to 12V up converter. There are several relatively inexpensive integrated circuits available to provide just this function, such as the LT1111 and MAX606, among others.

You can find sample circuits within their respective datasheets (available on the Web).

B. H. Suits
Houghton, MI

[#6112 - June 2011]
Precision 60 Hz Reference

I'm looking for a simple, highly stable 60 Hz reference AC signal. AC power lines are accurate over long timeframes, but can fluctuate short term. I've seen suggestions of taking a color burst crystal and dividing down, but filtering is necessary to reach an AC waveform. Hope someone has an elegant solution.

I would suggest using an Exar XR-2206CP-F function generator IC; **www.jameco.com** lists this IC for $5.49 as part #34972. The datasheet can be downloaded from their website in pdf form. Figure 12 on the datasheet shows all the connections needed to make the chip work. Temperature stability is given as 20 ppm/deg C typ.

Output can be boosted by using an op-amp if needed.

Dale Freye
Grand Haven, MI

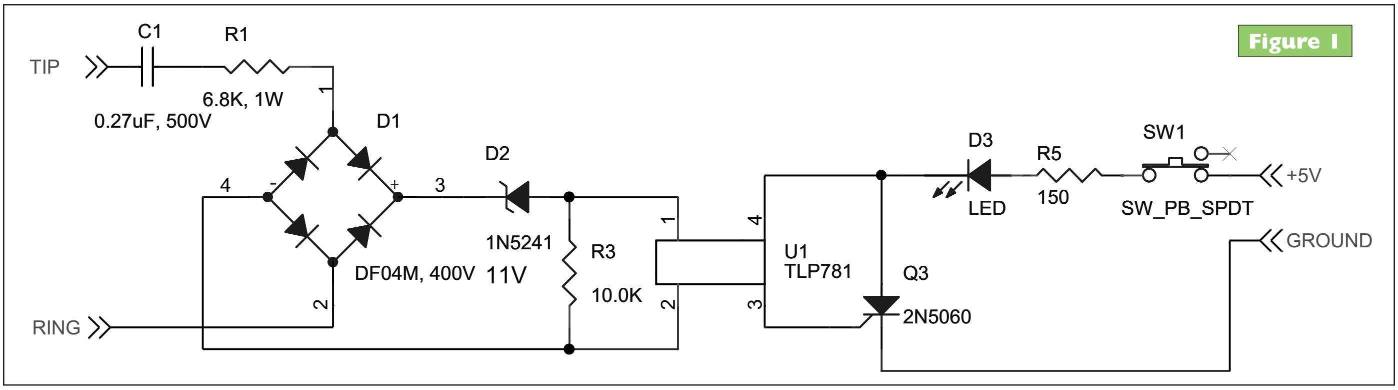

Figure 1

[#6113 - June 2011]
Voice Mail Alert

I need a circuit to connect to my telephone wiring so the ring signal will cause an LED to light up and stay lit until it is manually turned off. The system is VOiP via modem and ATA.

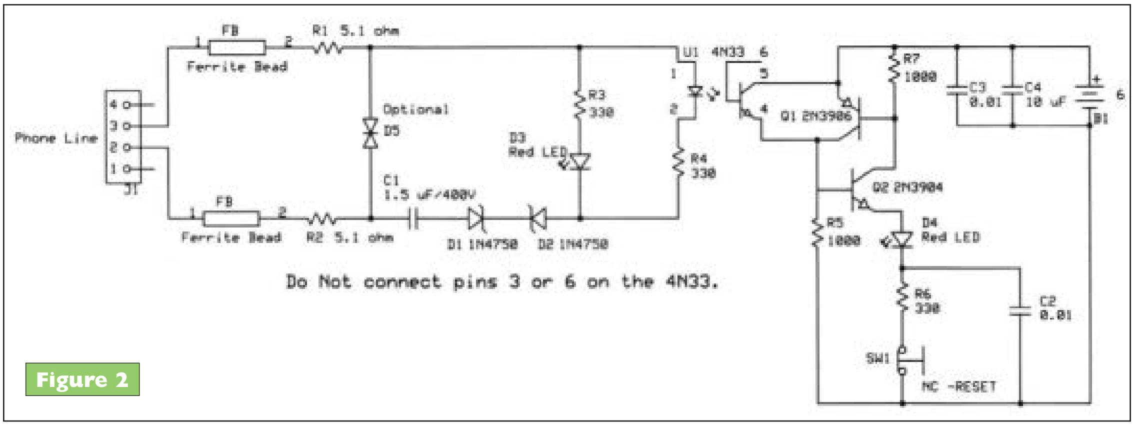

Figure 2

#1 Figure 1 shows a circuit for a ring detector.

Geoff Probert
via email

#2 About a year ago, I built a circuit (**Figure 2**) that will turn on an LED (D4) when a phone line rings, and the LED will remain on until someone pushes the normally-closed pushbutton. The two 2N3409 transistors create a silicon-controlled rectifier (SCR).

The 4N33 optical coupler isolates the latching-SCR circuit from the phone line. D5 is a Littlefuse metal-oxide varistor; part #V20E300P or equivalent. I used batteries as a power source, but a wall wart would also do the job. LED D3 serves as a "ringing" indicator.

Jon Titus, KZ1G
Herriman, UT

[#6116 - June 2011]
Points Ignition To Solid-State

Can someone help with a crossover design or existing schematic to turn my 1989 points ignition to a solid-state design? Four cylinder — OMC or Ford 2.3 140.

What you want is a well heatsinked, heavy duty power FET with a high current, back EMF damper diode, driven by a Hall effect sensor, triggered by magnets attached to the cam of your distributor.

I've been down that road. When I decided to upgrade the ignition on my beloved 76 MGB "Booker T.," I tried a few things including driving a transistor off the points, etc.

The unquestioned, best solution turned out to be a product by Pertronix (**www.pertronix.com**). It fixed everything about my ignition. It amounts to a chunk of plastic about the size of the last joint of your pinkey, attached to a plate that screws into the place your breaker points were. Hook up two wires, slip the supplied plastic magnet "knob" over the distributor cam, and you're done!

One of the great things is, in the (unlikely) event the unit ever fails, you can — with no more than a screwdriver — put the old points and condenser back and limp home. The setup I ended up with didn't require a ballast resistor. Voltmeter checks indicated there is one "somewhere." I ended up using the "hot" wire from the ignition switch to drive a standard 30 amp automotive (black cube) relay that closes a new (fused) circuit from the battery directly to the Pertronix module.

I don't work for Pertronix but would gladly take their money if they wanted me to. I would also suggest you look at their "flamethrower" coil. It made a noticable difference over the Lucas coil in the MG.

I bought the chrome one knowing — as every hillbilly hotrodder does — every piece of crome under the hood adds horsepower.

Larry D. "The Wiz"
via email

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Continued from page 28

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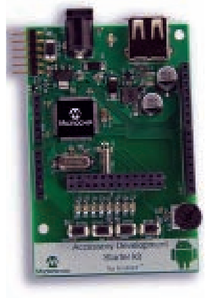

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250mm x 200mm (9.8"x7.8") Pre-Heat area

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Item# **BK7050** **$419.00**

300mm x 300mm (11.8"x11.8") Pre-Heat Area

www.CircuitSpecialists.com/BK7050

*BlackJack SolderWerks is a Circuit Specialists, Inc. brand.

Multifunction Digital Multimeter

Auto Zero, Auto Polarity & Auto Power Off

CSI2010 is an easy to operate ,accurate , rugged, battery operated, handheld 3½ digit DMM for measuring DC and AC voltage, DC and AC current, Resistance and Diode, Capacitor, Transistor (HFE), Continuity, etc.. CSI-2010 is an ideal instrument for use in the field, lab, workshop or educational environment

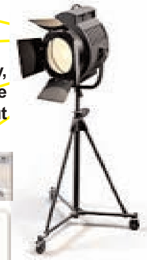
Item# **CSI2010** **$24.95**

www.CircuitSpecialists.com/CSI2010

Spotlight On: Power Supplies

Circuit Specialists carries a wide range of power supplies.

We stock a large variety of power supplies from PowerSupply1, HengFu, TwinFly, Sparkle Power and our own Circuit Specialists CSI brand..Included in our lineup are Single, Dual & Triple output enclosed power supplies, Single, Dual & Triple Output Bench Power Supplies, Variacs, and Computer Power Supplies.



Great for OEM's or Replace that missing unit!

High Quality, Feature Rich, Great Prices!

Available in a wide range of voltages and current ratings. Ships from stock!

With digital programmable controls and RS-232 & USB Interfaces!

HEAVY DUTY! up to 200V

Low Cost AC Variacs!

See them @ www.CircuitSpecialists.com/power-supplies

60 Watt Digital Soldering Station

For use with traditional or Lead Free Soldering

This is a terrific soldering station featuring a microprocessor controlled temperature set up system with great versatility. The unit includes 3 preset temperature settings that are user definable so you can turn on the system & push one button to go to the temperature range you desire. Specific system temps can also be set with an easy to use push button up/down button AND when you turn off this station, the unit keeps the last used temperature in memory & automaticly returns to that setting the next time the user turns the system on. The temperature display can be set to display in Celsius or Fahrenheit scale.

The CSI-Station-3DLF is a powerful 60 watt soldering system. The fast heat recovery provided by a 60 watt system like this allows the user to solder both traditional solder and lead free solder. This system features a grounded tip to protect delicate circuits from static charge. Also included is a seperate iron holder. Circuit Specialists stocks a large supply of tips for this station.

Features:

* 60 watt dual core ceramic heater
* 150 to 450 degree Celsius Temperature range
* Versatile easy to read liquid crystal display
* 3 preset & user definable temperature settings.
* Automaticly remembers previous temperature setting
* Display in Celsius or Fahrenheit scale
* 3 foot cord length from station to iron tip
* Broad selection of replacement tips available

Item# **CSI-Station-3DLF** **$49.00**

www.CircuitSpecialists.com/CSI-Station-3DLF

Circuit Specialists carries a wide selection of traditional & lead-free soldering equipment, including soldering irons, soldering stations, hot-air rework stations, focused infrared systems, reflow ovens, pre-heating systems, regular and lead-free solder, solder flux, and soldering aids for both thru-hole and surface-mount soldering.

See our complete line of soldering equipment at:

www.CircuitSpecialists.com/soldering-equipment

CircuitSpecialists.com

1000's of Items Online! 1-800-528-1417 Fax: 480-464-5824 Since 1971

We carry a LARGE selection of Power Supplies, Soldering Equipment, Test Equipment, Oscilloscopes, Digital Multimeters, Electronic Components, Metal and Plastic Project Boxes, Electronic Chemicals, PC Based Digital I/O Cards, Panel Meters, Breadboards, Device Programmers, and many other interesting items. Check out our website at: *www.CircuitSpecialists.com*

Best Value, Low Cost Station
CSI-Station1A

Easily our best value in our selection of soldering stations. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! The CSI-Station1A features a grounded tip & barrel for soldering static-sensitive devices and uses a ceramic heating element for fast heat up & stable temperature control.

The control knob is calibrated in Fahrenheit & Celsius (392° to 896°F and 200° to 480°C). One of the nicest features is the high quality comfort grip soldering iron. The iron connects to the station via an easy screw-on connector making iron replacement a snap. The 1 meter length iron cord provides plenty of length for users to set up the station in a convenient location. Another nice feature is the soldering iron holder. Made of rugged aluminum,it is a seperate piece from the main station & allows the user maximum convenience.....you don't have to reach all the way back to the station to store the iron. Yet another feature is the stackable design of the CSI-Station1. The main station is designed for an additional unit to be placed on top of it allowing for space saving placement of the CSI-Station1A. Also included at no additional charge is one user replaceable ceramic heating element so that you will be prepared! Large selection of soldering tips available too.

Item# CSI-STATION1A **$29.95**

www.circuitspecialists.com/csi-station1a

Programmable DC Electronic Loads

Thease devices can be used with supplies up to 360VDC and 30A. It features a rotary selection switch and a numeric keypad used to input the maximum voltage, current and power settings. These electronic DC loads are perfect for use in laboratory environments and schools, or for testing DC power supplies or high-capacity batteries. It also features memory, and can also be connected to a PC, to implement remote control and supervision.

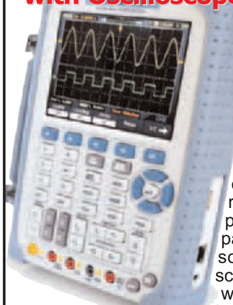
360V/150W (CSI3710A) $349.00

www.circuitspecialists.com/csi3710a

360V/300W (CSI3711A) $499.00

www.circuitspecialists.com/csi3711a

200MHz Hand Held Scopemeter with Oscilloscope & DMM Functions



Includes 1 Year USA Warranty

You get both a 200 MHz Oscilloscope and a multi function digital multimeter, all in one convenient lightweight rechargeable battery powered package. This power packed package comes complete with scopemeter, test leeds, two scope probes, charger, PC software, USB cable and a convenient nylon carrying case.

- 200MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 200MHz Bandwidth with 2 Channels
- 500MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/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 # DSO1200 *New Low Price!* **$589.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

- 60MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 60MHz Bandwidth with 2 Channels
- 150MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/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 *New Low Price!* **$429.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter w/Oscilloscope, DMM Functions & 25 MHz Arbitrary Waveform Generator

- All the features of the DSO1060 plus a 25 MHz Arbitrary Waveform Generator.
- Waveforms can be saved in the following formats: jpg/bmp graphic file, MS excel/word file
- Can record and save 1000 waveforms
- DC to 25 MHz Arbitrary Waveform Generator

Item # DSO-8060 *New Low Price!* **$519.00**

www.circuitspecialists.com/DSO-8060

Programmable DC Power Supplies

- Up to 10 settings stored in memory
- Optional RS-232, USB, RS-485 adapters
- May be used in series or parallel modes with additional supplies.
- Low output ripple & noise
- LCD display with backlight
- High resolution at 1mV

Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W
Price	$199.00	$199.00	$199.00

Aardvark II
Dual Camera
Wireless Inspection Camera
With Color 3.5" LCD
Recordable Monitor
Your Extended Eyes & Hands!

See It! Clearly in narrow spots, even in total darkness or underwater.
Find It! Fast. No more struggling with a mirror & flash light.
Solve It! Easily, speed up the solution with extended accessories.
Record It! With the 3.5" LCD recordable monitor, you can capture pictures or record video for documentation.

The Aardvark Wireless Inspection Camera is the only dual camera video borescope on the market today. With both a 17mm camera head that includes three atachable accessories and a 9mm camera head for tighter locations. Both cameras are mounted on 3ft flexible shafts. The flexible shaft makes the Aardvark great for inspecting hard to reach or confined areas like sink drains, AC Vents, engine compartments or anywhere space is limited. The Aardvark II comes with with a 3.5 inch color LCD monitor. The monitor is wireless and may be separated from the main unit for ease of operation. Still pictures or video can also be recorded and stored on a 2GB MicroSD card (included). The Aardvark's monitor also has connections for composite video output for a larger monitor/recorder and USB interface for computer connection. Also included is an AC adapter/charger, video cable and USB cable. Optional 3 ft flexible extensions are available to extend the Aardvark's reach (Up to 5 may be added for a total reach of 18 feet!).

Item # AARDVARK II **$249.00**

www.CircuitSpecialists.com/aardvark

PC Based USB Digital Storage Oscilloscopes

Turn your Windows based computer into a powerful 2 channel digital oscilloscope. Using the PC's USB port for data communications between the included hardware & software to create the oscilloscope display on the PC's monitor allowing you to preform functions the same as on a standard scope. The unit ships with 2 probes, software CD, users manual and USB cable.

DSO-2090	DSO-2150	DSO-2250	DSO-5200	DSO-5200A
40 MHz	60 MHz	100 MHz	200 MHz	200 MHz
$169.00	$209.00	$259.00	$289.00	$355.00

www.CircuitSpecialists.com/Oscilloscopes

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210
Phone: 800-528-1417 / 480-464-2485 / Fax: 480-464-5824