PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

NUTS AND VOLTS

EVERYTHING FOR ELECTRONICS

www.nutsvolts.com
May 2011

Scratch Building A Radio Controlled Submarine

FUNdamentals For Beginners
How A 555 Timer Works

✦ Design Cycle
Riding an RF Energy Harvester

✦ Creating a Chipino Shield
Intro on how to create a shield for your Chipino/Arduino type modules

✦ Using Jewelry
to make reliable connections

✦ Near Space
Programming the Near Space Ultralight

✦ Electronics Q&A
Comb Filter Design
Video Amp
Hysteresis Circuit

U.S. $6.50 CANADA $7.50
05
0 71486 02421 7


RUN YOUR DEVICES
IN 6TH GEAR
1 3 5
2 4 6 R
Try out our new board mikroMMB for PIC32 $99
COMPILERS
mikro C from $199
mikro b from $149
mikro p from $149
switch to PIC32
C, Pascal and Basic
mikroElektronika is the only PIC32 compiler manufacturer in the world to offer compilers for three programming languages:
- mikroC PRO for PIC32
- mikroBasic PRO for PIC32
- mikroPascal PRO for PIC32
Backward compatibility
If you need more power, just switch from PIC or dsPIC to PIC32 easily. We have been carefully planing backward compatibility for all of our library functions, so you will be able to literally copy/paste your existing codes and build them with just a few adjustments.
Lots of libraries
What is the point of compiler if you have to write your libraries from scratch, or to pay for each and every single one? With our compilers, you'll have over 500 library functions, and a head start in development. No PIC32 compiler offers so much at this price. It's the best value for the money.
mikro e MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS
www.pic32compilers.com
www.mikroe.com

Equip your bench with LeCroy

Performance you need, a price you can afford

Oscilloscopes Starting at $695
LogicStudio – Logic Analyzer at $990
ArbStudio – Waveform Generator from $2,490

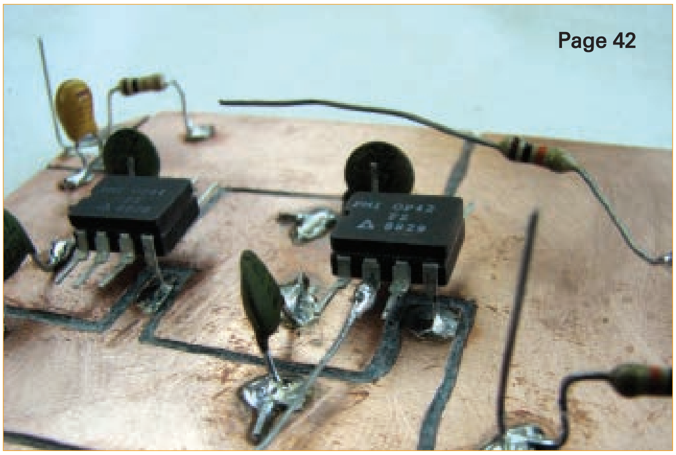
LeCroy

www.lecroy.com • 1-800-5-LeCroy

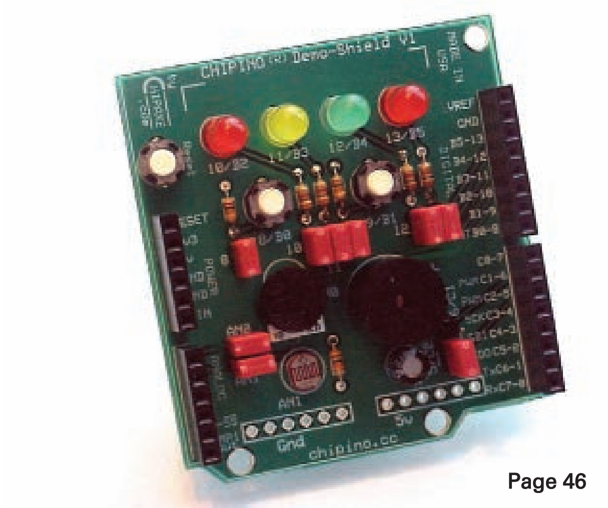
Nuts & Volts

May 2011

www.nutsvolts.com



Page 42



Page 46

Projects & Features

FUNdamentals For Beginners

Just getting started in electronics? Try these simple demos to illustrate electronics principles and how components function in actual circuits!

Departments

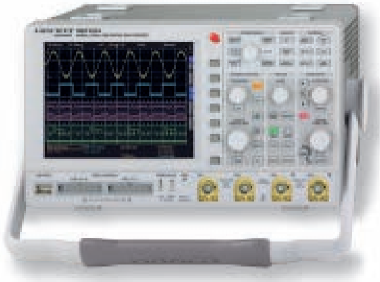
Columns

Nuts & Volts (ISSN 1528-9885/CDN Pub Agree #40702530) is published monthly for $26.95 per year by T & L Publications, Inc., 430 Princeland Court, Corona, CA 92879. PERIODICALS POSTAGE PAID AT CORONA, CA AND AT ADDITIONAL MAILING OFFICES. POSTMASTER: Send address changes to **Nuts & Volts, P.O. Box 15277, North Hollywood, CA 91615** or Station A, P.O. Box 54, Windsor ON N9A 6J5; cpcreturns@nutsvolts.com.

GREAT VALUE IN TEST & MEASUREMENT

Call for educational discount

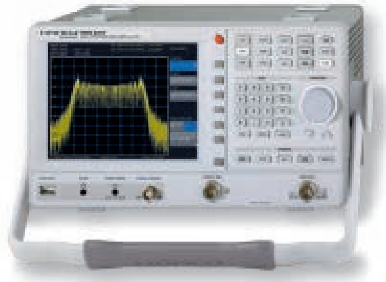
350 MHZ 2/4 CHANNEL DIGITAL OSCILLOSCOPE HMO 3522/HMO 3524



USB · USB Stick · optional IEEE-488 · optional TCP/IP · DVI Output · inclusive

- ☑ 4 GSa/s Real time, 50 GSa/s Random sampling, low noise flash A/D converter (reference class)
- ☑ 2 MPts memory per channel, memory Zoom up to 100,000:1
- ☑ MSO (Mixed Signal Opt. HO 3508/HO 3516) with 8/16 logic channels
- ☑ Vertical sensitivity 1 mV...5 V/div. (into 1 MΩ/50 Ω) Offset control ±0.2...±20 V
- ☑ 12 div. x-axis display range
  20 div. y-axis display range with **V**irtual**S**creen function
- ☑ Trigger modes: slope, video, pulsewidth, logic, delayed, event
- ☑ FFT for spectral analysis ☑ Lowest noise fan
- ☑ 6 digit counter, Autoset, automeasurement, formula editor, ratiocursor
- ☑ Crisp 6.5" TFT VGA display, LED backlight, DVI output

3 GHZ SPECTRUM ANALYZER HMS 3000/HMS 3010



1GHz: HMS1000 HMS1010

USB · USB Stick · optional IEEE-488 · optional TCP/IP · DVI Output · inclusive

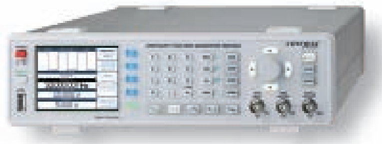
- ☑ Frequency range 100 kHz...3 GHz
- ☑ Amplitude measurement range -114...+20 dBm
  DANL -135dBm with Preamp. Option HO3011
- ☑ Sweep time 20 ms...1000 s
- ☑ Resolution bandwidth 100 Hz...1 MHz in 1–3 steps, 200 kHz (-3 dB)
  additional 200 Hz, 9 kHz, 120 kHz, 1 MHz (-6 dB)
- ☑ Spectral purity < -100 dBc/Hz (@100 kHz)
- ☑ Video bandwidth 10 Hz...1 MHz in 1–3 steps
- ☑ Tracking Generator (HMS 3010) -20 dBm/0 dBm
- ☑ Integrated AM and FM demodulator (int. speaker)
- ☑ Detectors: Auto-, min-, max-peak, sample, RMS, quasi-peak

PROGR. 2/3/4 CHANNEL HIGH-PERFORMANCE POWER SUPPLY HMP SERIES

USB · RS-232 · optional IEEE-488 · optional TCP/IP · inclusive

- ☑ HMP2020: 1 x 0...32 V/0...10 A 1 x 0...5.5 V/0...5 A, max. 188 W
- ☑ HMP2030: 2 x 0...32 V/0...5 A 1 x 0...5.5 V/0...5 A, max. 188 W
- ☑ HMP4030: 3 x 0...32 V/0...10 A, max. 384 W
- ☑ HMP4040: 4 x 0...32 V/0...10 A, max. 384 W
- ☑ 188/384W output power realized by intelligent power management
- ☑ Low residual ripple: < 150 µV$_{rms}$ due to linear post regulators
- ☑ High setting- and read-back resolution of up to 1 mV/0.2 mA
- ☑ HMP4030/HMP4040: Keypad for direct parameter entry
- ☑ Galvanically isolated, earth-free and short circuit protected output channels
- ☑ Advanced parallel- and serial operation via V/I tracking
- ☑ EasyArb function for free definable V/I characteristics
- ☑ FuseLink: individual channel combination of electronic fuses
- ☑ Free adjustable overvoltage protection (OVP) for all outputs
- ☑ All parameters clearly displayed via LCD/glowing buttons

25/50 MHZ ARBITRARY FUNCTION GENERATOR HMF2525/HMF2550



USB · USB Stick · optional IEEE-488 · optional TCP/IP · RS-232 · inclusive

- ☑ Frequency range 10 µHz...25 MHz/50 MHz
- ☑ Output voltage 5 mV$_{pp}$...10 V$_{pp}$ (into 50 Ω) DC Offset ±5 mV...5 V
- ☑ Arbitrary waveform generator: 250 MSa/s, 14 Bit, 256 kPts
- ☑ Sine, Square, Pulse, Triangle, Ramp, Arbitrary
  waveforms incl. standard curves (white, pink noise etc.)
- ☑ Total harmonic distortion 0.04 % (f < 100 kHz)
- ☑ Burst, Sweep, Gating, external Trigger
- ☑ Rise time <8 ns, in pulse mode 8...500 ns variable-edge-time
- ☑ Pulse mode: Frequency range 100 µHz...12.5 MHz/25 MHz,
  pulse width 10 ns...999 s, resolution 5 ns
- ☑ Modulation modes AM, FM, PM, PWM, FSK (int. and ext.)
- ☑ 10 MHz Timebase: ±1ppm TCXO, rear I/O BNC connector
- ☑ Front USB connector: save & recall of set-ups and waveforms
- ☑ 3.5" TFT: crisp representation of the waveform and all parameters

LCR-BRIDGE HM8118

incl. HZ188

USB · RS-232 · optional IEEE-488

- ☑ Basic Accuracy 0.05 %
- ☑ Measurement functions L, C, R, |Z|, X, |Y|, G, B, D, Θ, Δ, D, M, N
- ☑ Test frequencies 20 Hz...200 kHz
- ☑ Up to 12 measurements per second
- ☑ Parallel and Series Mode
- ☑ Binning Interface HO118 (optional) for automatic sorting of components
- ☑ Internal programmable voltage and current bias
- ☑ Transformer parameter measurement
- ☑ External capacitor bias up to 40 V
- ☑ Kelvin cable and 4 wire SMD Test adapter included in delivery
- ☑ Galvanically isolated USB/RS-232 Interface, optional IEEE-488

1,2 GHZ/3 GHZ RF-SYNTHESIZER HM8134-3/HM 8135

USB · RS-232 · optional IEEE-488

- ☑ Outstanding Frequency range 1 Hz...1,2 GHz/3 GHz
- ☑ Output power -127...+13 dBm/-135...+13 dBm
- ☑ Frequency resolution 1 Hz (accuracy 0.5 ppm)
- ☑ Input for external time base (10 MHz)
- ☑ Modulation modes: AM, FM, Pulse, Φ, FSK, PSK
- ☑ Rapid pulse modulation: typ. 200 ns
- ☑ Internal modulator (sine, square, triangle, sawtooth) 10 Hz...150 kHz/200 kHz
- ☑ High spectral purity
- ☑ Standard: TCXO (temperature stability: ±0.5 x 10^{-6})
  Optional: OCXO (temperature stability: ±1 x 10^{-8})
- ☑ Galvanically isolated USB/RS-232 Interface, optional IEEE-488
- ☑ 10 configuration memories including turn-on configuration

HAPRO Electronics

Tel: +1-516-794-4080 · Fax: +1-516-794-1855 · sales@haproelectronics.com

www.hameg.com

HAMEG® Instruments
A Rohde & Schwarz Company

DEVELOPING PERSPECTIVES

There's An App — And Hardware — For That

If you own a tablet or phone running either an Android or Apple iPhone OS, you know that there's likely an app (or application) out there for you. In addition to general interest apps — including a few thousand games — there are tools to help identify resistor values, design digital circuits, and calibrate your room stereo. There are even a few hardware add-ons that transform your phone or tablet into an oscilloscope, digital multimeter, or guitar effects processor.

For example, my favorite hardware add-on for the iPad is the iRig audio interface adapter from IK Multimedia. The adapter — available for about $40 from Amazon — plugs into a 3.5 mm audio jack. Simply plug in your electric guitar in one port, your headphones in another, and use the selection of virtual amplifiers and effects pedals to change the tone and volume of your electric guitar signal. Instead of lugging around a practice amplifier and pedals, you can simply slip the finger-sized adapter and your iPhone/iPad in your pocket, and practice wherever you like.

Compared with the cost of a single effects pedal (typically $50-$150), the iRig is a bargain. There are competing products such as the Peavey AmpKit Link that are more affordable ($30, Amazon). Even so, $30 is a lot to pay for a simple audio interface.

While the software of Android-based systems is open by design, getting into the hardware of any phone or tablet is often problematic. For example, if you want full access to an iPhone's power and digital input/output, there's the proprietary adapter. My favorite source is SparkFun (**www.sparkfun.com**). They sell a basic connector for $5, and a more useable and less delicate breakout connector for $15. The basic connectors are a pain to deal with because of their low profile which means you'll have to work with a fine tip soldering iron and even finer wire.

Although there are a few alternatives to working with the Apple software development tools, at present, it's the environment with the most access to the internal hardware and control of anything you connect to the proprietary port. You'll have to pay Apple a modest fee for the privilege of working with their software development kit ($99, **developer.apple.com**). If you're working with the Android operating system, tools are available online for free (**developer.android.com**), but you'll have to buy a license if you want to sell your application to the world.

Returning to the iRig audio interface adapter, notice that it plugs into the audio I/O port and not the proprietary Apple connector. The four-conductor, 3.5 mm audio jack is standard on most smart phones and tablets. As such, if you develop, say, an oscilloscope interface that plugs into the audio jack on the Apple iPad, the same hardware should work on a phone running the Android operating system. By the way, a great source for four-conductor jacks and cable is to repurpose a 3.5 mm to three RCA AV camcorder video cables ($2 for a six foot cable, Amazon).

If interfacing hardware to your smart phone or tablet intrigues you, a great resource is Project HiJack (**http://code.google.com/p/hijack-main**) from the University of Michigan. HiJack is an open source hardware and software platform for creating peripherals

NUTS AND VOLTS
EVERYTHING FOR ELECTRONICS

Published Monthly By
T & L Publications, Inc.
430 Princeland Ct.
Corona, CA 92879-1300
(951) 371-8497
FAX **(951) 371-3052**
Webstore orders only **1-800-783-4624**
www.nutsvolts.com

Subscriptions
Toll Free **1-877-525-2539**
Outside US **1-818-487-4545**
P.O. Box 15277
North Hollywood, CA 91615

FOUNDER/ASSOCIATE PUBLISHER
Jack Lemieux

PUBLISHER
Larry Lemieux
publisher@nutsvolts.com

ASSOCIATE PUBLISHER/ VP OF SALES/MARKETING
Robin Lemieux
display@nutsvolts.com

EDITOR
Bryan Bergeron
techedit-nutsvolts@yahoo.com

CONTRIBUTING EDITORS
Jeff Eckert, Russ Kincaid, Joe Pardue, Fred Eady, John Fattaruso, Michael Wernecke, Jon Williams, Paul Verhage, Chipaxe Team

CIRCULATION DIRECTOR
Tracy Kerley
subscribe@nutsvolts.com

SHOW COORDINATOR
Audrey Lemieux

MARKETING COORDINATOR WEBSTORE
Brian Kirkpatrick
sales@nutsvolts.com

WEB CONTENT
Michael Kaudze
website@nutsvolts.com

ADMINISTRATIVE ASSISTANT
Debbie Stauffacher

PRODUCTION/GRAPHICS
Shannon Christensen

for mobile phones.

Like the iRig, HiJack devices harvest power and use bandwidth from the mobile phone's headset interface. Check out the link for example source code and schematics for a variety of projects ranging from an EKG monitor to a temperature and humidity sensor.

Even if you're not interested in creating hardware for your smart phone or tablet, the project is worth exploring for the method used to harvest power from the audio interface. The designers manage to rectify an audio signal to create a 3V DC power supply capable of powering a microcontroller and sensors. Operating at nearly 50% efficiency, the energy harvesting circuitry is worth studying.

Good luck on your app development. **NV**

READER FEEDBACK

READERS GET STEAMED UP OVER ARTICLE (IN A GOOD WAY)

The article by John Molnar in the March '11 issue of *Nuts & Volts* on the computer controlled air/steam engine really caught my attention and interest. I've read through the article and have some questions I would like to ask.

1. How do you lubricate the repurposed weedwacker engine now that you are running it on air and steam?

2. How do you cool the engine while it is running?

3. How do I find a source of compressed air to run the engine?

4. I'm one of those people who doesn't have shop space, but I do have an outdoor deck that I can use on good weather days to work on a project like this one. Can you suggest a workbench or stand strong enough to take a vise that can support a (running) weedwacker engine? That is, can I buy a commercial workbench, or do I need to build one of wood?

5. How noisy is the engine? I'm deaf myself, but my wife is not, and I live on a densely populated street. There is no sense in upsetting these good folks.

Can you suggest effective ways to muffle the engine?

6. Can you suggest an electric generator that can be mated to a weedwacker and produce 115V electricity? (This would be a great topic for a second article in *Nuts & Volts*.)

7. Can the weedwacker engine operate equipment which can produce steam which, in turn, can run the engine? How about operating equipment to compress air which is used to run the engine? (Showing how to supply compressed air and steam to the engine would be another great follow-up article in *Nuts & Volts*.)

I will keep my eye out for a weedwacker engine. Thank you for writing quite an interesting article.

Bob Cochran

Response: Thanks for the mail. I'll try to answer your questions.

Lubrication: On the weedwacker engine, the lower end is actually open as the engine in the article is "single acting." I heavily grease the crankpin with lithium grease which lasts a long time on air since the engine runs cool. Also, on air, a few shots of 50 wt oil in the exhaust port every hour or so keeps the rings and cylinder wall lubed. With steam, a special "steam oil" is used with a device called a "displacement lubricator" that sits on a tee on the inlet side. When steam condenses in the small chamber, the resulting water sinks and forces a tiny amount of oil into the inlet line, thus the term "displacement." Steam oil mixes with water better they say, but I believe it is highly refined single weight oil.

Noise: Nothing like an internal combustion engine. Just a putting sound; no muffler needed at all. Your neighbors would probably not even hear it.

The big issue is having a safe boiler to produce enough steam to make meaningful horsepower, and whatever one burns needs to be cheap and locally plentiful.

The compressed air I use comes from an old Sears garage compressor.

The engine in the article evolved over time and a practical engine would need to be larger and — for steam use — much better bronze solenoids are need.

I'll post a video clip of the article engine on the N&V *website.*

John Molnar

I just received my March *Nuts & Volts*. Congrats on the John Molnar air/steam engine project. The issue of valve timing for steam engines has always been a "least worst" solution for each engine. Having some experience with model steam, I really enjoyed reading John's approach/solution. Thanks for a great project!

There are a number of publications out for the model builder of live steam projects. *Experimental Flash Steam* by J.H. Benson and A.A. Rayman is an older publication but still one of the best. It covers theory, various engine projects, valve timing, and safe flash boiler construction. A note about safety. You are correct that a flash boiler is the safe way for steam generation. Only generate steam as needed.

A small suggestion: Please check the soleniod valve "pressure and temperature rating" for the inlet control solenoid. I am sure it is fine for compressed air but I have serious concerns when 25 PSI steam is used. Steam at 25 PSI will be well over 100°C (212°F) and I doubt the plastic valve body/seat is rated for that type of service.

James F. Ward

Response: Thanks for the email and thoughts! Yes, I should have mentioned the valves from STC I specified are for air only. They are about $18 from the China importer STC. I also have a set of bronze valves rated for steam up to 300° (25 PSIG is ~266°F), but I assumed most readers that attempted the project would stick with air. (I think I paid $60/valve several years ago for the bronze.)

Actually, the auto timing would best be applied to a double-acting engine with Corliss type action. The uniflow engines never really made it due to the material restraints of the period.

John Molnar

I skimmed over the John Molnar article in *Nuts & Volts* and I am interested in this project. I would like to make a few comments. Air solenoids are NOT suitable for steam use. Steam at 100 PSIG is around 320° and will melt the seals in the valves. You'll need to get steam rated valves from Granger or McMaster-Carr. A mono tube boiler might not have the capacity to power your steam conversion. A small water tube or vertical boiler will better power your engine. I come from a 30-year background of 1-1/2" scale live steam trains and I feel that building any kind of boiler is beyond the readers of *NV*. I have been interested in building something in the 10 HP range as the boiler is the limiting factor. A 10 HP boiler will be about 20" in diameter and about 6' tall.

Art

Response: Thanks for your mail! Well, I agree re: the valves. The ones I use for steam are bronze STC valves, capable of steam operation. I run no more than 25 PSIG which (if I recall) is about 266°F, saturated. The air solenoids are cheap; $18 from STC.

I also agree re: boilers. The real intent of the article was more to indicate how an engine or timing-dependent device can simply be controlled with minimal hardware. My professional background is (was!) in electronics and digital hardware. I enjoy "controlling things" with digital logic. But back to steam. Yeah, hopefully folks won't attempt coffee-can boilers, as I did emphasize in the sidebar. Obviously, I couldn't describe HOW to construct a mono-tube, and really didn't want to get into pressure vessels at all for obvious reasons. My guess anyone duplicating the experiment will use air.

I have a collection of PMR and Stuart "small" engines and am in the process of scratch-building a 48" scale launch using the Graham twin. The propane fired boiler for that is 4" x 10" copper with 100% rivoted end plates and fire tube.

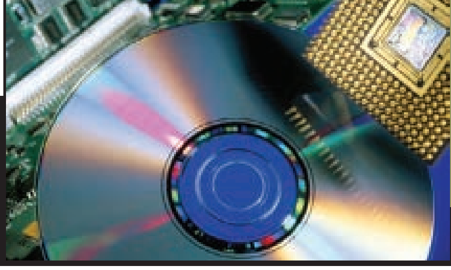
John Molnar

I read the article "Computer Controller Air/Steam Engine" in the March '11 issue of *Nuts & Volts* with great interest. As a past contributing author and control systems engineer for several decades, I felt compelled to share some observations with you. First, the solenoid valves listed in the parts list are NOT rated for steam service. This company does indeed carry steam rated SVs but not in the 1/4" size and at a cost of more than $90 each.

With my years of experience in SV operation, I don't think they're going to last too long operating multiple times per second. They will wear out mechanically just from the sheer number of operations in short order. Next, since this is a two cycle engine, the author neglected to mention the fact that lubrication WAS provided by the oil mixed in with the gasoline ... always required in two cycle operation.

Typically, pneumatic systems in the "real world" have oiler/misters attached upstream and utilize "Marvel Mystery Oil" for a lubricant. I've seen pneumatic systems in operation for decades, unmaintained except for re-filling the oilers. In the article's case, the lack of lubrication will quickly wear out the rings and compression will rapidly be lost. That two cycle engine was designed that way and does require

continued on page 65



TECH KNOWLEDGEY 2011

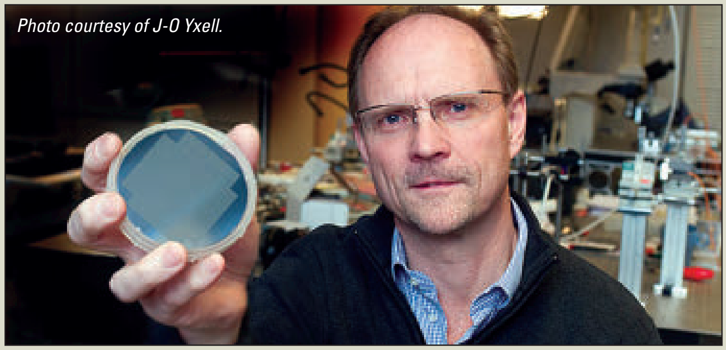
EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

FAST LASER BOOSTS FIBER OPTIC SPEED

Photo courtesy of J-O Yxell.

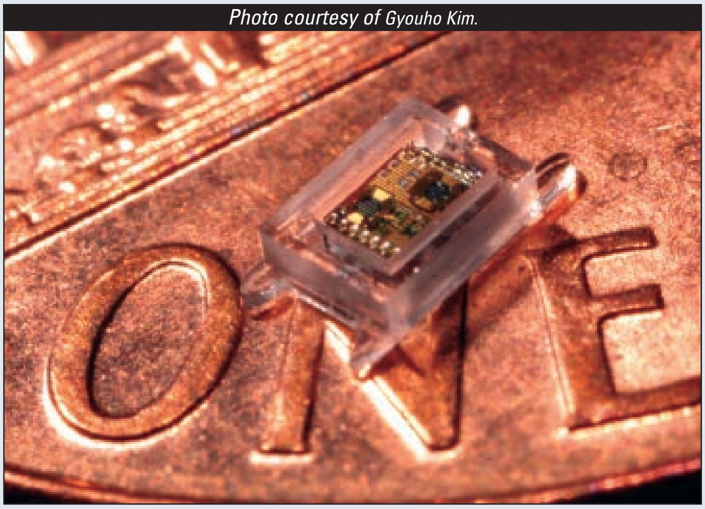


■ Developer Anders Larsson displays a wafer that can contain up to 100,000 lasers.

Today's commercial lasers can transmit clean data at only about 10 Gbit/s via fiber optics. However, Anders Larsson and coworkers at Sweden's Chalmers University of Technology recently demonstrated that a different type of laser — which is cheaper and more energy efficient — can crank that up to 40 Gbit/s which could allow huge speed gains in computers, mobile devices, and Internet traffic. What we're talking about is a surface-emitting laser which — as the name implies — emits light from the surface of the laser chip rather than the edge. This means that they can be both fabricated and tested on the wafer before being sawed into chips for assembly, thus reducing the cost of testing them by about 90 percent. According to Larsson, "The laser's unique design makes it cheap to produce, while it transmits data at high rates with low power consumption." Thus, it offers a path to transitioning from electrical to optical cables in computers and peripherals, replacing, for example, USB cables. By using multiple channels, it should be possible to create computer cables with a capacity of several hundred Gbit/s. Chalmers researchers still need to make some design modifications and improve methods of controlling the laser, but they are aiming for data rates eventually reaching 100 Gbit/s per channel. For details, you can visit the Chalmers Fibre Optic Communications Research Centre (FORCE) at **www.chalmers.se/mc2/force-en**. ▲

DAWN OF THE AGE OF MILLIMETER COMPUTING?

Photo courtesy of Gyouho Kim.



■ University of Michigan's Phoenix chip, billed as the first complete mm scale computing system.

We're all familiar with Moore's Law (the number of transistors per chip doubles about every two years), but a lesser-known corollary is Bell's Law which states that a totally new class of computers emerges every decade. Thus, we have moved from mainframes to PCs to notebooks to smartphones in about four decades. Some folks at the University of Michigan (**www.umich.edu**) are pretty sure that millimeter-scale computing is the next step, and they have developed what they believe to be the first complete system. They recently unveiled the third-generation Phoenix chip which combines a microprocessor, pressure sensor, memory, battery, solar cell, and radio transmitter all in a package that's about the size of the "N" on a one-cent piece. Intended to be an implant for glaucoma patients, it takes measurements every 15 min, consuming an average of only 5.3 nW. The solar cell keeps it charged, and it can store a week's worth of information. As observed by Prof. Dennis Sylvester, "Our work is unique in the sense that we're thinking about complete systems in which all the components are low power and fit on the chip. We can collect data, store it, and transmit it. The applications for systems of this size are endless." ▲

COMPUTERS AND NETWORKING

THINK PADS UPDATED

Last month, Lenovo (**www.lenovo.com**) introduced upgrades to its Thinkpad lineup consisting of the X220 laptop and the X220 convertible tablet PCs. The company cites improved battery life (up to 24 hr operation on a charge), an improved spill-resistant keyboard, and a 50% improvement in drop test performance among the major changes. Note, however, that the 24 hr operation is based on the use of an external battery. Otherwise, you're looking at about 15 hours which still isn't too shabby. Both use Intel Core® i7 processors with Turbo Boost Technology 2.0 and have some handy features for voice and video conferencing including keyboard noise suppression, private chat and conference call microphone modes, and a dedicated mute key. They're equipped with a 45% larger touchpad and 12.5 in scratch-resistant Gorilla Glass screens; some versions offer USB 3.0. Prices start at $899 for the laptop and $1199 for the convertible. ▲

■ Lenovo's X220 convertible tablet PC.

NEW MACBOOK FEATURES THUNDERBOLT

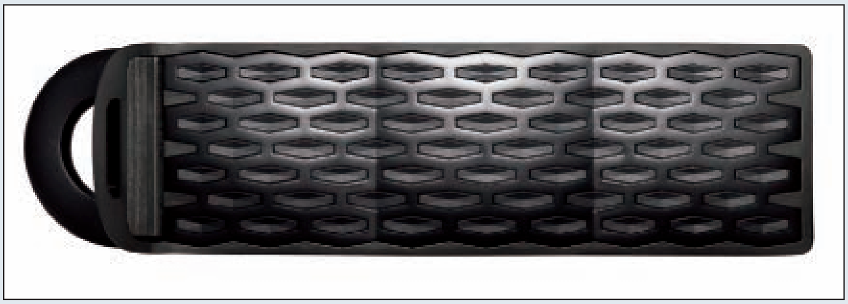
Meanwhile, on the OS X side of the street, Apple has updated the MacBook Pro family with next-generation chips (Intel i5 and i7 dual- and quad-core chips up to 2.7 GHz and Intel HD Graphics 3000) that it claims provide up to double the processing speed over the previous generation. They also sport a new FaceTime® HD camera that provides tripled resolution for HD video. The most revolutionary feature is its Thunderbolt I/O technology, developed by Intel in collaboration with Apple. Formerly known as Light Peak, Thunderbolt offers 10 Gbit/s data transfer, and Intel says it will hit 100 Gbit/s by the end of the decade. It also delivers PCI Express directly to peripherals such as RAID arrays, and can support FireWire and USB devices and Gigabit Ethernet via adapters. It also supports DisplayPort for high res displays and works with existing adapters for DVI, HDMI, and VGA. Most notably, Thunderbolt devices can be daisy-chained, so you can string them out from a single port with no need for a hub or switch. You'll be seeing other companies adopting the technology eventually, and LaCie, Western Digital, Seagate, and Sony are reportedly on board already. Details are available at **www.apple.com/thunderbolt**/ and **www.intel.com/technology/io/thunderbolt/index.htm**. As usual, all of this comes at a cost, and you'll shell out at least $1399 for the 13 in model and $2499 for the 17 in one. ▲

■ New MacBook Pro sports a range of upgrades.

TOUR THE SISTINE CHAPEL

If you're an art fan but don't have the time or money to visit the Vatican, try out the high res virtual tour that's now offered. With the assistance of Pennsylvania's Villanova University, the Holy See has put together tours of the Sistine and other chapels and basilicas so you can get an up-close look at the Creation of Adam and other frescoes by Michelangelo, Raphael, Bernini, and Botticelli. The resolution of the zoom feature is so good you could spot a fly on Adam's nose. You can also visit the Vatican Secret Archives (which don't actually seem to be all that secretive) and other locations. Just go to **www.vatican.va**, pick a language, and click on Basilicas and Papal Chapels. ▲

BLUETOOTH HEADSET PLUS



■ Jawbone ERA, an enhanced Bluetooth headset.

Admittedly, people look pretty dorky with one of those Bluetooth things clamped to their ears, but let's face it ... you're already walking around in Crocs and a Star Trek T-shirt, so what's the difference? Plus, if you want to use a handheld cell phone while driving, you can be arrested in at least eight states. So, if you're ready to enter the cyborg world, check out the Jawbone ERA headset at **www.jawbone.com**. According to the company, it's "the first and only headset with a built-in accelerometer, MotionX™ technology, a multiprocessor architecture, HD audio, and a connected app platform to enable a rich, new, hands-free experience." The accelerometer doesn't seem to do much so far, but it does allow you to double-tap on the unit to answer or end a call, and you can bring it into pairing mode with the cell phone by shaking it. Jawbone "has a full roadmap of innovation and enhancements under development" to add functionality. It also comes with NoiseAssassin® 3.0, a military-grade noise cancellation feature, plus a voice caller ID function. The company also has installed a 25% larger speaker than in previous models. You can pick one up at the usual places for about $129. ▲

NEW MULTIPOINT TOUCHSCREEN DEMONSTRATED

Generally speaking, touchscreens employ either capacitive or resistive sensors. Screens used in devices such as smartphones tend to use the capacitive sensors to recognize dual-touch movements such as pinch/zoom, but you can't use a pen or stylus with them. Conversely, the resistive variety (which is significantly cheaper) can work with a pen or stylus but can't support multi-touch operations. So, Toshiba Electronics Europe (**www.toshiba-components.com**) has demonstrated a prototype system that uses a proprietary algorithm to combine both technologies. Aimed primarily at medical and industrial markets, the Resistive Touch Technology Demonstrator employs an ARM9 development board for the touchpad and display, plus a PCB that amplifies the touch stimulus and calculates position and movement. Although it isn't yet commercially available, Toshiba indicated that the new touchscreen product will be introduced later this year, so stay tuned. ▲

TORMENT YOUR FRIENDS AND FAMILY, CHEAP

If you want another way to annoy friends and coworkers, consider the EvilTron from ThinkGeek Mindlabs (**www.thinkgeek.com**). As noted by the company, "The human mind can play devious tricks on itself, especially when given a small amount of outside stimuli to work with. Your thoughts can easily lead you into a maze of paranoia and put you into a very uncomfortable state of heightened awareness. That odd noise that just came from the attic or the 'face' you just saw hovering for a split second outside your window — these things can really stir your thoughts. So, we used this simple principle to create our newest mind toy, the ThinkGeek EvilTron." What you get is a disc the size of a quarter that you hide somewhere out of sight, as above a ceiling tile or in a car. EvilTron then emits one of five different sounds (unsettling creaking, scratching sounds, gasping last breath, sinister child laughter, and someone whispering, "Hey, can you hear me?") or a random combination of these. One could question how likely it is to create genuine fear and paranoia, but it still sounds like fun. You can get one for $9.99, two for $14.99, or three for $17.99, so you don't have to choose between disrupting the home or office. ▲

■ The EvilTron, designed to create fear in people around you.

INDUSTRY AND THE PROFESSION

AUTOMATED ELECTRONICS RECYCLING ARRIVES

As we know, US consumers buy about 500 million electronic devices every year, most of which become obsolete every time Steve Jobs makes an announcement. Most of us would rather trade in or sell the old gadgets than see them go into landfills as toxic waste, but there are few places where you can drop them off. However, San Diego-based ecoATM has a solution that might just catch on. The company's eCycling stations are fully automated kiosks that use machine vision, electronic diagnostics, and artificial intelligence to buy back used electronics directly from consumers. The latest version has a built-in cash dispenser, allowing it to operate much like an ATM. The user can be paid in cash or store credit, and the machine automatically takes care of trade-in or trade-up promotions for retailers and manufacturers. This could turn out to be an "only works in California" thing, but the company says trial locations have been in operation for a year and have paid out hundreds of thousands of dollars. You can find out more at **www.ecoatm.com**. **NV**

■ The Kenbak-1 computer, arguably the first commercial personal computer.

■ BY FRED EADY

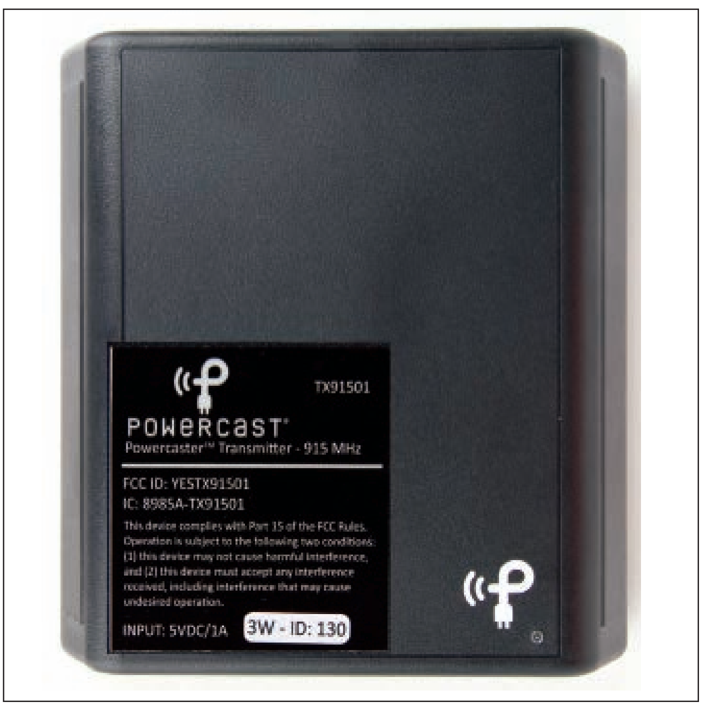
RIDING AN RF ENERGY HARVESTER

What do you get when you mix three watts of 915 MHz RF with some special silicon attached to an antenna and a capacitor? The answer is obvious. You get 3.3 volts DC. This month, I'll explain how a three watt 915 MHz Powercaster transmitter coupled with a Powercast P2110 Powerharvester receiver can be used to power a PIC24F series microcontroller, an MRF24J40MA 802.15.4 2.4 GHz radio, and a gaggle of sensors. It all begins with the 915 MHz transmitter.

A WIRELESS POWER SOURCE

The power needed to drive our PIC, MRF24J40MA 2.4 GHz radio, and sensors is derived from a Powercast 915 MHz Powercaster transmitter. In addition to the electrical energy, the transmitter also periodically transmits eight bits of encoded data within the RF power stream. The data is in the form of a standard RS-232 frame and contains the transmitter ID. The transmitter ID can be used to identify the power source of mobile sensor modules that move between multiple 915 MHz Powercaster transmitter domains. I superimposed the tag attached to the rear of our 915 MHz transmitter to the frontal shot of it in **Photo 1**. As you can see, our transmitter ID is 130 decimal. The transmitter ID is encoded in a nine-bit RS-232 frame clocked at 16660 bps.

The 915 MHz transmitter is factory aligned and its radio configuration and power output cannot be altered. A pair of wall wart jacks on the bottom and rear allows it to be wall mounted or sit upright on a flat surface. A built-in antenna with 8 dBi of gain is housed under the covers. A five volt DC power source is all that may be externally attached. There are no knobs or electronically accessible configuration options. A lone LED displays the status. Green is good. Red is bad. To install the transmitter, just mount it in an eight foot or higher unobstructed line-of-site view of the nodes it is to power and plug it in. The transmitter's radiation pattern is 60° high by 60° wide and is vertically polarized.



■ PHOTO 1. No, it is not the monolith the apes danced around in *2001: A Space Odyssey*. The Powercast 915 MHz Powercaster transmitter has no knobs or configuration options that can be accessed in the field. It is what it is — a five volt powered, wall mountable, three watt 915 MHz transmitter. The power output and transmitter ID can be seen on the superimposed rear tag.

WHERE THERE'S RF, THERE'S PROBABLY AN ANTENNA

The Powercast Lifetime Power Energy development kit for wireless sensors includes the pair of antennae shown in **Photo 2**. The smaller printed circuit board (PCB)

■ PHOTO 2. The dipole antenna is intended for short range power production. The larger twin-bladed patch antenna has a defined radiation pattern and offers almost 4x signal gain over the dipole.

antenna is configured as a dipole. It is omni-directional and is intended to operate as a vertically polarized element. The linear gain of the dipole antenna is 1.25.

The larger patch antenna's RF connector is hidden from view on the back side of the larger of the antenna plates. Unlike the omni-directional dipole, the directional patch antenna has an energy pattern and a substantial amount of gain. The vertically polarized patch antenna has a linear gain of 4.1.

So far, we've established an RF energy source and a means in which to capture that energy. We need to convert the captured RF energy to power we can use to drive our PIC, radio, and sensors.

AN RF ENERGY HARVESTER

I'm sure that by now you know that the word "battery" will only be used to describe the absence there of. The P2110 Powerharvester receiver is an SMD module that converts RF to DC for micro-power devices used in battery-free applications. When it comes to help with RF energy harvesting, the P2110 receiver captured by the Canon in **Photo 3** only requires an antenna and a capacitor to squeeze 3.3 VDC out of the incoming RF. A voltage adjust resistor placed between the V_{SET} and V_{OUT} pins can be added to the receiver circuitry to raise the harvested voltage to a maximum of 5.25 volts, or lower the voltage to a minimum of 1.8 volts.

Take a look at **Figure 1**. The receiver sucks the harvested RF energy in from the antenna into its internal RF to DC converter. The converted DC is stored in a capacitor. The value and quality of the storage capacitor determines how much energy can be siphoned from the receiver's V_{OUT} pin. Lower value capacitors will yield shorter operation cycles. Larger value storage capacitors provide longer operation cycles.

Fred Eady's First Rule of Embedded Computing states that nothing is free. The tradeoff between a larger and smaller valued storage capacitor is the time that the storage capacitor takes to charge. Larger value storage capacitors provide longer operation cycles but take longer to charge. Consider this storage capacitor value equation:

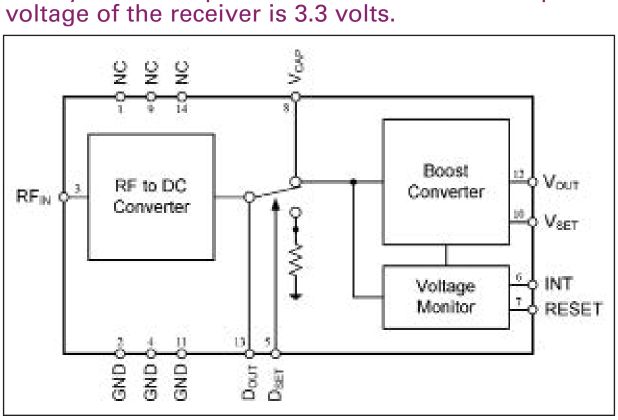
$$C = 15V_{OUT}I_{OUT}t_{ON}$$

Where:
C = Estimated storage capacitor value
V_{OUT} = Output voltage of the P2110
I_{OUT} = Average output current from the P2110
t_{ON} = On-time of the output voltage

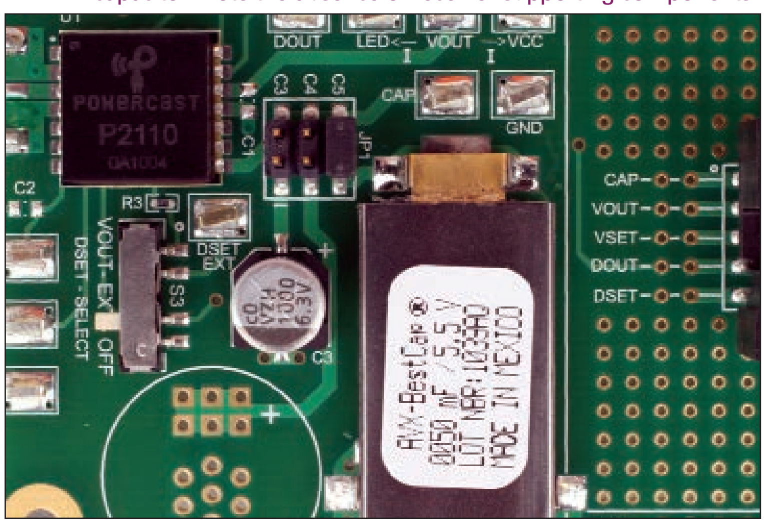
If we hold V_{OUT} at a constant value, it's easy to see that as on-time increases, the value of the storage capacitor must increase. The same holds true for I_{OUT}. The storage capacitor value must increase as current output demand increases. I_{OUT} and t_{ON} are also inversely proportional as the more I_{OUT} you require, the less t_{ON} you get and vice versa.

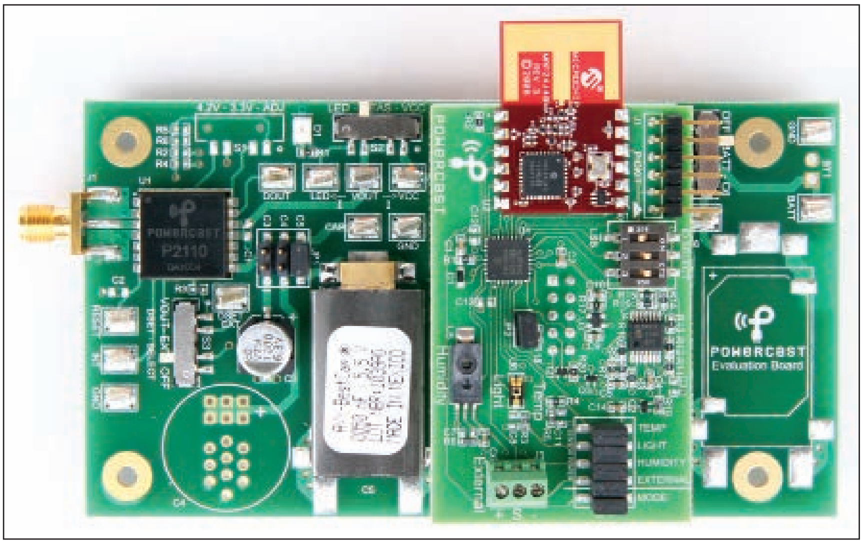
When the capacitor charge threshold is reached, the boost converter comes into play and boosts the storage capacitor voltage to a preset level. The boosted voltage is presented to the load on the receiver's V_{OUT} pin. If the receiver's V_{SET} pin is not hosting an

■ FIGURE 1. The P2110 Powerharvester receiver operation is logical. Basically, the harvested RF energy is stored in a capacitor and boosted for use by the micro-power device. The default output voltage of the receiver is 3.3 volts.



■ PHOTO 3. The high quality 50 mF capacitor stores the converted RF energy. The capacitor to its left (C3) is a test capacitor. Note the absence of receiver supporting components.





■ PHOTO 4. The P2110 Powerharvester receiver evaluation board has lots of hooks and is designed to be probed heavily. I took advantage of the hooks to grab a digital view of how the receiver behaves under the influence of the PIC24F16KA102 on the piggy-backed sensor module.

output voltage adjust resistor, the boosted voltage on the V_{OUT} pin will be +3.3 VDC. The receiver can source up to 50 mA of current. When the capacitor is discharged to its low voltage threshold, voltage to the V_{OUT} pin is turned off. Thus, the receiver supplies an intermittent stream of regulated power. The energy delivered in a power cycle is dependent upon the required load current and the power cycle on-time. Typically, a 15 mS power cycle is sufficient to drive a low power RF-equipped sensor node.

Let's revisit **Figure 1** and talk about the rest of the receiver's pins. Some of the pin functions are obvious. So, let's begin with the analog output pin D_{OUT} which provides an analog voltage level that corresponds to the harvested power. Remember the transmitter ID that is encoded in the RF power stream? Well, with the help of some basic analog circuitry, the D_{OUT} pin also plays an important part in capturing the transmitter ID frame.

The active-high D_{SET} digital input redirects the harvested DC power to an internal sense resistor. As you can see in **Figure 1**, the harvested power is diverted from the V_{CAP} pin and the storage capacitor is not charged while D_{SET} is logically high. The sampled receive signal voltage is routed to D_{OUT}. Thus, an RSSI (Received Signal Strength Indicator) function is enabled in this way with the D_{SET}/D_{OUT} pin pair.

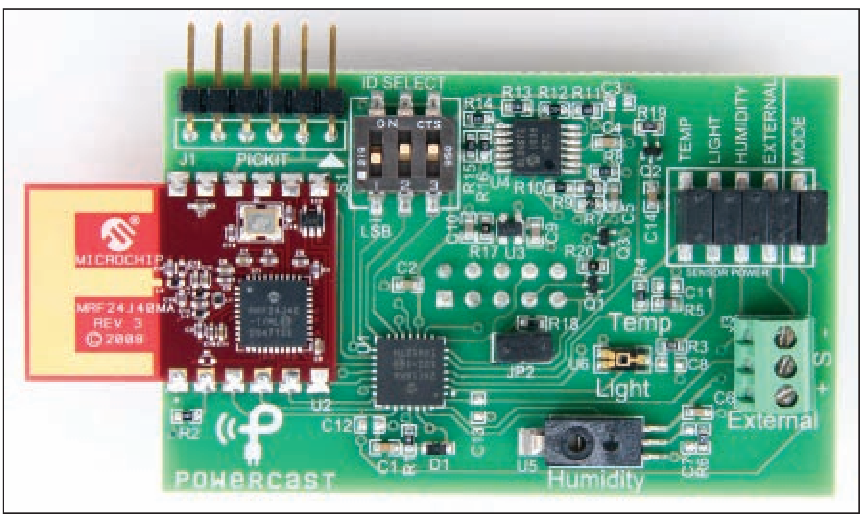
The P2110 receiver contains a voltage monitor subsystem that allows the voltage at the V_{OUT} pin to be turned off by applying a logical high to the RESET pin. Use of the RESET function allows the load voltage at V_{OUT} to be terminated before the storage capacitor reaches its low voltage threshold. Energy is conserved as the microcontroller can use the RESET pin to cut power immediately upon the completion of its task. In our case, the task is reading and transmitting the sensor data. In that the storage capacitor is not allowed to reach its low voltage threshold, the recharge time to our maximum charge threshold is shortened. Using the RESET pin has its advantages in that a larger value storage capacitor can be used to supply more energy to the load without impeding operational recharge time.

The voltage monitor's INT pin is a digital output that goes logically high when voltage is present at the V_{OUT} pin. The logically high level of the INT pin falls between the V_{CAP} maximum and minimum voltage levels which are 1.25 and 1.02, respectively. If the amount of harvested energy increases to a point as to drive the V_{CAP} voltage level above 1.25 volts, the receiver will clamp the V_{CAP} voltage to less than 2.3 volts. Clamping the V_{CAP} voltage protects low voltage supercaps that are used as storage capacitors.

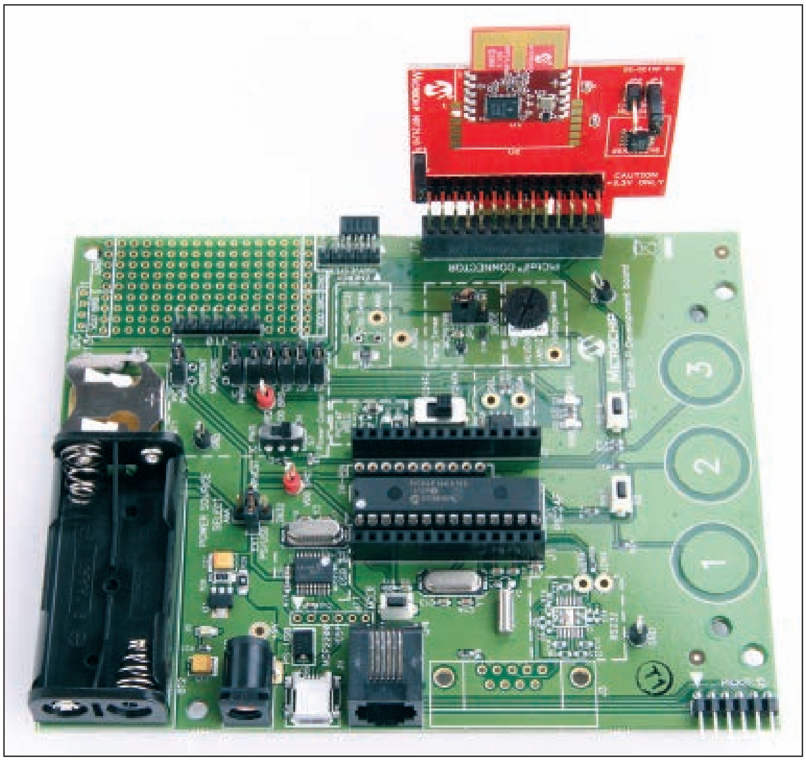
The receiver and the storage capacitor share real estate on the P2110 Powerharvester Receiver Evaluation Board which is acting as a motherboard for our sensor module in **Photo 4**.

WHERE THERE'S A PROBE, THERE'S PROBABLY A SIGNAL

The full brunt of the RF energy that is harvested by the P2110 receiver is aimed at the wireless sensor board you see in **Photo 5**. From left to right, the wireless sensor board is made up of a MRF24J40MA 2.4 GHz radio, a nanoWatt PIC24F16KA102



■ PHOTO 5. This is the typical rig a P2110 Powerharvester receiver would be assigned to. Every active component on this wireless sensor board has the ability — one way or another — to fall into a power-saving sleep mode. Note the PICkit connector.



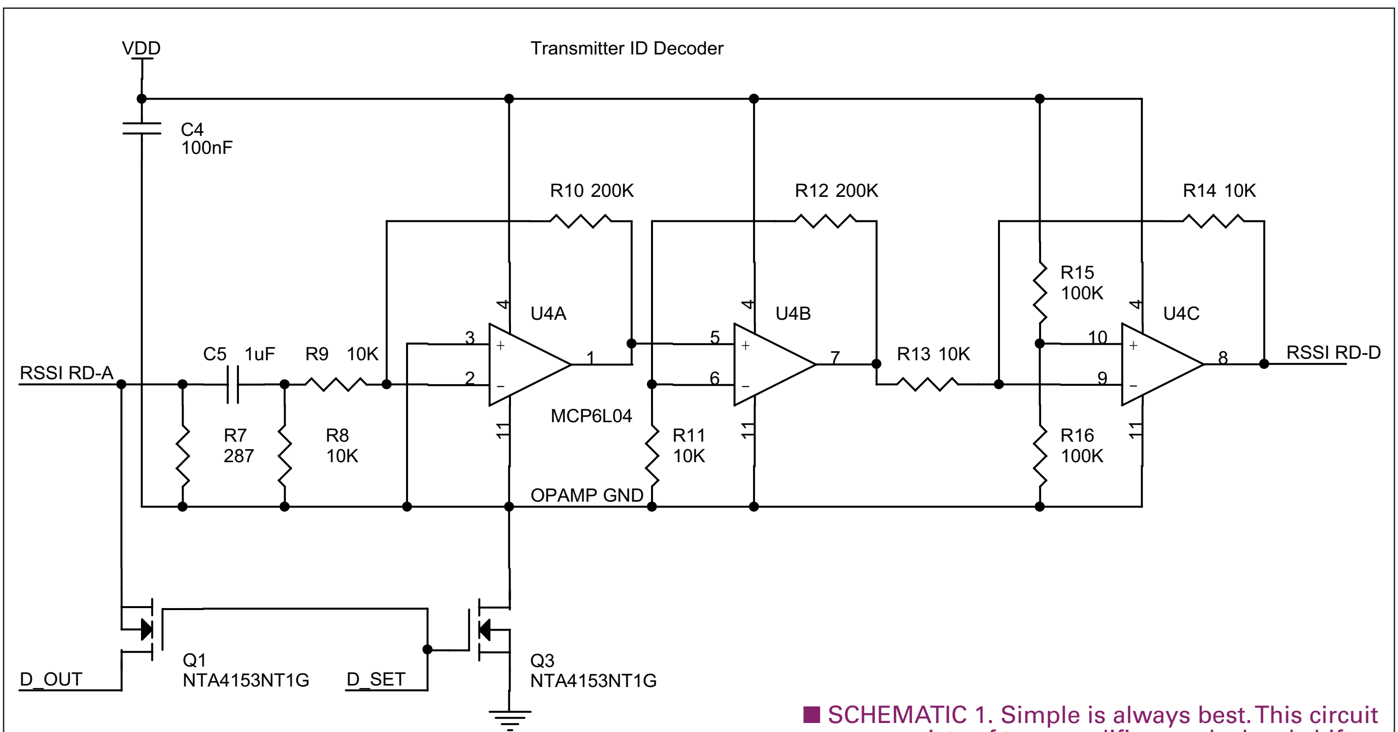
■ PHOTO 6. This is the access point whose sole purpose in this application is to gather the sensor data from wireless sensor boards and present it to humans via HyperTerminal.

microcontroller, a 3.0 volt LDO voltage regulator, an MCP6L04 operational amplifier, and a trio of sensors. There's also a PICkit programmer portal for those that want to roll their own code.

The MRF24J40MA mounted on the wireless sensor board is used by the PIC24F16KA102 to transmit the sensor data to an access point. Our access point — which is actually a Microchip XLP 16-bit development board — is under the lights in **Photo 6**. Basically, the access point is an MRF24J40MA coupled to a PIC24F16KA102 that supports an MCP2200 USB portal. The PIC24F16KA102's task is to collect and process the incoming sensor data and prepare it for display via a HyperTerminal session.

Recall that the 915 MHz Powercaster transmitter encodes its transmitter ID into the RF energy stream. The access point's application expects to see the transmitter ID in the wireless sensor board's sensor data stream. That means that the wireless sensor board must contain circuitry to decode the transmitter ID. The RF portion of the transmitter ID decode task is taken care of by the receiver. The transmitter modulates the transmitter ID using ASK (Amplitude Shift Keying). The receiver provides the demodulated transmitter ID logic levels at its D_{OUT} pin. The D_{OUT} logic levels — which are in RS-232 frame format — must be boosted to 3.0 volt logic levels before feeding them to the PIC24F16KA102's UART. That's where the MCP6L04 shines. The MCP6L04 is a quad rail-to-rail op-amp that only requires 85 µA of current for normal operation.

Let's walk the transmitter ID signal through it decoder circuit outlined in **Schematic 1**. The assigned PIC I/O pin drives D_SET logically high. At this point, the wireless sensor board application awaits the transmitter ID frame. Driving D_SET logically high turns on MOSFETs Q1 and



■ SCHEMATIC 1. Simple is always best. This circuit consists of two amplifiers and a level shifter.

■ SCREENSHOT 1. This CleverScope capture freezes the transmitter ID bit stream. Thanks to the MCP6L04, the bits presented to the PIC24F16KA102's UART transition are between 0 and +3.0 volts.

Q3. When D_SET is logically high, MOSFET Q3 powers up the MCP6L04 op-amp and MOSFET Q1 allows the receiver's analog D_{OUT} signal to drive the input of the powered-up op-amp array. Op-amp U4A is an inverting amplifier whose output feeds U4B which is a non-inverting amplifier. The signal at pin 7 of U4B is — as far as voltage goes — good enough to drive the PIC UART. Op-amp U4C's job is to establish a virtual ground that forces the amplified transmitter ID signal to swing logically high and logically low in a 3.0 volt environment. In simple terms, U4C is a level shifter.

Screenshot 1 is a CleverScope capture of the processed transmitter ID signal that appears at pin 8 of U4C. If you look carefully, you can see the RS-232 bits destined for the PIC's UART transitioning between 0 and +3.0 volts. The UART doesn't know that its incoming data stream didn't come from another UART and doesn't care. As long as the logic levels are met and the RS-232 frame requirements are in place, the UART will assemble the incoming bits and present the byte to the receive buffer for further processing.

THE DIGITAL VIEW

Pulling the transmitter ID out of the air is just one piece of the total power cycle. **Screenshot 2** is a Saleae logic analyzer view of a typical P2110 receiver power cycle. The Saleae logic analyzer sequence is triggered on the rising edge of the V_{OUT} pin, which corresponds with the initial application of power to the wireless sensor board. Let's walk through a receiver power cycle from the very beginning.

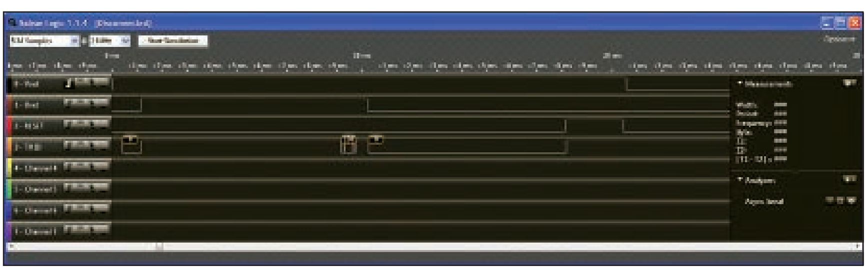
The 915 MHz transmitter is correctly positioned and powered up. A power stream of 915 MHz RF energy begins to emanate from the transmitter's integral antenna. Wireless sensor board antennae in the range of the transmitter soak up the RF energy and begin to feed it to the receiver. Each wireless sensor board is addressable via a three-position DIP switch. So, for the purposes of this discussion, let's concentrate on the wireless sensor board with a node address of 5 which is within range of the transmitter with an ID of 130.

At this point, the receiver is busy charging Node 5's 50 mF storage capacitor. Once the storage capacitor reaches it charge threshold, +3.3 volts appears on the receiver's V_{OUT} pin. The rising edge of V_{OUT} triggers the Saleae logic analyzer capture as power is applied to the number 5 wireless sensor board.

With power applied, the PIC24F16KA102 performs a POR (Power On Reset) and the sensor application is kicked off. Before the sensors are powered up, the wireless sensor board application attempts to retrieve a valid transmitter ID. According to the Saleae logic capture in **Screenshot 2**, 1.149 mS after power appears at V_{OUT}, the PIC24F16KA102 initializes the wireless sensor board, obtains the board's node address, sets the receiver D_{SET} pin, enables the UART, and waits for the UART to fish out a valid RS-232 frame:

```
// Initialize the system
BoardInit();
GetBoardID();
// Turn on circuit to read TX ID,
// and enable reading of RSSI later
PC_DSET = 1;
// Clear UART1 read buffer
U1RXREG;
U1RXREG;
U1RXREG;
U1RXREG;
// Clear RX buffer ready flag
IFS0bits.U1RXIF = 0;
// Enable UART1, used to read in TX ID
U1MODEbits.UARTEN = 1;
// Wait for UART1 to see a valid TXID
while(!IFS0bits.U1RXIF);
```

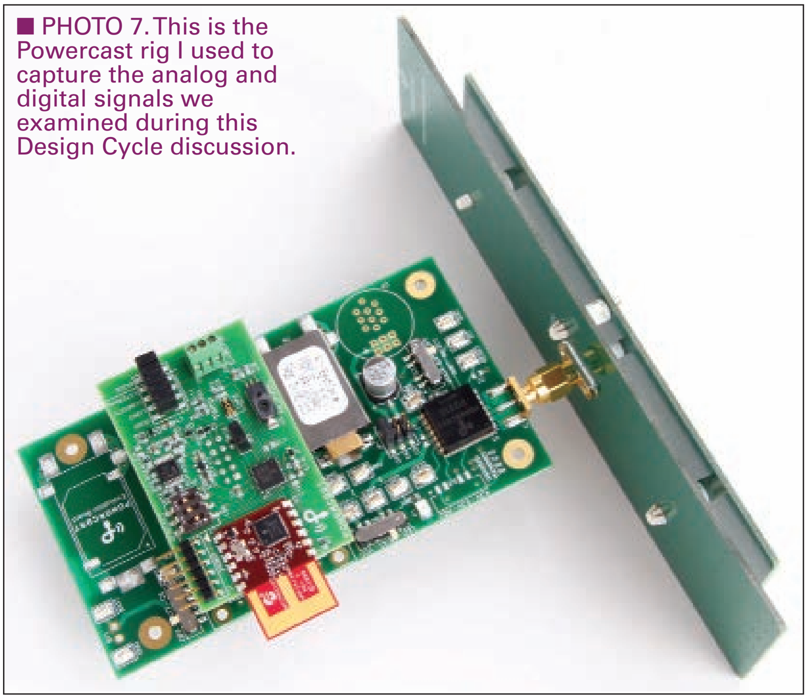
Pay particular attention to the comment "and enable reading of RSSI later." Let's revisit **Schematic 1** (the transmitter ID



■ SCREENSHOT 2. This is a digital capture of an actual Powercast P2110 Powerharvester receiver power cycle under the control of the PIC24F16KA102-equipped Powercast wireless sensor board you see in Photo 5.

decoder). When D_SET is driven logically high, MOSFET Q1 opens a signal path from the receiver's D_{OUT} pin to RSSI RD-A (RSSI READ Analog) which is the input of the transmitter ID decoder hardware module. What you don't see in **Schematic 1** is that the analog signal at RSSI RD-A is also routed to an analog-to-digital input on the PIC24F16KA102. So, while D_SET is logically high, an RSSI measurement is taken at RSSI RD-A during the sensor read task.

When a valid transmitter ID byte is received, it is saved for transmission by the MRF24J40MA in the 2.4 GHz sensor data stream and the analog-to-digital sensor read task is invoked. If a valid transmission ID is not received, the TXID value is set to 0xFFFF which indicates a transmitter ID receive error and the sensor read task is invoked. The termination of the sensor read task is indicated by forcing D_SET logically low. The Saleae logic digital capture in **Screenshot 2** tells us that the D_{SET} logical high duration for this power cycle was 9.031 mS.



■ PHOTO 7. This is the Powercast rig I used to capture the analog and digital signals we examined during this Design Cycle discussion.

The Saleae logic analyzer can be configured to capture and decode asynchronous serial data streams. So, I assigned an async serial analyzer to the Saleae logic analyzer's TXID input. As you can see in the capture, the transmitter ID was detected 7.9685 mS into the logically high D_{SET} period and decoded as 130 decimal (0x82 hexadecimal). Since all of the sensor read activity ended at the falling edge of D_{SET}, the sensor read task was completed in 0.4575 mS. Here's how the code fell into place during the remaining moments of the D_{SET} interval:

```
IFS0bits.U1RXIF = 0;    // clear UART1 ready flag
TXID = U1RXREG;         // read UART1 buffer
TXID_Check = TXID & 0x0100; // used to check for
                            // valid ID

// If an error occured while reading the TXID,
// wait for another one
if (U1STAbits.FERR == 1 || TXID_Check != 0)
{
       while(!IFS0bits.U1RXIF);

       IFS0bits.U1RXIF = 0;
       TXID = U1RXREG;
       TXID_Check = TXID & 0x0100;

       // This time, if an error occured
       // transmit the error code
       if (U1STAbits.FERR == 1 ||
       TXID_Check != 0)
       {
              TXID = 0xFFFF;
              }
              }

       // Disable UART1
       U1MODEbits.UARTEN = 0;

       // Get all sensor data
       AdcRun();
              // Turn off TX ID receiver
              // circuit, and disable RSSI
              PC_DSET = 0;
```

The quest for a valid transmitter ID involves a total of two tries before the UART is deactivated. The sensors are powered up and read along with the RSSI voltage in the AdcRun() function. Once all of the sensor data and RSSI data are captured, the D_{SET} pin is forced logically low by the PIC24F16KA102 and the sensor task ends.

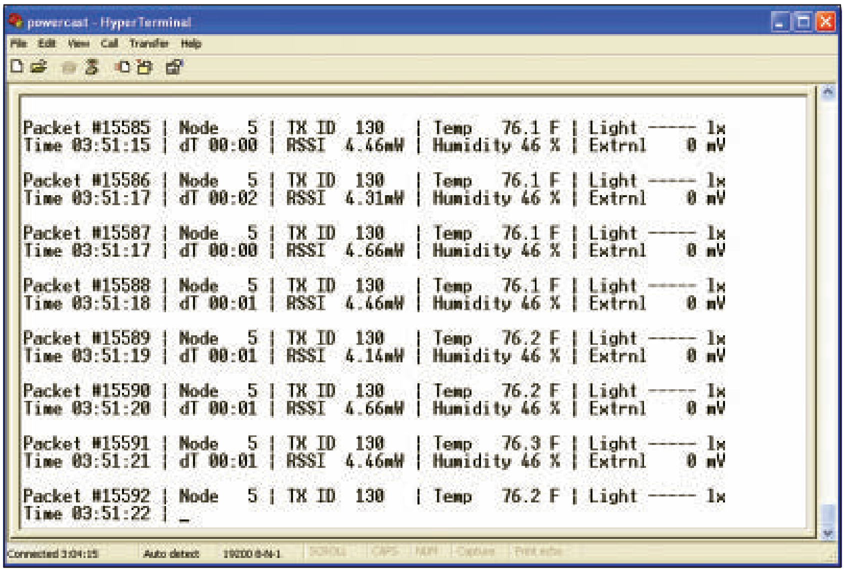
The remainder of the receiver power cycle (7.931 mS) is used to assemble and transmit the sensor data to the access point. Upon completion of the transmit cycle, the PIC asserts the RESET signal and terminates the voltage at the receiver's V_{OUT} pin. At this point, the power cycle is complete and the charging of the storage capacitor commences. The good news is that the assertion of the RESET signal does not allow the storage capacitor to reach its low voltage threshold. Thus, the storage capacitor recharge time is dramatically decreased.

The actual receiver power cycle time is 18.11 mS. The additional 2.4195 mS of power at V_{OUT} captured after the rising edge of the RESET signal is not being emitted by the receiver V_{OUT} pin.

At worst case, if there's enough energy available, the PIC falls into SLEEP mode after forcing the receiver's RESET line logically high:

```
MiApp_BroadcastPacket(FALSE); // Send packet
PHY_RESETn = 0;
PC_Reset = 1;          //force P2110 Power
                       //harvester Receiver HIGH
 Sleep();
while(1);
```

When the PIC24F16KA102 drives RESET logically high, the wireless sensor board sensors are not being powered. If the PIC managed to execute the SLEEP instruction, it is drawing minimal current. The receiver's V_{OUT} pin is driving the input of the 3.0 volt LDO voltage regulator and a 1.0 µF voltage regulator input capacitor. The charge held in the 1.0 µF voltage regulator input



```
powercast - HyperTerminal
File Edit View Call Transfer Help

Packet #15585 | Node   5 | TX ID  130   | Temp    76.1 F | Light ----- lx
Time 03:51:15 | dT 00:00 | RSSI  4.46mW | Humidity 46 % | Extrnl    0 mV

Packet #15586 | Node   5 | TX ID  130   | Temp    76.1 F | Light ----- lx
Time 03:51:17 | dT 00:02 | RSSI  4.31mW | Humidity 46 % | Extrnl    0 mV

Packet #15587 | Node   5 | TX ID  130   | Temp    76.1 F | Light ----- lx
Time 03:51:17 | dT 00:00 | RSSI  4.66mW | Humidity 46 % | Extrnl    0 mV

Packet #15588 | Node   5 | TX ID  130   | Temp    76.1 F | Light ----- lx
Time 03:51:18 | dT 00:01 | RSSI  4.46mW | Humidity 46 % | Extrnl    0 mV

Packet #15589 | Node   5 | TX ID  130   | Temp    76.2 F | Light ----- lx
Time 03:51:19 | dT 00:01 | RSSI  4.14mW | Humidity 46 % | Extrnl    0 mV

Packet #15590 | Node   5 | TX ID  130   | Temp    76.2 F | Light ----- lx
Time 03:51:20 | dT 00:01 | RSSI  4.66mW | Humidity 46 % | Extrnl    0 mV

Packet #15591 | Node   5 | TX ID  130   | Temp    76.3 F | Light ----- lx
Time 03:51:21 | dT 00:01 | RSSI  4.46mW | Humidity 46 % | Extrnl    0 mV

Packet #15592 | Node   5 | TX ID  130   | Temp    76.2 F | Light ----- lx
Time 03:51:22 | _

Connected 3:04:15   Auto detect   19200 8-N-1
```

■ SCREENSHOT 3. The access point application provides the packet number, time, and delta time. The raw data for the node, TX ID, RSSI, temp, humidity, light, and external display entries originated at the wireless sensor board.

capacitor is the only power source that is active. As shown in the Saleae logic capture, it takes 2.4195 mS for the charge on the voltage regulator input capacitor to dissipate.

POINTY HATS AND FEATHERS

Well, it looks like those guys and gals that wear those funny looking pointy hats adorned with moons and stars have done it again. Powering a PIC and a 2.4 GHz radio from radio waves is indeed a feather in their pointy caps.

THE REST OF THE STORY

Screenshot 3 represents the HyperTerminal output supplied by the access point application. The raw data used to produce the data in **Screenshot 3** originated in the Powercast equipment shown in **Photo 7**.

Every bit of Powercast code and every electrical connection we've discussed can be yours for a download from the Powercast website. The only thing you can't get from the website is the Saleae logic capture which is available from the *Nuts & Volts* site. Download the Saleae logic software if you want to use my session capture to double-check my timings.

The folks at Powercast figured you'd want to add their transmitter and receiver to your Design Cycle. So, they included a Microchip PICkit3 in the standard equipment included with the Powercast Lifetime Power Energy Harvesting development kit for wireless sensors. **NV**

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

SOURCES

Powercast Corporation
Powercast P2110 Powerharvester Receiver
Powercast 915 MHz Powercaster Transmitter
Powercast Wireless Sensor Board
Powercast Lifetime Power Energy Harvesting Development Kit for Wireless Sensors
www.powercastco.com

Microchip
XLP 16-bit Development Board (Access Point)
MRF24J40MA PICtail Daughter Card
PICkit 3 Programmer
www.microchip.com

Saelig Company
CleverScope
www.saelig.com

Saleae
Logic Analyzer
www.saleae.com

I2I Controls

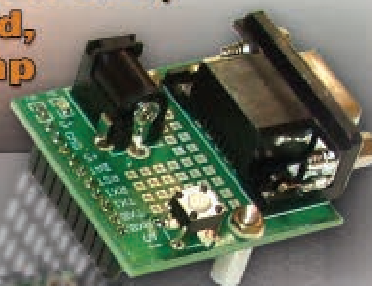
by engineers, for engineers

The SPECTRUM ACE™ 2a Starter Kit comes with the SPECTRUM ACE™ 2a CPU, the SPECTRUM ACE™ Comm Board, connector pack and a 5V DC 1 amp UL listed power supply.

The *full power* of ALEC™ is at your command!

for only

$119.00!



I2I Controls offers three different SPECTRUM ACE™ CPUs plus a number of expansion and evaluation boards, all ready to run right out of the box.

Don't be scared. Come inside and splash around. You never know, *you may even like it!*

All SPECTRUM ACE™ CPU boards contain ALEC™. With a built-in text editor, integrated debugging and trace, we make development easy.

The SPECTRUM LITE™ Evaluation Package comes with a SPECTRUM LITE™ CPU, the SPECTRUM LITE™ proto-board, and a 5V DC 1 amp power supply.

Whether you are a novice or an expert, this is a great way to get started!

$89.00

SPECTRUM ACE™ and ALEC™ are the perfect combination of power and intellect. Program embedded applications with ease. Our expansion boards all have an ALEC™ command interface, so every environment is fair game.

Start your day with a hot cup of coffee and end it *with a hot application!*

www.i2icontrols.com

Q&A

WHAT'S UP:

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

- ✔ Comb Filter Design
- ✔ Video Amp
- ✔ Hysteresis 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**

HYSTERESIS CIRCUIT

Q I have been trying to make a cut-out circuit for my solar panel/12V battery setup. I want a relay to close when the battery voltage reaches 12.5 volts and open when it drops below 10.5. I have tried using a LM393 comparator with a 6.2V Zener as a reference voltage. I can tweak the component values to get within range but 12.1 to close and 9.6 to open is the best I have been able to do. Any suggestions would be appreciated.

— Jim Adams

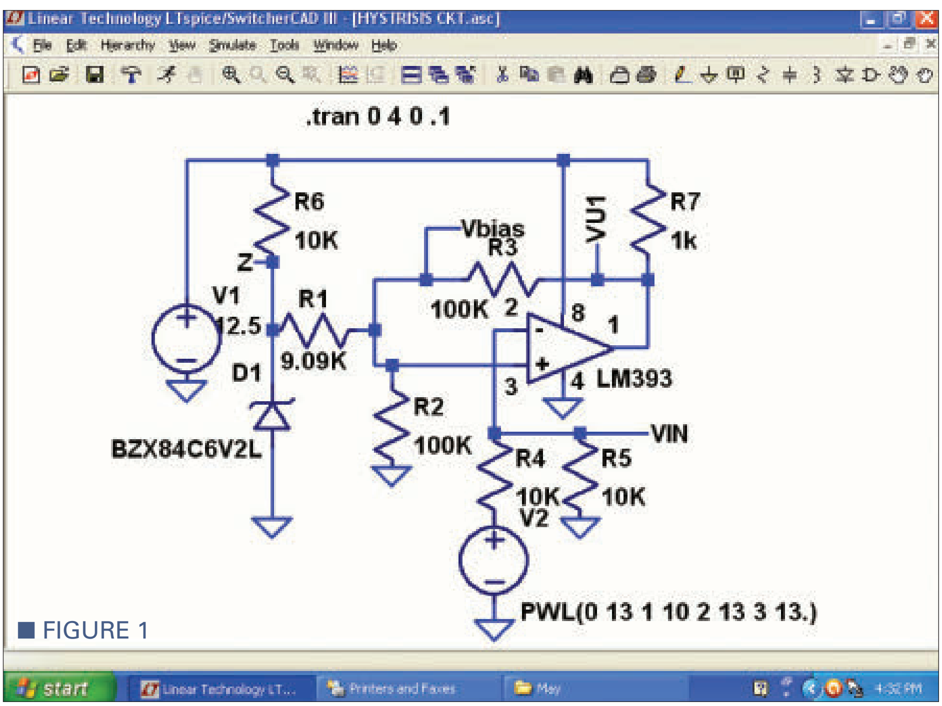
A I answered a similar question in the January '11 issue, page 24, but there was a typo in Figure 4 and I have improved the description. The solution to your problem is in **Figure 1**. Here is how the values are calculated:

First, divide the input so the measured input (Vin) is not greater than the reference voltage (Vref); in this case, 6.2V. Choose the feedback resistor (Rf), in this case, 100K. Estimate the high and low voltage at the output of the op-amp — (Vouthi) and (Voutlo). Calculate the high and low voltages at Vin (Vswhi) and (Vswlo), in this case, 6.25 and 5.25 volts. Then:

```
Vbias = (Voutlo*Vswhi –
Vouthi*Vswlo)/(voutlo – Vswlo –
Vouthi + Vsw hi)
Rb = Rf*(Vswhi – Vswlo)/(Vouthi
– voutlo – Vswhi + Vswlo)
```

Rb is the impedance of the voltage divider R1, R2, and Vbias is the voltage at the junction of R1, R2. The solution to that problem is:

```
Let k = Vbias/(Vref – Vbias),
 then
R1 = Rb*(1 + k)/k
R2 = k*R1
```



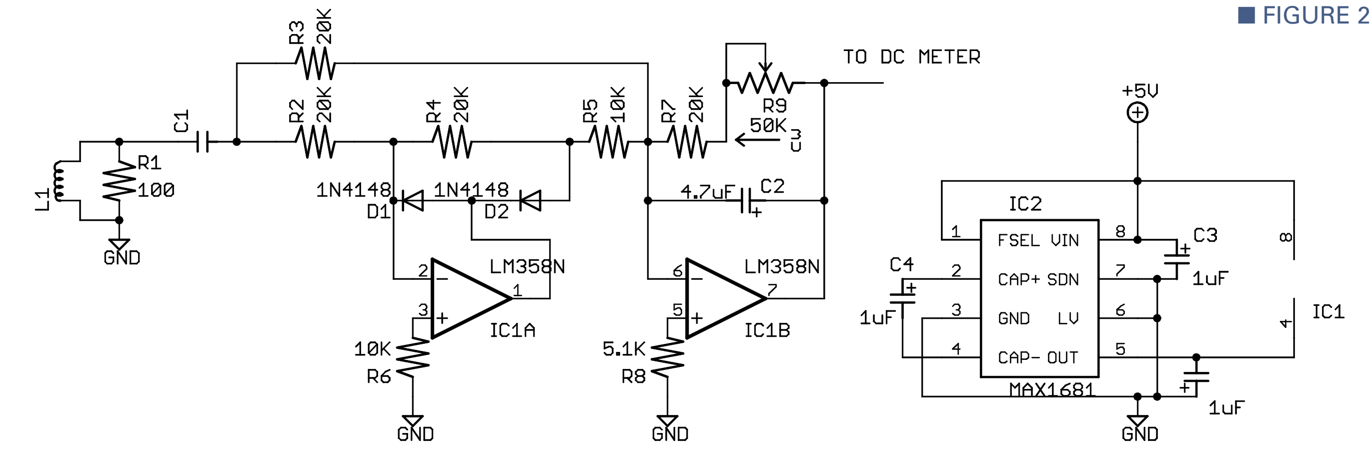
■ FIGURE 1

CURRENT TRANSFORMER/LED INDICATOR

Q In the February issue, you answered Bill Hosking's question concerning an indicator light for his spa. I have a similar issue but would like to detect and monitor the running of a deep well pump with a microprocessor. The pump is 230V, 1.5 HP. Could you expand on the possible use of a CT with a circuit to get a 3–5 volt DC output? I thought about using a pair of opto-isolators as the load for the CT, but realized this would only produce a 60 Hz pulsed output.

— Rick Hodges

A **Figure 2** is a full-wave rectifier circuit which will give 0 to 3.75 volts output using LM358, or zero to five volts using a rail/rail op-amp like



■ FIGURE 2

the MC33202. The max output can be adjusted via R9. The MAX1681 is used to make a negative voltage so that the zero current from the pump will give zero volts out. If you have a ± supply, the circuit can be simplified by eliminating the MAX1681. I assume that the startup current of the pump is 10 amps which — with a 1000:1 CT — will give 10 mA output and 1 VRMS across the 100 ohms. As noted in this month's **mailbag**, the output of the open circuit CT could be lethal, so be careful.

COMB FILTER DESIGN

Q Can a MAX-295 digital filter(s) make a bank of bandpass filters with the following needs?

0-500 Hz	LP filter
500-1500 Hz	BP filter
1500-2500 Hz	BP filter
2500-3500 Hz	BP filter
3500-4500 Hz	BP filter
4500-5500 Hz	BP filter
5500-6500 Hz	BP filter
6500-7500 Hz	BP filter
7500-8500 Hz	BP filter
8500-9500 Hz	BP filter
9500-10.500 Hz	BP filter
10.500-11.500 Hz	BP filter
11.500-12.500 Hz	BP filter
12.500-13.500 Hz	BP filter
13.500-14.500 Hz	BP filter
14.500 Hz	HP filter

Can this be done with a number of MAX-295 digital filter chips? There are 16 channels of bands I wish to filter for a project of mine.

— Craig Kendrick Sellen

A The MAX-295 is a low-pass filter and is not configurable to bandpass. It could do the first and last filters only. The LMF100 filter is a state variable type and can do low-pass, high-pass, and bandpass. The LMF100 is in stock at Arrow, Newark, and Digi-Key. You can also make a bandpass with op-amps, but there will be some frequency shift due to the phase shift of the op-amp. The nice thing about switched capacitor filters is that the frequency is determined by the clock. In the LMF100, the frequency is also determined by resistor ratios so you can make a stagger tuned filter using a one clock frequency.

The filters you have specified are constant bandwidth which

MAILBAG

Dear Russell: Re: Cat 5 cable tester, January '11, page 22. The capacitance of Cat 5 cable is quite tightly controlled at about 52 pF/m, so a capacitance meter can be used to easily distinguish between a connector with wire attached versus a connector with no wire attached. In fact, you can get pretty good estimates of the cable remaining in the box this way.

— Mark Dresser

Response: Thanks Mark, that is useful information.

Dear Russell: Re: A current indicator circuit, February '11, page 22. A reader who wishes to be anonymous wrote with some safety concerns regarding current transformer use.

1. Always provide a ground on the secondary.
2. Always provide a local physically protected low resistance load or short circuit across the CT.
3. The most likely fault is voltage breakdown of the secondary insulation.

— Anonymous

Response:

1. *I should have shown a ground on my schematic. A floating secondary can be at any potential.*
2. *A varistor or back-to-back zeners would be a way to protect the CT from damage.*
3. *A 1000:1 CT can produce a potentially lethal 10 mA if it is not loaded.*

Dear Russell: Re: Model Railroad Sequencer, January '11, page 25. I have a question regarding your Q&A column in January, where you are helping Dominick Senna with a model railroad sequencer. For the relay outputs on the 115 VAC side, you specified using a varistor to protect the relays from the inductive kickback of wall adapters turning off. I am not familiar with a varistor in this role; I would have gone with a bi-directional TVS diode. Is there an advantage in using the varistor over the TVS?

— Judy May

Response: They do the same job but I think the varistor is more reliable because it is not subject to short circuit failure. The varistor usually fails as open due to the wires fusing when overloaded.

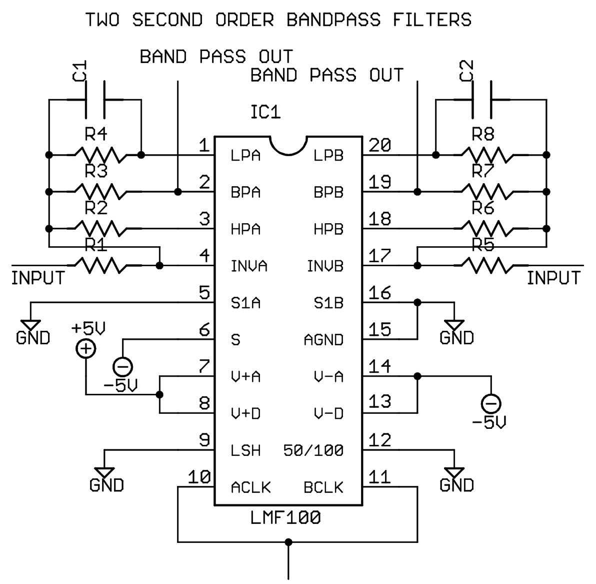


FIGURE 3

means the Q increases as the center frequency goes up. High Q filters are more difficult to build. It is usual to make a comb filter with constant Q designs such as 1/3 octave bandpass.

The LMF100 is a dual filter; I have designed the 13.5 kHz to 14.5 kHz, and 12.5 kHz to 13.5 kHz filters using each half of the chip to see how it works; see **Figure 3**. **Figure 4** is a plot of the response. **Figure 5** is a chart of the resistor values for the filters. I built the high and low end to see if all the bands can be realized with a single clock frequency. It sort of worked at the low end but the value of R4 was 134.3K, the center frequency was 1,007 Hz instead of 866, and the output was distorted below 600 Hz. I reduced the clock frequency to 100 kHz, increased R2 to 10K, and reduced R4 to 13.3K (13.3 is a standard 1% value). The center frequency then was 860 Hz and there is no distortion at low frequencies. Based on that experience, I recommend keeping R4 as low as practical. **Figure 6** is a plot of the low-pass and high-pass filters.

VIDEO AMP

Q When it comes to RF and video, I don't know what to do. I just bought a 24 foot cable to tie my laptop into my new HDTV. The cable I bought has an S-video and sound jacks on one end, and the standard yellow, red, and white RCA jacks on the other end.

I believe the cable is the problem, where the signal is marginal. The audio is great. When I first plugged in the cable, the picture was black and white so I thought that maybe this is the wrong cable. After 10 minutes, all of a sudden the color came on and stayed for an hour, but then it went back to black and white. Another six minutes and the color was on again.

What I believe I need is a video booster of some kind at the TV end with RCA jacks for both in and out. It would be good if the circuit ran on nine volts; I would know the battery was dead when the TV lost color.

— Toby Norton

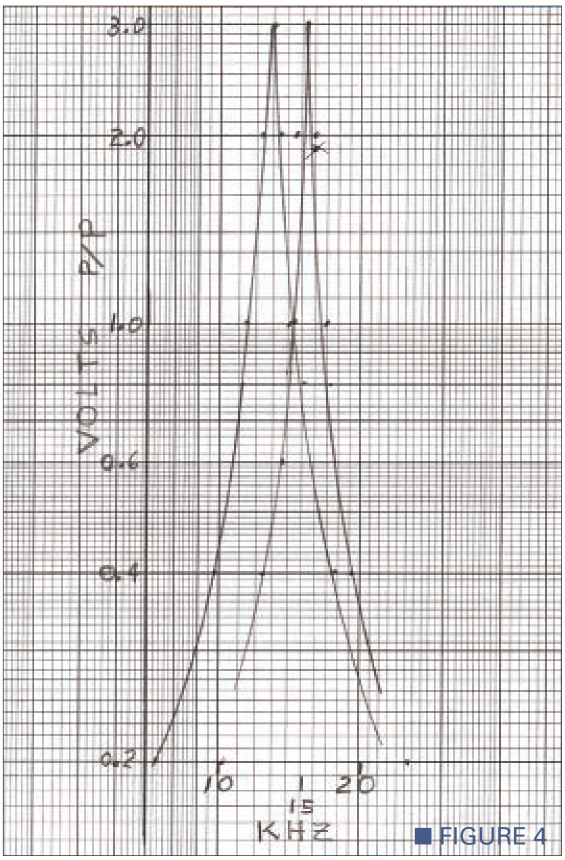


FIGURE 4

FIGURE 5. Resistor Table.

BAND	F0	Q	R1/R5	R2/R6	R3/R7	R4/R8
HZ	HZ		OHM	OHM	OHM	OHM
Clock frequency = 100 KHz						
0 – 500	500	.707	10K	2500	3535	10K*
500 – 1500	866	.86	10K	10070	10K	13.43K
1500 -2500	1940	1.93	10K	10050	10K	2671
2500 -3500	2960	2.95	10K	10030	10K	1145
3500 -4500	3970	3.96	10K	10030	10K	636
Clock frequency = 1 MHz						
4500 -5500	4970	4.96	10K	1002	10K	4057
5500 – 6500	5980	5.96	10K	1003	10K	2806
6500 -7500	6980	6.97	10K	1001	10K	2055
7500 -8500	7980	7.97	10K	1001	10K	1572
8500 -9500	8990	8.96	10K	1003	10K	1241
9500 -10.5K	9990	9.96	10K	1003	10K	1005
10.5K – 11.5K	11K	11	10K	1K	10K	826
11.5K – 12.5K	12K	12	10K	1K	10K	694
12.5K – 13.5K	13K	13	10K	1K	10K	592
13.5K – 14.5K	14K	14	10K	1K	10K	510
14.5K – HIPASS	14.5K	.707	10K	10K	4876	4756**
You can useclosest 1% resistor value but if frequency is critical, include a variable with R4.						
*Output from pin 1 or 20						
** Output from pin 3 or 16						

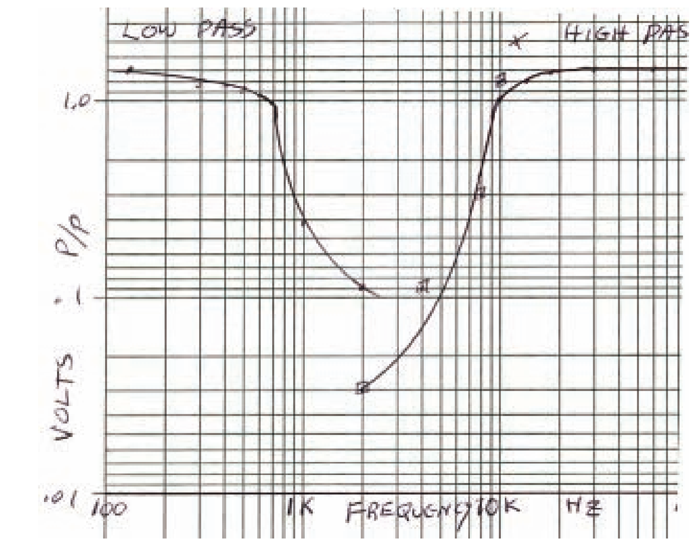
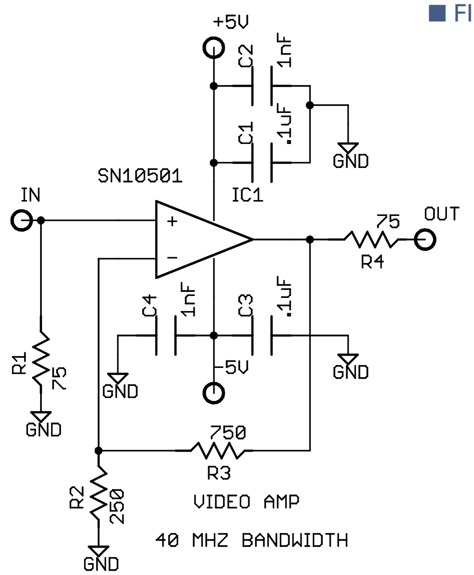


FIGURE 6

A I think you are right; the cable is the problem. There is bound to be loss in the conversion of S-video to NTSC video. The conversion degrades the video and 24 feet is a tripping hazard, so I recommend that you throw that cable away and buy a shorter cable that is S-video on both ends. I am sure your new HDTV has an S-video input jack.

That being said, if you still want to try the video amp, try the circuit of **Figure 7**. The IC has a gain of four but 6 dB is lost in the cable, so the overall gain is two. I think you could get away with making R2 75 ohms which would give the IC a gain of 10 and an overall gain of five. The bandwidth would only be 10 MHz, but standard TV is only 6 MHz so the definition should still be good. I have provided a layout in **Figure 8** because a high frequency layout is not for the faint of heart. I don't recommend running this video amp on a nine volt battery because you will be replacing it weekly or so, depending on how much TV is watched. **NV**

FIGURE 7



PARTS LIST

PART	DESCRIPTION	PART NUMBER	PRICE EA
IC1	VIDEO AMP	595-SN10501D	2.01
R1, R4	75 OHM, 1%, 1/8W	290-75-RC	0.05
R2	250, 1%, 1/8W	290-249-RC	0.05
R4	750, 1%, 1/8W	290-750-RC	0.05
C1, C3	0.1uF, 50V, X7R	140-CC502B104K-RC	0.09
C2, C4	1000pF, 50V, X7R	140-CC501B102K-RC	0.04
RCA JACK	(2) GOLD CONTACT	164-4321	2.07

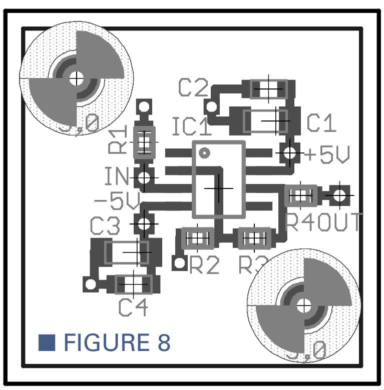
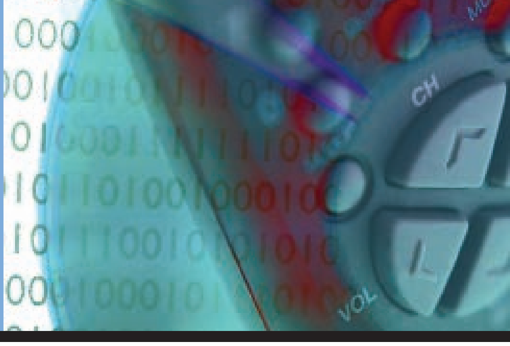


FIGURE 8



NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

GSPA SERIES PROTOTYPING ADAPTERS

Global Specialties announces the release of a series of five new high-end prototyping adapters. The GSPA series includes a variety of PLCC and SOP to DIP adapter packages which are built to provide maximum surface contact for years of reliable use. The GSPA series adapters are perfect for education, prototyping, production, and R&D, where high reliability component testing and multiple-use applications are required. Each model is sold separately and is compatible with all Global Specialties electronic trainers and solderless breadboarding systems. Model numbers in this series include:

- GSPA-PLCC-32: 32-pin PLCC to DIP Adapter
- GSPA-PLCC-44: 44-pin PLCC to DIP Adapter
- GSPA-PLCC-48S: 48-pin PLCC to DIP Adapter
- GSPA-SOP-8B: eight-pin SOP to DIP Adapter
- GSPA-SOP-16: 16-pin SOP to DIP Adapter

For full product specifications for these new high-end prototyping adapters, as well as the complete line of other Global Specialties Prototyping and Test & Measurement products, visit their newly updated website listed below.

For more information, contact:
Global Specialties, LLC
22820 Savi Ranch Parkway
Yorba Linda, CA 92887
Frank Menichello: **800-572-1028**
Web:
www.globalspecialties.com

MINIMA 6T AND MINIMA 6E SIX-CHANNEL, FULL-RANGE MICRO RECEIVERS

Utilizing their advanced 2.4 GHz AFHSS technology, Hitec's new full-range micro receivers are an excellent choice for modelers flying smaller aircraft. The Minimas are available in both top- and end-pin configurations, and feature Hitec's exclusive, dual-diversity mini boosted, omni-directional antenna (M-BODA). With wide voltage operation from 4.8 to 8.4 volts, these receivers can bring more to your hobby.

Minima 6T — Top Port
6 Channel 2.4 GHz AFHSS Micro Receiver
Features:
- Smart Scan Mode
- Dual Diversity Mini Boosted Omni-Directional Antenna (M-BODA)
- Hold and Fail-Safe Function
- Wide Operating Voltage: 4.8~8.4 volts
- Full Range Operation

Specifications:
- Dimensions: 1.22 x 0.82 x 0.28 in
- Weight: 0.23 oz

Stock#: 26610
Estimated Street Price: $46.49

Minima 6E — End Port
6 Channel 2.4 GHz AFHSS Micro Receiver
Features:
- Smart Scan Mode
- Dual Diversity Mini Boosted Omni-Directional Antenna (M-BODA)
- Hold and Fail-Safe Function
- Wide Operating Voltage: 4.8~8.4 volts
- Full Range Operation

Specifications:
- Dimensions: 1.25 x 0.82 x 0.43 in
- Weight: 0.23 oz

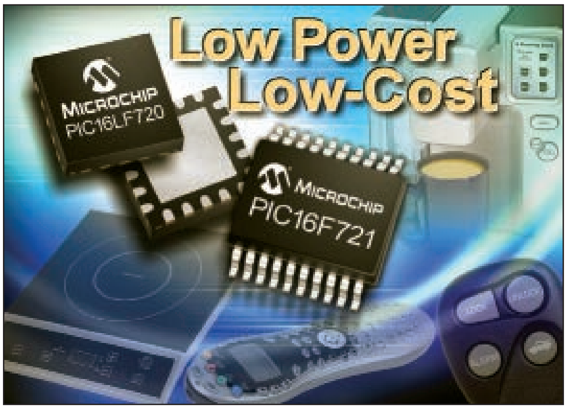
Stock#: 26612
Estimated Street Price: $46.49

For more information, contact:
Hitec
12115 Paine St.
Poway, CA 92064
Tel: **858-748-6948**
Fax: **858-748-1767**
Web: **www.hitecrcd.com**

NEW 20-PIN FAMILY

Microchip Technology Inc., announces the expansion of its existing 28-/40-pin PIC16F72X microcontroller (MCU) family with two new 20-pin devices: the PIC16F(LF)720 and PIC16F(LF)721. The new MCUs feature low power consumption making them suitable for various low-power and battery-powered applications. These MCUs offer up to 7 KB of self-write Flash program memory, a temperature-indicator module, an eight-bit analog-to-digital converter (ADC), a capture/compare PWM module, and various serial communication peripherals, such as I²C, SPI, and AUSART.

The highly integrated MCUs enable engineers to reduce board size, component count, and overall cost for a variety of applications in the appliance (e.g., blenders, refrigerators, dishwashers); consumer/home electronic (e.g., TV remote controls, toys, phones, set-top boxes); industrial (e.g., digital water heaters, security systems, humidity sensors); and automotive (remote lock systems, power seats, level sensors, lighting control) markets, among others. The PIC16F(LF)720/1 are general-purpose MCUs that offer integrated control peripherals with newer features, such as self-write memory and a temperature indicator module. The self-write Flash program memory can be used to perform remote firmware updates, while the temperature-indicator module provides a means for measuring the temperature of the surrounding environment. Additionally, the integrated communication peripherals can be used for serial data transfer between other devices on or off the PCB. These MCUs are available in packages as small as a 4 mm x 4 mm QFN, to enable space-constrained applications. The PIC16F(LF)720/1 MCUs are available in a 20-pin, 4 mm x 4 mm QFN package, as well as 20-pin PDIP, SOIC, and SSOP packages.



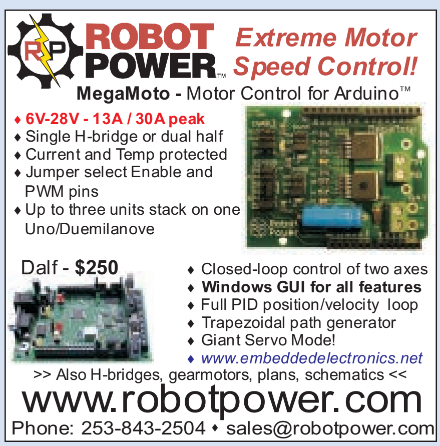
For more information, contact:
Microchip Technology, Inc.
Web: **www.microchip.com**

HT67Fxx TinyPower™ A/D WITH LCD FLASH MCU SERIES

Holtek announces the release of its new eight-bit TinyPower™ A/D with LCD type Flash MCU series. This device series includes the full feature range of the Enhanced Flash MCUs while also incorporating Holtek's unique TinyPower technology. With its ultra low power consumption, fast wake-up, multiple clock sources, and range of operating modes that greatly reduce power requirements, this new device range is positioned to meet the demands of today's environmentally conscious products. The device range is suitable for applications such as household appliances,

continued on page 77

SHOWCASE




do more wire less
Wixel
USB. Wireless. Programmable. All for $19.95.
Introducing the Wixel, a programmable microcontroller module with integrated USB and a 2.4 GHz radio. Write your own program or load pre-compiled, open-source apps to give your next project a wireless serial link, create a remote sensor network, and so much more.
actual size
Pololu
Engage Your Brain
learn more at www.pololu.com/wixel

IT'S SPRINGTIME AT RAMSEY!

Four-Mode Keyless Entry Test Set NEW!

- ✔ Troubleshoot vehicular keyless entry and wireless remote control systems!
- ✔ Detects and verifies key fob to vehicle signals as well as vehicle to key fob signals!
- ✔ Separate visual indicators for the presence of 315/433MHz, 125kHz, 20kHz and IR signals!
- ✔ Can also test virtually any wireless IR/RF control and building access systems!
- ✔ Can even test household and home entertainment IR remote controls for the presence of IR signal output!

Ahh!!... the conveniences of today's technology in our modern world! Voice recognition, LED's instead of incandescent bulbs, on-board computers, on-board hard drives, automatic parallel parking, automatic radar cruise control, and of course, wireless remote controls! They make it so simple, just have the "key" (called a key fob) somewhere in your pocket or purse, get near the vehicle, it knows that you are there! Touch the door handle and the vehicle unlocks. Get in and touch the start button and the vehicle starts. You have yet to use a key through the whole process! And don't forget all the wireless controls for your house lights, building access and entertainment systems. They're so great… until they don't work!

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!

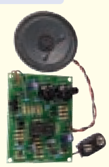
WCT3	Four-Mode Keyless Entry Test Set Kit	$59.95
WCT3WT	Four-Mode Keyless Entry Test Set, Factory Assembled & Tested	$99.95

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171	Voice Changer Kit	$14.95

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.

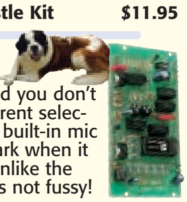
MK134	Steam Engine & Whistle Kit	$11.95

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

The Learning Center!

Beginners To Advanced... *It's Fun!*

- ✔ Learn and build!
- ✔ 130, 200, 300, & 500 in one electronic labs!
- ✔ Practical through hole and SMT soldering labs!
- ✔ Integrated circuit AM/FM radio lab!
- ✔ Fuel Cell, Solar Hydrogen, and Bio-Energy labs!
- ✔ 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!

PL130A Gives you 130 different electronic projects together with a comprehensive learning manual describing the theory behind all the projects.

PL200 Includes 200 very creative fun projects and includes a neat interactive front panel with 2 controls, speaker, LED display and a meter.

PL300 Jump up to 300 separate projects that start walking you through the learning phase of digital electronics.

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

SP3B Whether young or old, there's always a need to hone your soldering skills. Either learn from scratch or consider it a refresher, and end up with a neat little project when you're done!

SM200K Move up to Surface Mount Technology (SMT) soldering, and learn exactly how to solder those tiny little components to a board!

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

Look for the QR tag like this throughout our catalog and print ads. Use the Tag app in your smart phone to automatically get more information for that specific product, or in this case, it will take you right to ***www.ramseykits.com!***

- ✔ *Build It!*
- ✔ *Learn It!*
- ✔ *Achieve It!*
- ✔ *Enjoy It!*

Follow Us and SAVE $$

Follow us on your favorite network site and look for a lot of super deals posted frequently... exclusively for our followers!

Digital Controlled FM Stereo Transmitter

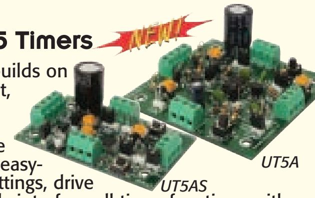
- ✔ PLL synthesized for drift free operation
- ✔ Front panel digital control and display of all set tings and parameters!
- ✔ Professional metal case for noise-free operation
- ✔ EMI filtering on audio and power inputs
- ✔ Super audio quality, rivals commercial broadcasts
- ✔ Available in domestic kit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

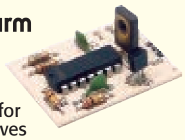
TS1 **Touch Switch Kit** **$9.95**

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**

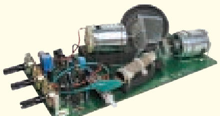
Mad Blaster Warble Alarm



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**

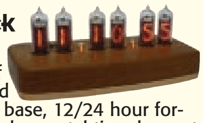
Laser Light Show



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**

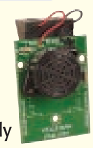
Retro Nixie Tube Clock



Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.

IN14TM **Teak Maple Nixie Clock Kit** **$329.95**

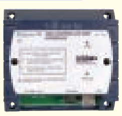
Water Sensor Alarm



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**

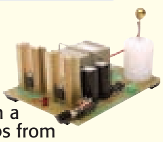
USB DMX Interface



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**

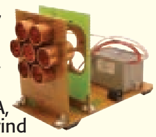
HV Plasma Generator



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**

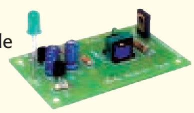
Air Blasting Ion Generator



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 airshows, hears the active traffic as it happens! Available kit or factory assembled.

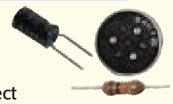
ABM1 **Passive Aircraft Receiver Kit** **$89.95**

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**

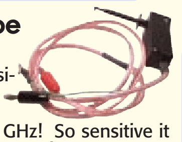
Electret Condenser Mic



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**

Get the latest 2011 Ramsey Hobby Catalog today! Filled with some of the neatest goodies around! Order yours today... Or be green and download the PDF at *www.ramseykits.com/catalog!*

800-446-2295
www.ramseykits.com

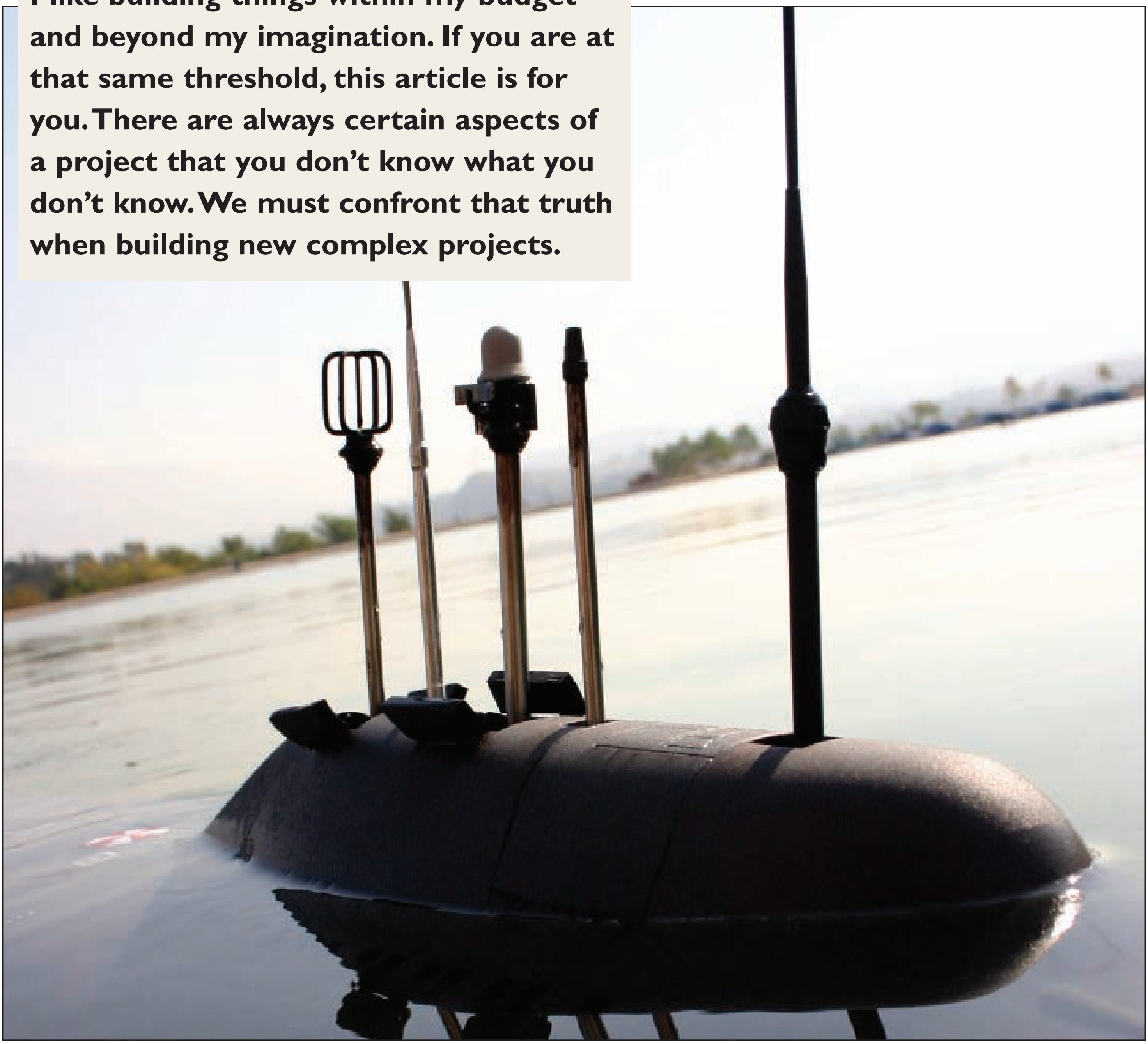
RAMSEY ELECTRONICS®
590 Fishers Station Drive
Victor, NY 14564
(800) 446-2295
(585) 924-4560

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

Part 1

By Michael Wernecke

I like building things within my budget and beyond my imagination. If you are at that same threshold, this article is for you. There are always certain aspects of a project that you don't know what you don't know. We must confront that truth when building new complex projects.



If building a submarine interests you, I have here a great project that will give you some good ideas and many techniques to learn. If you have a robotics project or an all-terrain vehicle or boat, follow along as I have some great building secrets to share with you, too.

Background

At the time I considered this project, I was working for the Disney Company as a model builder for the movies "Con-Air" and "Deep Rising." I was hopeful that my project might succeed with a little help from the Disney model building geniuses. I would learn and deal with devices and concepts unknown to me at the time of initial commitment, and this developing knowledge would make my Alfa submarine project a reality. Though not an engineer — but with some experience in the Army Engineer Corps as a heavy equipment repairman — I eventually evolved as one, with this submarine project as a measure of my skills.

I didn't know very much (in fact, I knew almost nothing) about air pressure control, compressed air holding tanks, manometers, Mapp gas, silver soldering copper, casting in urethane, casting tin bismuth in a silicon rubber mold at temperature, making complex silicon rubber molds or making prototypes of cardboard and wood before committing to metal fabrication; anodizing, using potting compounds, making various tools to make parts, the importance of wire gauge and of amperage, and many other issues regarding this build. Thus would begin a 10 year electro-mechanical nautical engineering project.

The construction and design of the operating system were to come from some general ideas mostly from my imagination and some well thought out common sense engineering. I didn't know at that time, but I was going to stretch my creative model building brain cells to their maximum. My motivating inspiration was to utilize an on-board air compressor to fill a pressure tank to expel air to blow ballast.

I built a 22 inch long model R/C sub sold by a company in Germany and I was very intrigued by the nature of a radio-controlled submarine. I succeeded with that model building endeavor and decided to take on a larger, more ambitious sub building project. I thus attempted to build part-for-part a five foot radio-controlled Russian Alfa class submarine. I designed and built the entire operating system.

Keeping The Water Out

Essential to the submarine — and contradictory to its nature — is to keep all interiors of the electrical/mechanical compartments dry.

The Alfa hull was to include five watertight capsules enclosed in four inch and seven inch diameter tubing. The hull included rudders and housings, propeller and shaft, alignment pins, rudder yokes, antenna array, clips to hold the top hull half to the lower hull half, the 12 volt battery, and the motor reversing relay switch. The first section is the rear watertight compartment housing the rudder servos and the 12 volt Pittman motor.

The second watertight compartment is the electrical heart of the ship containing the incoming power, as well as the speed control, R/C receiver, automatic pitch control, motor reversing mini servo, air compressor on-off micro switch, and ballast blow micro switch and servo.

The third watertight compartment (made up of a seven inch diameter PVC pipe) contains the air compressor, two Clippard valves for ballast blow and incoming air, and the servo to open the ballast tank air evacuation hole. The fourth area is the ballast tank and compressed air holding tank located within the ballast tank. The final capsule contains the motor reversing relay.

These capsules all have end-caps with a rubber sealing gasket at each end.

What exactly is pressfitting?

Pressfiting is pressing an item (standoff) into another part (propeller hub) with an arbor press. The 25/64" hole in the hub is slightly smaller than the six-sided threaded standoff and needs no glue to hold it in place.

Plans And Plugs

I liked the simple exterior design of the Russian Alfa Class sub and I found I could buy plans for it through a Canadian company called Deep Sea Designs. My concern was building an operating system more than building up a complex sub with detailed deck work, deck cannons, and railings.

The plans arrived and needed some verification as some Department of Defense (DoD) photos of the Alfa exterior didn't match what the plans showed. The plans have only surface details and the sections on them. The interior was totally engineered by me.

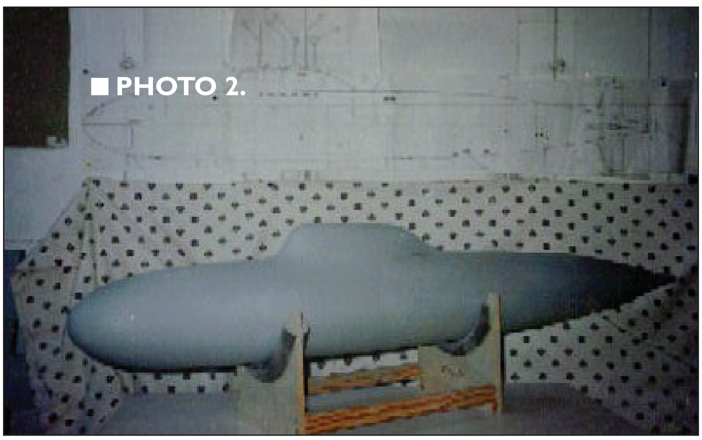
There weren't many details available of the Alfa then, and there still aren't now. The DoD released some photos of the Alfa at sea and that's about it. I found that the sail (conning tower) was too short on the blueprints, so I lengthened it to match the DoD photos.

The hull buildup is the same as building an airplane fuselage or planking a wooden ship model. Balsawood and plywood are the materials of choice for the hull plug (the plug is the solid hull from which the mold is made).

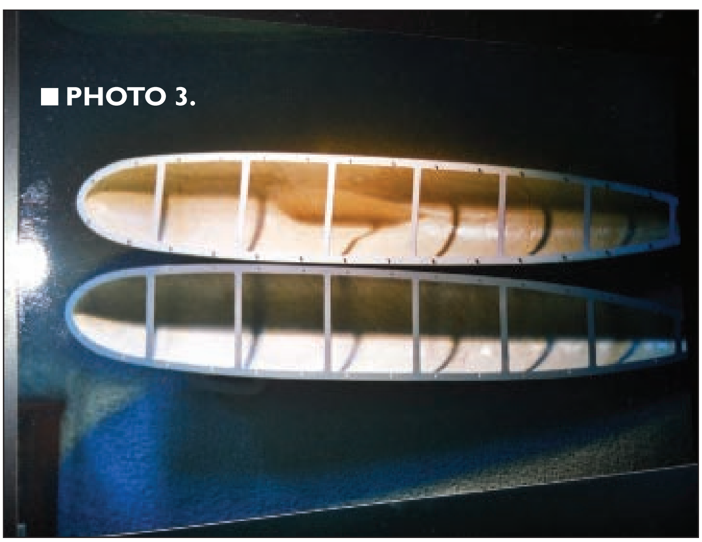
The plug is discarded after use and provides the stepping off point for surface details such as the hatches, torpedo tubes, vent holes, and doors.

I made the conning tower separately and attached it later to the main plug. All the hatches, torpedo tubes, and vent holes had to be located, as well as the ship centerline for later casting in two parts. After I trimmed and sanded the balsa plug, I coated it with epoxy and engraved the hatch and vent hole locations with a carbide tipped tool. I made templates where necessary and located 75+ locations top and bottom.

■ PHOTO 1.



■ PHOTO 2.



■ PHOTO 3.

The completed finished hull plug is shown with me holding it in **Photo 1**. **Photo 2** shows the finished hull plug with a profile of the blueprint shown in the background. I made a two-part fiberglass/epoxy mold and cast the two-part hull shown finished in **Photo 3**. The hull upper and lower halves were cast in fiberglass cloth impregnated with epoxy resin. **Photo 4** shows a close-up of the stern alignment pins.

This hull building procedure can be applied to any original model robotic device one may wish to make. It also remains the standard procedure to follow. Epoxy mold building and casting is not easy, and trying it first on a small scale is advisable. Epoxy has various setup times so using something one is familiar with will save time and product. Remember, I selected a very simple two-part hull to cast. A more complicated shape would require a more complex plug and mold; experience is the key to success.

Making Prototypes

Other hull components like rudder brackets, rudders, hatches, and the propeller were all wooden prototypes cast in hard urethane plastic "siltool A/B" produced by Silpak, Inc., in Pomona, CA. These were cast from simple two-piece molds providing good practice for the more difficult mold used for the propeller. A great product to make rubber molds from is the crazy sounding "OOMOO." Google this name, and there it is. The OOMOO producers have removed the air from the two-part OOMOO, thus creating an air bubble free mold. I recommend this, though I found out about it only recently. I used a Silpak two-part silicon rubber mold material that also worked fine, but did produce bubbles under flat parts. I have no vacuum chamber to extract air. **Photo 5** shows my mold setup. I used this wooden base and support style on three of my molds and I liked the idea.

■ PHOTO 4.

The mold is stabilized and easy to work with. The mold in **Photo 6** shows my early solution to casting the rudder extensions and the creeper propellers at the same time. The creeper propeller acts as the air/gas escape sprue and casts the creeper propeller at the same time. Later, I cast the creeper propeller separately in tin bismuth — a fairly low melting point alloy. The tin bismuth could be poured directly into the silicon mold while hot, without damage to the mold. I couldn't believe this until I tried it. White metal works the same.

It Gets Complicated

Here comes some real mold building fun. I had planned to have the propeller made at a machine shop out of brass, but I found the cost rather prohibitive. Thus, I decided to make the propeller myself.

When I began this project, I had some uncertainty regarding the propeller. I found no actual photos of it. I went strictly by Greg's blueprints. I was almost convinced that the propeller was actually a scimitar type like the Akula submarine and not the five-bladed one on the drawing. I decided to go with the five-blade design which I found out later to be correct.

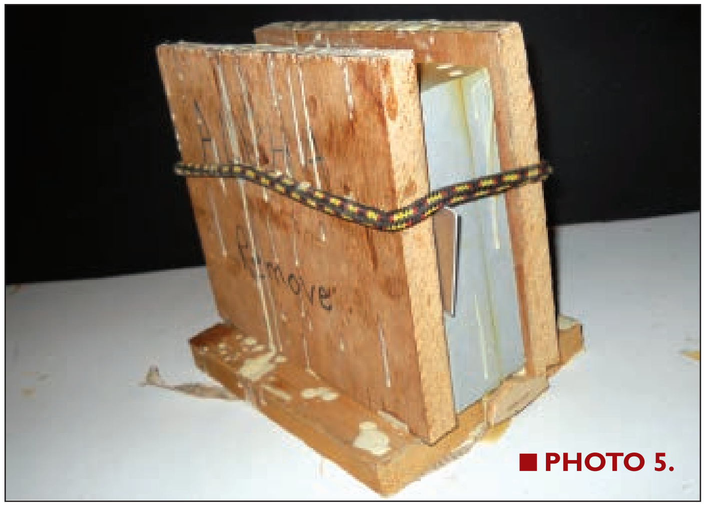
Photo 7 shows my propeller buildup sequence. I was nervous about the propeller due to its complexity because of the blade's pitch. I concluded that I would cast the propeller in hard urethane and cast a threaded aluminum standoff into it for added prop shaft strength. The lightweight hard urethane proved a good product for the propeller, as a heavy brass propeller would have added unnecessary drag and would have overheated the motor. The sequence of hubs in **Photo 7** shows the original brass hub on the right which I turned on the lathe to the scale on the blueprint. I made a silicon rubber mold of this simple hub by immersing it in the silicon to the base of the hub, then casting it in hard urethane plastic.

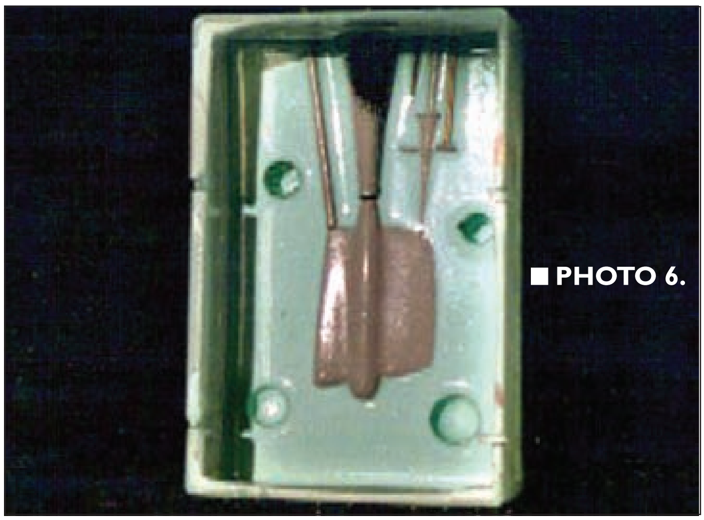
After the urethane hub was cast, I made the black hub with the grooves at points where the propeller blades were later attached. I then made the simple two-piece mold pictured to the left. After casting the black urethane hub with grooves, I mounted this hub in a jig as shown in **Photos 8** and **9**. This special-built jig allows for the hub to be held in place while a 25/64 hole is drilled into it to press-fit a threaded aluminum standoff in place. The standoff insert is for latter alignment, so the hub can be bolted to the propeller blade attachment jig.

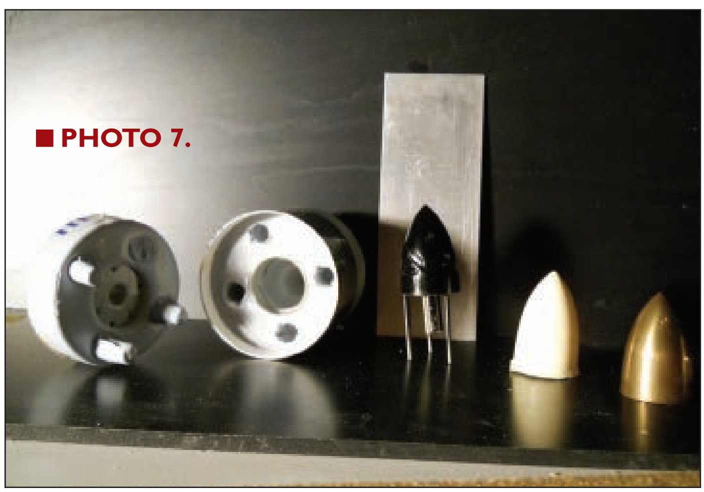
I made a single propeller blade out of wood, then made five castings of it in hard urethane to be attached to the prepared hub. The prepared propeller hub was attached to a simple jig where I glued the blades to the hub one at a time. I used super glue and sanded and filled the blades as needed to create a good propeller for casting. This jig setup is shown in **Photo 10**.

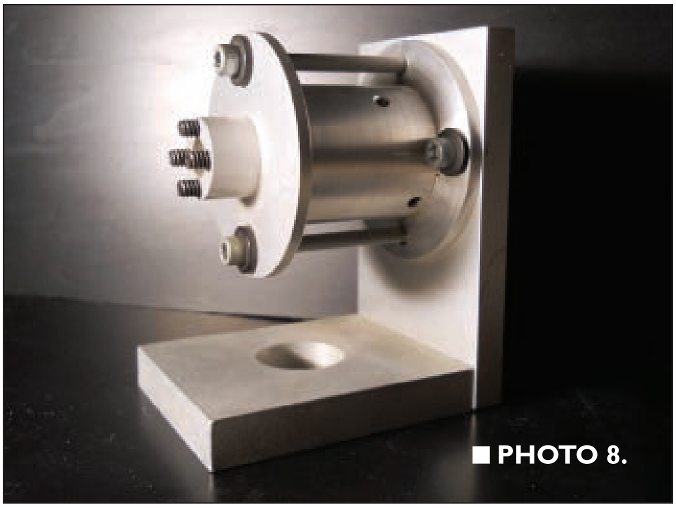
Once the propeller was perfected, I prepared it for the making of the silicon mold. I estimated where I would need venting sprews and glued plastic dowels along the rear edges of the propeller to the height I thought the top of the silicon would be. Herein were three unique challenges.

One challenge was how to cast this propeller in a two-piece mold. The second challenge was how to align the standoff in such a way that I could cast it into the propeller at pouring time. Remember that when the propeller is cast, the negative space is what remains in the mold to receive the liquid urethane. At the same time, the aluminum standoff must be suspended in its position within the empty space at the proper height and centered.

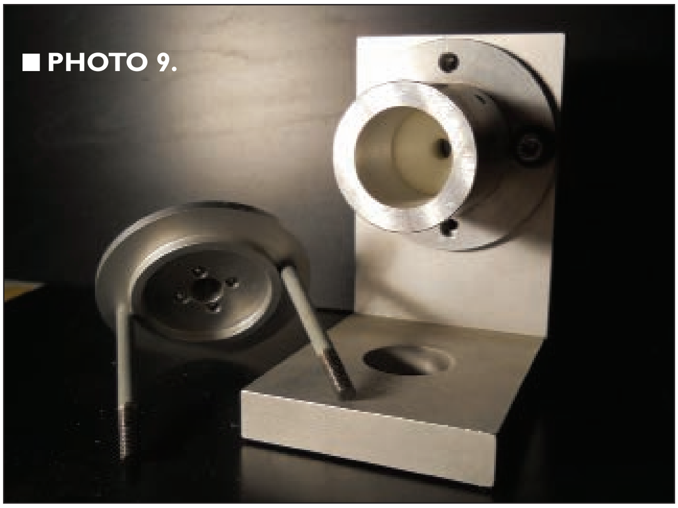

■ PHOTO 5.


■ PHOTO 6.

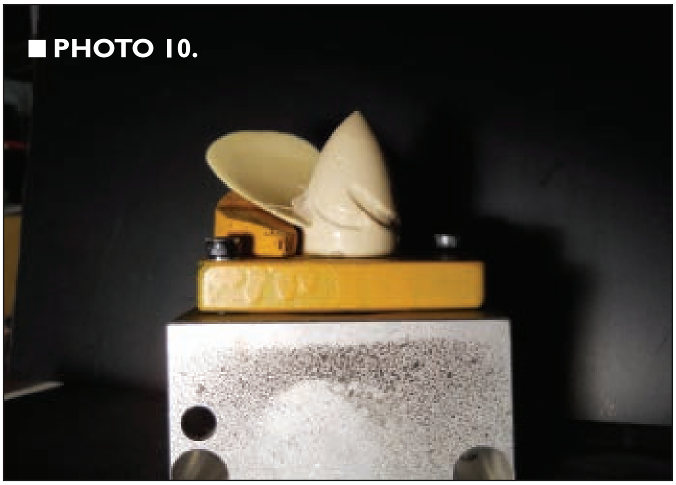

■ PHOTO 7.



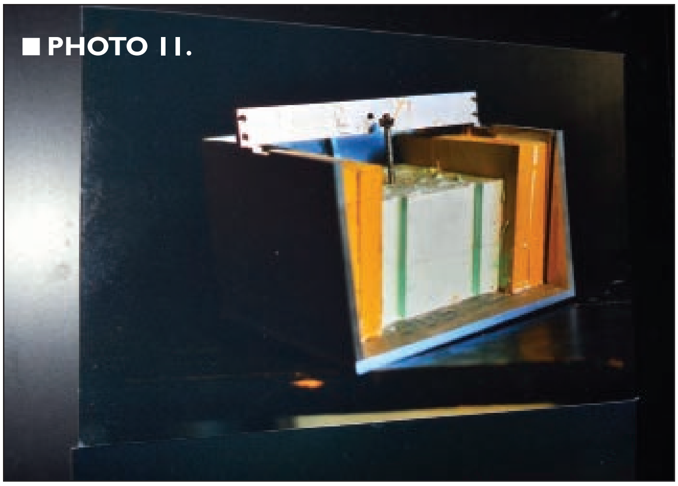
■ PHOTO 8.



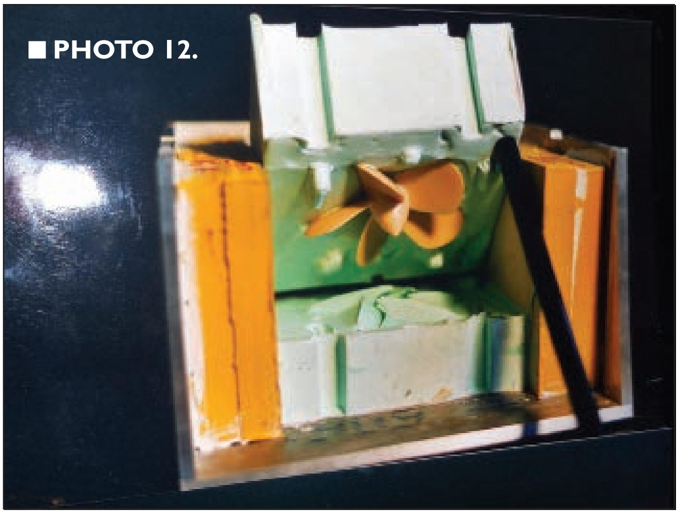
■ PHOTO 9.



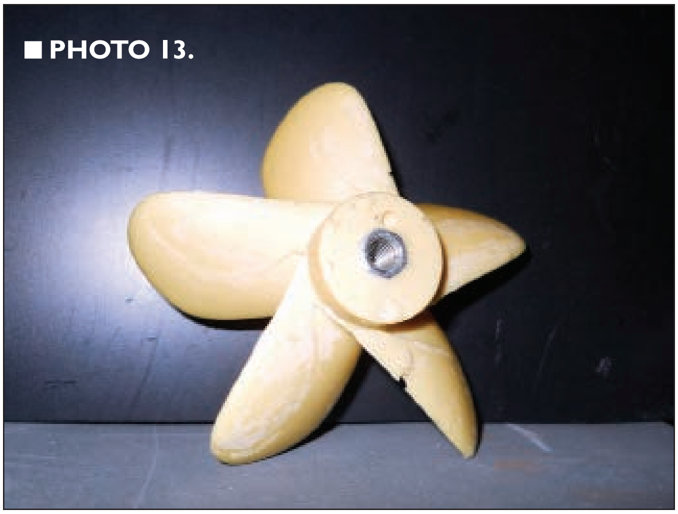
■ PHOTO 10.



■ PHOTO 11.



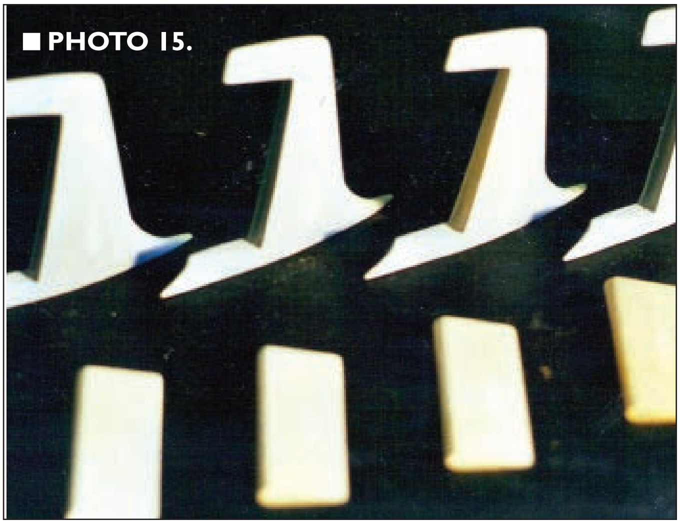
■ PHOTO 12.



■ PHOTO 13.

Photo 11 shows how this is done. This **photo** shows the completed mold in its casting box. The aluminum bar across the top will hold the threaded rod pictured with its bolt. The threaded rod penetrates the mold at the center of the empty propeller location with the aluminum standoff attached to it. I can just unscrew it when the propeller is cast. **Photo 12** shows the open mold with the cast propeller in its location.

The third and more difficult challenge was casting this unusual propeller shape with its undercut blades in a two-piece mold. Look carefully and you can see how I solved this issue. With the prototype propeller set in and hardened into the silicon in the lower mold half, I tilted the completed lower half of the mold five separate times and filled in the undercut spaces. I filled in the spaces under each propeller blade individually, thereby eliminating the empty space beneath them. Because of the flexible nature of the silicon mold, I could make this work without needing to be really precise. I searched for perfection in the centering of the standoff in the propeller,


■ PHOTO 15.


■ PHOTO 14.

but there were times I failed to reach these high standards. I cast multiple propellers till I got a really good one. **Photo 13** shows the standoff cast into a sample propeller.

I've included a photo of the mold for the rudder housing in **Photo 14**, so you can see how the air escape risers are included to prevent air bubbles from forming at the ends of parts which then leave un-cast areas in the part. Hatches, rudders, and the bald head radar unit in the antenna array were cast this way. Rudders and rudder supports can be seen in **Photo 15**. Mold-making techniques improve with practice and are a useful skill to know, no matter what form of project one pursues.

The next part in this series will begin with finishing the stern of the ship by installing the rudder yokes, rudder housing, and rudders. Part 2 will also explain and show the actual assembly of the components into the overall body of the sub itself. Part 3 will cover common sense approaches to maximizing your radio control system and dealing with electrical issues. If you would like to correspond with me on this submarine build, you can contact me at ocean_tech04@yahoo.com. We'll dive into this together. **NV**

Build Your Next Project With A Little Jewelry

By John Fattaruso

www.nutsvolts.com/index.php?/magazine/article/may2011_Fattaruso

Electronic hobbyists have used a variety of construction techniques over the decades, and usually analog circuits with moderate gain running at audio or even low RF frequencies can be built successfully without a lot of careful attention to wiring practice. However, for circuits with high gains or those operating at high frequencies, projects wired with simple point-to-point methods can often turn into frustrating exercises in quelling troublesome instabilities or oscillations.

Digital circuits with very fast rise and fall times can also run into ringing and signal reliability problems. Fixed layout printed circuit "hobby" boards with spaces provided for an array of DIP chips provide somewhat better properties at high frequencies compared to point-to-point wiring, but they still leave much to be desired with the limited width of their power supply traces and lack of a good ground plane. It is well known that the best high frequency performance from electronic circuits is achieved on multi-layer printed circuit boards (PCBs), with dedicated board layers for power supplies and ground. However, for building one or two prototype circuits, this method involves significant time delays for fabrication, is often too expensive for hobbyists, and (even in professional settings) makes circuit changes difficult during the experimental phase.

An approximation to the PCB's low impedance supply and ground connections may be had by simple isolation of wide conductive islands on a blank single-sided copper clad board; such circuit boards can be built quickly and cheaply with handtools. Good high frequency performance derives from the electromagnetic properties of wide, flat conductors — a geometry that minimizes inductance and therefore minimizes the voltage drop at high frequencies along distributed circuit nodes that are assumed to be at one potential. Varieties of these techniques have been used around hobbyist and amateur radio circles for quite some time, but I would like to present a version of these ideas here that makes good high frequency interconnections between chip pins and discrete components quickly and easily.

Enter the Jewelry

To begin, visit your local craft or hobby store and find the aisles with supplies for stringing bead necklaces. There you will find products called "crimp beads" or "crimp tubes." A typical brand available in my area (and also by mail order from **amazon.com** and other sources) is shown in **Figure 1**. These come in various sizes, usually numbered #0 through #4, and when bought in this quantity can be had for about US $0.01 apiece. The intended purpose for these tiny parts is to be crimped onto a necklace string as a clamp to hold clasps, colored beads and other decorative items in their designed places. However, by fortunate coincidence, the various diameters of the crimp parts are also comparable to the thickness of pins and leads typically used for electronic components as shown in **Figure 2**. The parts shown in **Figure 1** are lightly gold plated and accept solder readily, but I have also had good results with other brands that are supposedly silver plated.

FIGURE 1. Gold plated crimp beads and crimp tubes in various sizes, available in craft stores.

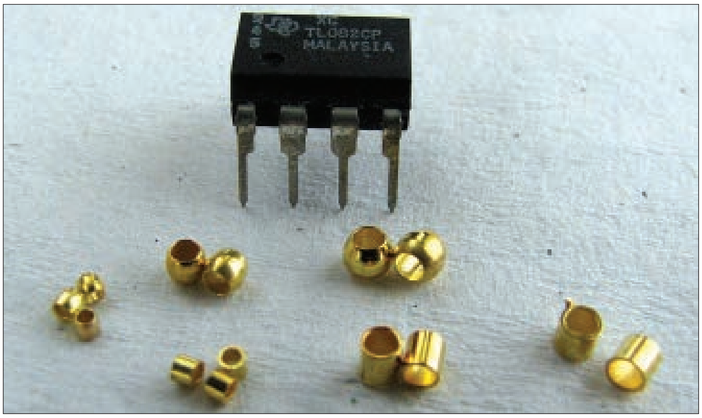


FIGURE 2. Comparison of sizes #0 through #3 of crimp beads and tubes with a DIP-8 package.

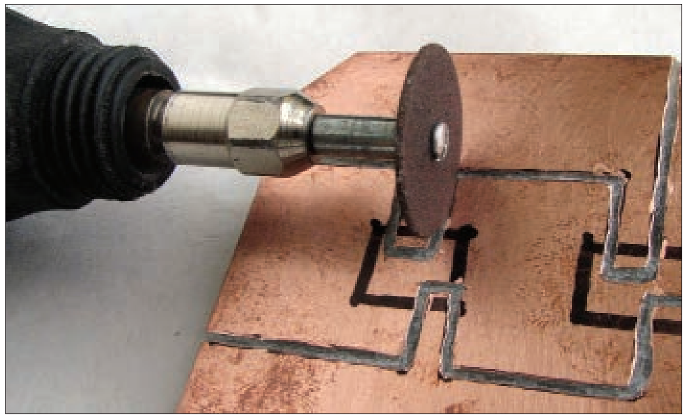


FIGURE 3. Forming an isolation path in the circuit board copper layer with a rotary cutting wheel.

Building the Circuit Board

To illustrate how the crimp beads and tubes make good high frequency circuit board construction a snap, I've included a few photos from a recent project — a low distortion audio sine wave generator. Now, the nominal signal frequencies of this instrument range only up to 250 kHz, but to keep distortion to a minimum, two wide bandwidth op-amps — an OP44 and OP42 — were used so that large loop gains are available to suppress nonlinearities even up near a MegaHertz. The unity gain frequency of the OP44 is 23 MHz which means that the power supply and ground impedances must be kept low up through tens of MegaHertz to avoid ringing or even parasitic oscillation.

The first step is to lay out regions on a single-sided copper clad board which will carry the various supply voltages and ground; mark their boundaries with a Sharpie or other permanent marker pen. I also like to add the outline of each chip package for reference. **Figure 3** shows how I cut the isolation paths in my boards, using a light touch of the edge of a cutting wheel on a Dremel or similar high speed rotary tool. Actually, I only cut the straight line segments of the isolation path with the cutting wheel, stopping just short of each 90 degree corner to avoid any stray cutting past the turn, and then completing the excavation around each corner using a small rotary engraving bit, such as the Dremel #106. The copper surface may be cleaned and prepared for soldering by lightly sanding with fine #240 grit sandpaper. I've labeled the resulting conductive regions in **Figure 4** with their intended voltages.

Prepare any DIP packages to be mounted by bending the lower portion of their pins outward at right angles. Any pins to be connected to supply and ground regions on the board below (such as the chip power pins, as well as any signal pins that are to be tied to a supply or ground) are bent close to their tips, but pins carrying signals to be connected to other components are bent about level with the bottom of the package. Then, when the chip is laid down and the supply pins are soldered to the appropriate copper region, the chip is supported with the remaining signal pins left floating above the board. Avoid bending the signal pins right where they emerge from the package body, as the lead frame metal has already been bent at that point in manufacturing and a second bend there can easily fatigue the metal and snap the pin off.

Figure 5 shows the board now with three DIP chips mounted along with their supply bypass capacitors. This method of circuit construction provides two very important features for good high frequency performance. First, there is a good ground plane over which the other components and the signal paths may now be wired, providing a low inductance return path around this common circuit node. Second — and just as important — the current loops that include the chip power supply pins and their respective bypass capacitors comprise wide, flat, low inductance

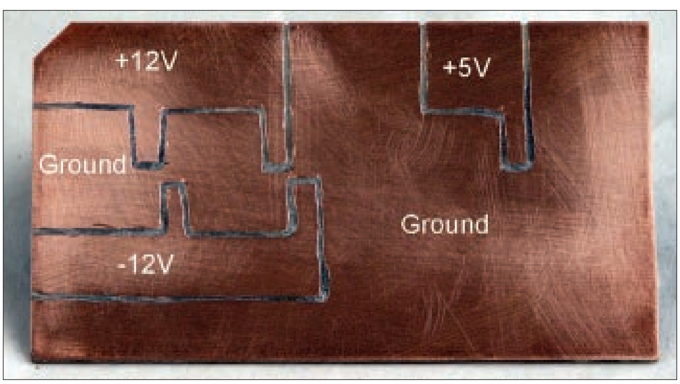


FIGURE 4. Isolated supply and ground regions cut in the copper layer, with corresponding voltages labeled.

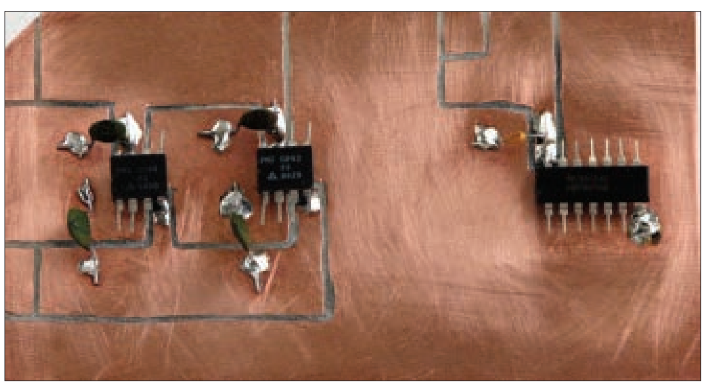


FIGURE 5. Three DIP chips and supply bypass capacitors soldered to the board.

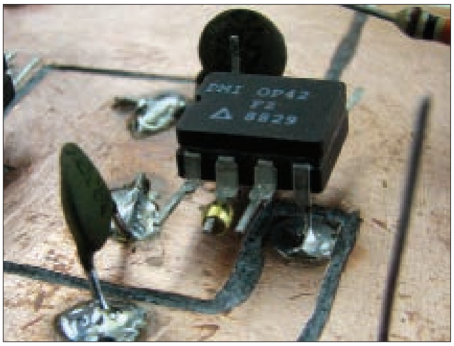


FIGURE 6A. Place a crimp bead or tube on the chip pin.

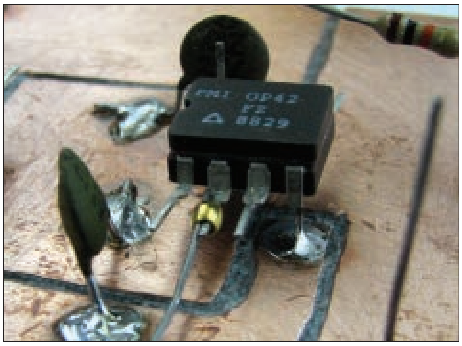


FIGURE 6B. Run the component lead inside the crimp part on top of the chip pin.

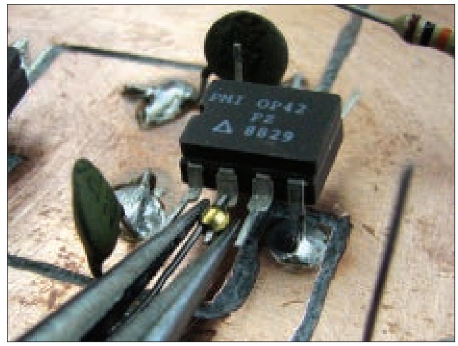


FIGURE 6C. Crimp the part from the sides with needlenosed pliers.

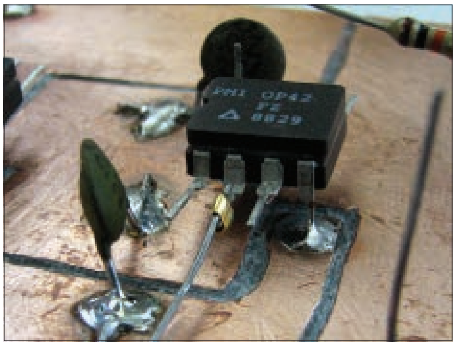


FIGURE 6D. Assembly is held tightly and is ready for a touch of solder.

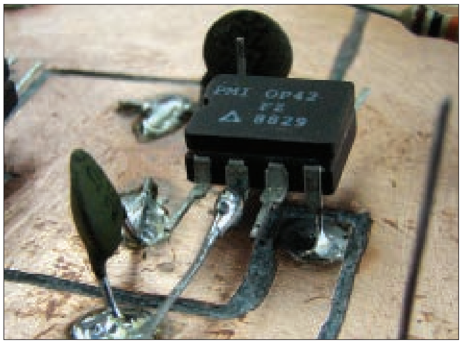


FIGURE 6E. Completed connection with a solder joint, leaving lateral clearance to adjacent chip pins.

board regions. This means that glitches and high frequency voltage drops on the supplies are minimized.

Completing the Circuit

Now that the chips are mounted and their supply voltages wired, the signal interconnections can be added. This is the step where I find the use of the jewelry crimp parts to be invaluable. With the 100 mil spacing of DIP pins, it's about impossible with only two hands to secure a wire or a lead from a component onto a pin and apply solder. A component lead could be wrapped around a pin, but usually when solder is added the resulting size ends up large enough to short to the adjacent pins. Consider the method shown in the sequence of **Figures 6A** through **6E**. Simply slide a crimp bead or tube onto a chip pin, run the connecting lead through it, and use a pair of needlenose pliers to crimp the assembly tight. This will serve the function of that missing third hand to hold the wiring assembly fast, and make it easy to quickly apply a soldering iron and a dab of solder, resulting in a solid connection. Make sure when crimping that the ends of the pliers are along the sides of the bead — rather than its top and bottom — so that the crimping will flatten the bead into a vertically oriented structure. If each bead is crimped only from the sides, even with solder plenty of clearance will be left between the pins of a DIP package. A light crimping is the best approach, leaving the connection steady enough to solder, but slightly loose so the wiring may be unsoldered easily to fix wiring errors or change component values later.

Figures 7A through **7C** show how this same technique can be used to allow hand-wiring to even smaller packages, in this case an SOT package containing a dual Schottky diode. Trying to hand-wire components this small can be nerve wracking, but using crimp beads (and magnifying head gear) makes it relatively easy.

The rest of the interconnects to complete the circuit can then be added, using a crimp bead or tube at any chip pin or discrete component lead to clamp the connection in preparation for soldering. Critical high frequency signals can be routed about as close to a chip package as is possible on PCBs, and working in three dimensions gives additional routing flexibility. A #1 bead or #2 tube works

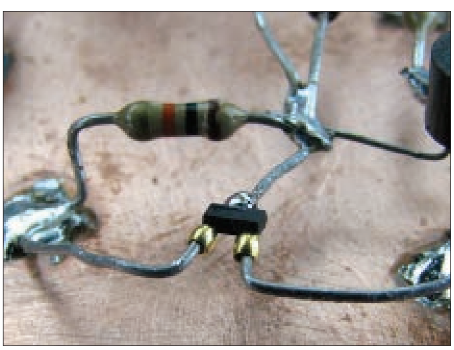


FIGURE 7A. Leads and crimp beads positioned on pins of an SOT component package.

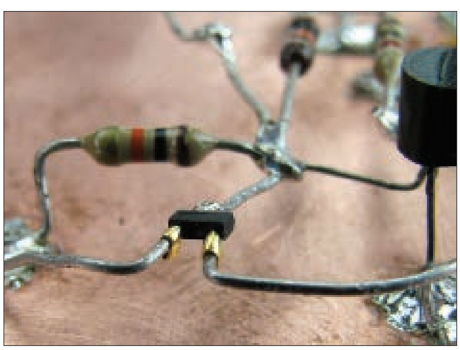


FIGURE 7B. SOT package connection after crimping.

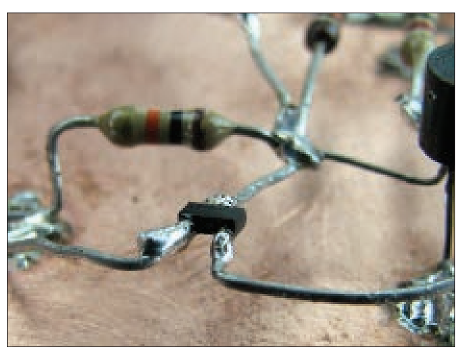


FIGURE 7C. Completed connections to the SOT package.

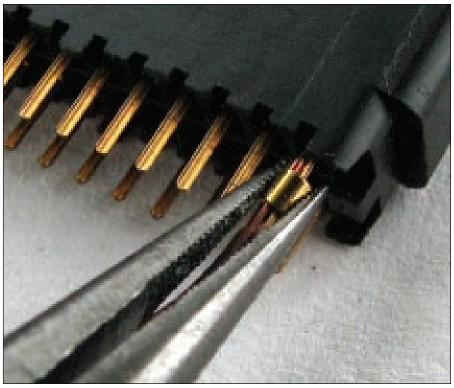


FIGURE 8A. The crimp tube technique used to wire to a connector pin.

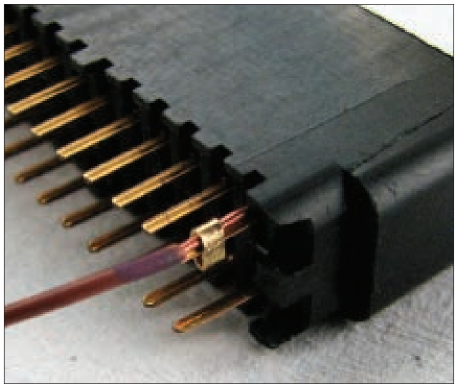


FIGURE 8B. Connection crimped and ready for soldering.

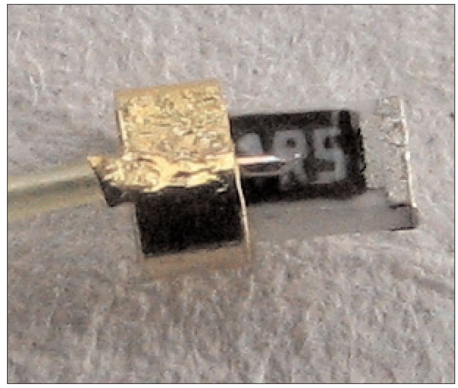


FIGURE 9. A crimp tube used to connect to a 1206 SM package, ready for a dab of solder.

well to connect just one wire or lead of typical diameter to a DIP or SO pin, and two or three leads may be clamped vertically with a #2 bead or #3 tube. Use a #0 bead or #1 tube to crimp a 30 gauge wire onto SO package pins. Of course, use a low wattage or temperature regulated soldering iron, and limit soldering time to two or three seconds to avoid damaging heat sensitive devices.

As seen in **Figure 7C**, for typical circuits with a few components here and there tied to a supply bus or ground, most of the wiring should be self-supporting between chip pins. If additional elevated anchor points are needed, however, a very high value resistor (such as in the range of 10 to 22 megohms) can be added with one end soldered to the ground plane. Other leads in the signal wiring plane can then be soldered to the free end of the resistor, being used only as a mechanical support and with a negligible electrical effect on most circuits.

Yet another advantage of this construction approach for high frequency circuits is that the interconnect wiring can be kept about a centimeter above the ground plane, and this minimizes the parasitic wiring capacitance to ground. But don't run the wiring too high, as this will introduce the inductance of large area current loops described by an interconnect line and its reflected return path in the ground plane. With a little practice, a prototype circuit board can be built in about the same time it would take just for the layout of a PCB, let alone waiting (and paying) for it to be fabricated.

Other Uses

You will find many other interconnection tasks made easy with these jewelry parts. **Figures 8A** and **8B** show how this method can be used for preparing a connector pin for soldering. You may have had the experience of searching for some part critical to a project, but finding the only one available in a tiny surface-mount package. **Figure 9** shows the use of a #3 crimp tube to make hand-wiring connections to a part in a 1206 package, in preparation for a small dab of solder. Form the tube into an oval shape with the pliers before slipping it over the end of the part.

I suppose in every electronics lab you will find some household items used in unintended ways. I am happy to report that these jewelry craft parts will be included in my lab because they are among the handiest tools I've ever found. **NV**

Creating A CHIPINO SHIELD

By The CHIPAXE Team

The various microcontroller development modules such as Arduino, Chipino, Amicus, Freeduino, etc., all share a common connector footprint. Even though they use different programming strategies and different microcontrollers, this one common feature of connector spacing allows them all to share the various plug-in shields. There are certainly exceptions to this but with a little effort, a well designed shield can be used by many different platforms. The team at chipaxe.com likes to work with the beginner crowd and help those just getting started to learn how to program microcontrollers. We wanted a shield that offered the fundamental components to teach digital inputs/outputs and analog inputs/outputs. In looking over the various shields available, we just couldn't find what we we're looking for so we designed our own. In this article, we will show you how you can do the same thing.

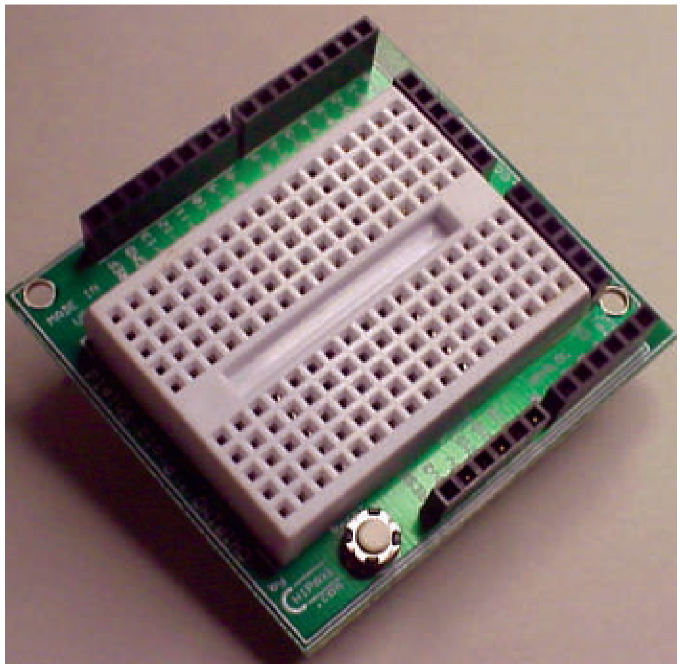


FIGURE 1. CHIPINO PROTO-SHIELD.

Chipino Proto-Shield

Our proto-shield shown in **Figure 1** isn't much different than the many other prototype shields out there, but it's a great place to start any shield project. To help the Chipino community, we open-sourced the ExpressPCB file for this shield and released it on the chipino.cc website. ExpressPCB is freeware circuit board layout software from **expresspcb.com** that allows you to send all the Gerber files to them with one click. They offer different pricing depending on what your needs are, but for around $60 including shipping you can get three prototypes manufactured and shipped right to your door in a short period of time. Our proto-board layout makes a great starting point for any Chipino-style shield.

ExpressPCB Layout

The proto-shield file is shown inside the ExpressPCB screen in **Figure 2**. It's ready to modify and that is what we did. We went through our list of minimum requirements for our new shield and decided we wanted the following:

- 4 - LEDs for Digital Outputs
- 2 - Momentary Switches for Digital Inputs
- 1 - Potentiometer for Analog Input
- 1 - Photoresistor for Analog Input
- 1 - Piezo Speaker for Analog Output

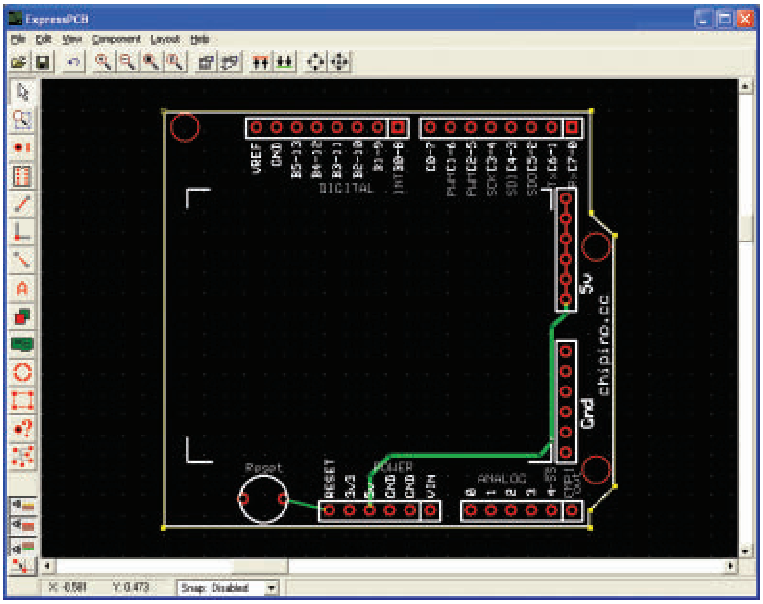


FIGURE 2. EXPRESSPCB PROTO-SHIELD LAYOUT.

We also wanted to add jumpers to the board so any of these features could be disconnected from the microcontroller. This feature allows the user to only connect the features they want and to stack shields without multiple items connected to the same I/O pins. Many shields we've looked at use the same pins, and without jumpers you are forced to cut traces to prevent collisions on the microcontroller board's I/O. We also wanted to make the shield with leaded parts so it could easily become a kit. This way, cub scouts or hackerspace groups could use this as a soldering project with a future purpose.

Chipino Demo-Shield

The final design layout is shown in **Figure 3** and we decided to call it the Demo-Shield. The board outline is larger than the shield because we created this with the low cost $60 layout option which required us to cut away the extra board when we received them. The spacing of the various components took some time and at the last minute we decided to offer two different connections to the piezo speaker. You can select either of the PWM pins on the Chipino to drive the piezo. We used 1/8 watt resistors to save space but used larger 5 mm LEDs for maximum visibility. Smaller 3 mm LEDs just didn't look right. We also added a ground plane to both sides of the board.

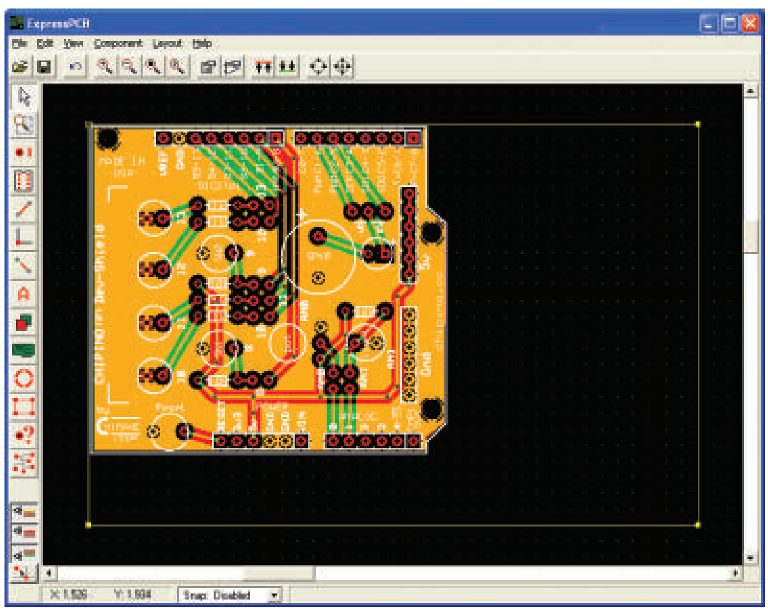
The final unit is shown in **Figure 4**. Notice how we used different color LEDs. We wanted to create applications that included a traffic light and also a red train crossing flasher. Putting red on the outside positions and yellow and green on the inside made this an easy implementation. The LEDs are connected to digital pins 10 through 13 of the Chipino. The switches are on digital pins 8 and 9. This was strategic as pin 8 in the B0 pin of the PIC16F886 used in the Chipino is also the external interrupt pin, so testing interrupts can be easily done with this board.

The potentiometer and photoresistor are connected to the analog pins AN0 and AN1, respectively. The photoresistor has a 10K pull-up but because this is a leaded board, you can solder in any size pull-up you want if you build it from a kit. The piezo connects to either the digital pin 5 or 6 selected with a jumper. These are PWM (pulse width modulation) pins on many different Chipino/Arduino style modules. Creating a tone with PWM is very easy to do. We put a 10 µf cap in series with the speaker to make the digital pulse a little more rounded which we feel gives a little better sound.

Sample Program

To program the Chipino, we like to use the Microchip HI-TECH C compiler and SimpleC library software from Chuck Hellebuyck's book *Beginner's Guide to Embedded C Programming – Volume 3*. We use this in all our code examples and documentation for the Chipino. Don't feel locked in with this option though, as the Chipino will work

FIGURE 3. DEMO-SHIELD LAYOUT.



with any compiler that supports the Microchip PIC. We have people using Flowcode, Proton Basic, PICBASIC PRO, Great Cow Basic, and I'm sure many more compilers we haven't heard of yet. We've even got people using 18F PIC microcontrollers in the Chipino so the versatility is getting noticed.

For this shield, we wanted to show a simple little example using SimpleC. The code snippet below will create a train crossing flasher with back and forth light between the red LEDs.

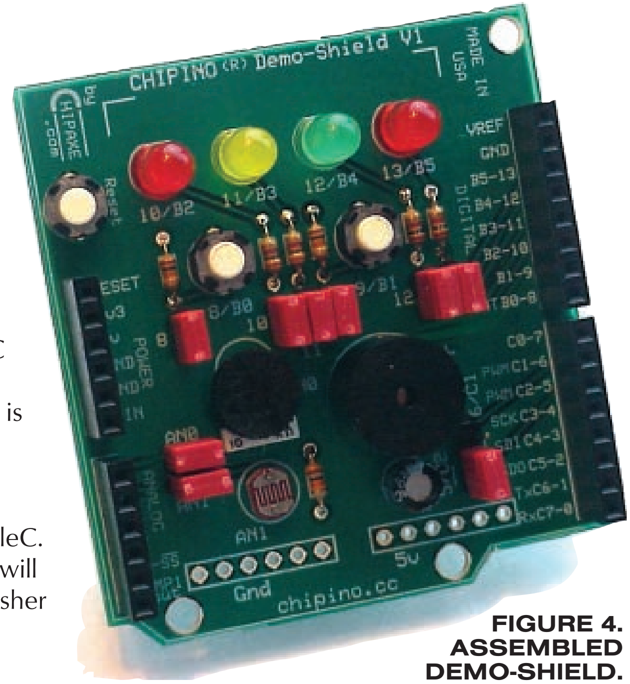


FIGURE 4. ASSEMBLED DEMO-SHIELD.

```
/******************************************
 Train Crossing LED Flasher example using
 SimpleC

       Connections:
       PIN 10(RB2) to LED Anode
       LED Cathode to 1k ohm
       1k ohm to Ground

PIN 13(RB5) to LED Anode
       LED Cathode to 1k ohm
       1k ohm to Ground
 *****************************************/

#include "simplec1.1.h"

void
main(void)
{
init_micro(); // Initialize I/O

while (1==1)
       {
       high(10);
       low(13);
       pause (1000); // Delay for 1 second (1.0000 sec)
       low(10);
       high(13);
       pause (1000); // Delay for 1 second
       }

}
```

Conclusion

The point of this article is to give a quick introduction on how to create a shield that fits your needs for the Chipino/Arduino style modules. The more shields that are created, the more options beginners have to learn what they can do with this great common connection scheme. Half the problem a beginner runs into is getting the hardware to work properly. With plug-in shields and microcontroller bases that share a connection layout, the beginner now has many plug and play options to learn from without any hardware worries. If you create an interesting shield from our open source file, please share it with us and the chipino.cc community. Just send it to support@chipaxe.com and we'll get it posted. **NV**

ALL ELECTRONICS CORPORATION

QUALITY Parts
FAST Shipping
DISCOUNT Pricing

CALL, WRITE, FAX or E-MAIL for a FREE 96 page catalog.
Outside the U.S.A. send $3.00 postage.

12 VDC 4PDT RELAY

Potter & Brumfield # KHP17D12. 12Vdc, 160 Ohm coil. 4PDT contacts rated 3 Amps @ 120Vac / 30Vdc, 1/10 HP. Nylon dust-cover, 27.5 x 21 x 34.5mm. Socket/ solder-lug terminals. Made in USA. UL, CSA.

CAT# 4PRLY-12N — $3.00 each

10 for $2.75 each

12 VDC FLASH ASSEMBLY

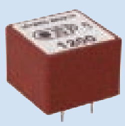
Bright xenon strobe assembly with horseshoe flash tube. Approximately 80 flashes per minute. 65 x 75mm PC board. 12 Vdc operation.

CAT# FSH-13 — $7.00 each

DURACELL 2 AMP BATTERY CHARGER/MAINTAINER

Three stage, integrated circuit controlled charging cycle for 12V sealed lead acid batteries, 5 -20 AH capacity. Charges and maintains batteries at peak stand-by-level until needed. Short circuit, over current, over voltage battery polarity protection. Three quick-connect adapters with ring terminals, alligator clips and cigarette lighter plug. UL. **CAT# BC-80** — $21.95 each

LINE MATCHING TRANSFORMER 1:1, 600 OHM



Oxford Electrical Products # OEP 1200. Resin encapsulated case, 18 x 18 x 13mm. PC leads.

CAT# TTX-1200 — $1.25 each

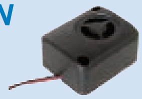
10 for $1.10 each

CORDLESS SCREWDRIVER

A good-quality cordless screwdriver with plenty of torque. Reversible. 130 RPM, no-load. Operates on 4 AA cells, rechargeable or standard. Uses standard 1/4" hex bits. Hex bits and batteries not included.

CAT# SDR-3 — $6.00 each

XL MINI PIEZO SIREN



Small, painfully-loud two-tone piezo siren for auto or home security devices. Operates 6-12 vdc, 110 ma. 108dB output (30cm). 1.81" x 1.55" x 0.88" high black plastic body. Two mounting holes on diagonal 1.80" centers. 7" wire leads.

CAT# ES-10 — $4.50 each

10 for $4.00 each

RIGHT-ANGLE GEAR HEAD MOTORS WITH WORM DRIVE

Powerful 12Vdc gearhead motors for automotive power seats. Right-angle gear-head with 89mm x 12mm diameter worm gear. No-load rating: 180 RPM @ 12Vdc / 1.3A. Overall length, 144mm . Motor diameter, 49mm. Available in right and left-hand configurations. Left-hand (LH) pictured.

LH **CAT# DCM-563**
RH **CAT# DCM-697**

$23.95 each

DIMMER / SPEED CONTROL

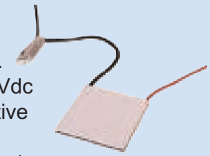
Independently control two 12-24 Vdc LED strips or DC motors to 18W. Smooth rotary potentiometers with on/off switches for precise control. Secure, clamp-down terminal strips with clear connection input/output markers. Includes specs and instructions. 40.5 x 49 x 25mm (excluding shaft and knob). **CAT# DMR-10** — $18.00 each

SELF-FUSING RUBBER TAPE

Stretch and wrap rubber tape for a moisture-tight, insulating seal on electrical connections. High resistance to salt water, steam, oil and most chemicals. 1" x 16.4' roll.

CAT# SFT-5 — $4.50 per roll

40MM X 44MM THERMOELECTRIC COOLER



New thermoelectric devices, prepped with a temperature cutoff switch. Originally intended for 12Vdc use in picnic and automotive coolers/ heaters. 127 thermocouples per device. deltaTmax=79degC, Thot=50degC, Vmax=16.1V. 40MM x 44MM x 3.3MM. Qmax=80.6W, Imax=8.1A

CAT# PJT-7 — $14.75 each

10 for $13.75 each

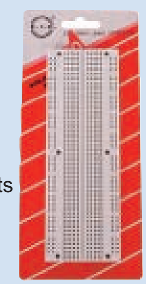
ULTRABRIGHT 5MM RED LED

Right-angle pre-formed leds. Slightly oval (4.5 x 5mm) flangeless package. Projects a slightly oval, bright red beam. Clear pink in off-state.

CAT# LED-150 — 10 for $2.00

100 for 16¢ each
500 for 12¢ each
1000 for 9¢ each

BREADBOARD, 840 CONTACTS



Breadboards accommodate all sizes of dips and discrete components. Interconnect with solid hook-up wire (#22 AWG recommended). Wires and components can be used and re-used many times without damage to board or components. Dual row of buss terminals on each side of terminal strip.

CAT# PB-840 — $7.65 each

Shop ON-LINE www.allelectronics.com
ORDER TOLL FREE 1-800-826-5432

MAIL ORDERS TO:
ALL ELECTRONICS CORP.
14928 OXNARD ST., VAN NUYS, CA 91411-2610

FAX (818) 781-2653 • INFO (818) 904-0524
E-MAIL allcorp@allcorp.com

NO MINIMUM ORDER • All Orders Can Be Charged to Visa, Mastercard, American Express or Discover • Checks and Money Orders Accepted by Mail • Orders Delivered in the State of California must include California State Sales Tax • NO C.O.D • Shipping and Handling $7.00 for the 48 Continental United States - ALL OTHERS including Alaska, Hawaii, P.R. and Canada Must Pay Full Shipping • Quantities Limited • Prices Subject to change without notice.

MANUFACTURERS - We Purchase EXCESS INVENTORIES... Call, Write, E-MAIL or Fax YOUR LIST.

#34 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

USB to UART for Electronic Prototyping — Part 2

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

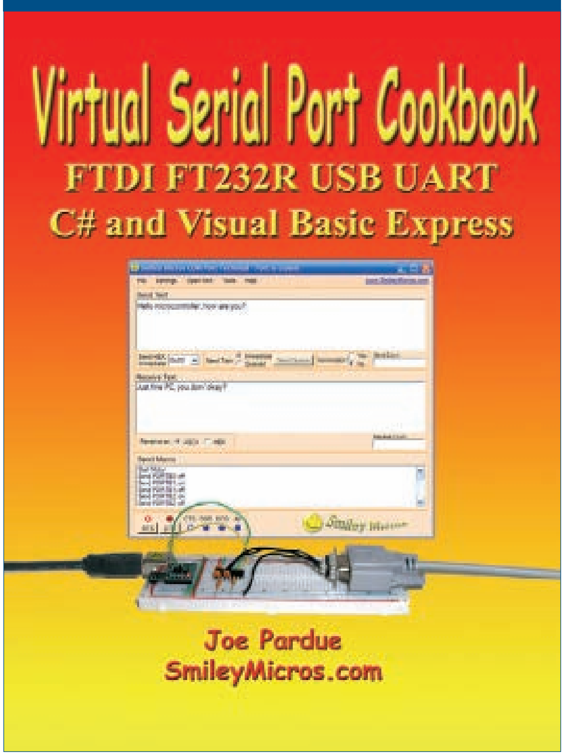
by Joe Pardue

Recap

Last month, we had the first of a two-part series providing a very convenient way to hook up a serial connection and provide a power supply for use in electronics prototyping on a solderless breadboard. This month, we will see how to use this for general-purpose input/output to read switches and light LEDs. Then, we will use a seven-segment LED to make the "World's Smallest Moving Message Sign." Finally we will create an Arduino compatible prototype on a breadboard.

This and the last Workshop are based on the revision of my book *Virtual Serial Port Cookbook* which is about the FTDI FT232R USB to UART converter that lets folks use their PC USB connection to emulate the much easier to use serial communication port that served our prototyping needs so well for so long. The revision is mainly to incorporate two additional FT232R prototyping boards: the Gravitech board (**http://store.gravitech.us/ftusbtouabrb.html** – note this is .us not .com) and the Bob-00718 from SparkFun (**www.sparkfun.com/products/718**).

■ FIGURE 1. *Virtual Serial Port Cookbook.*



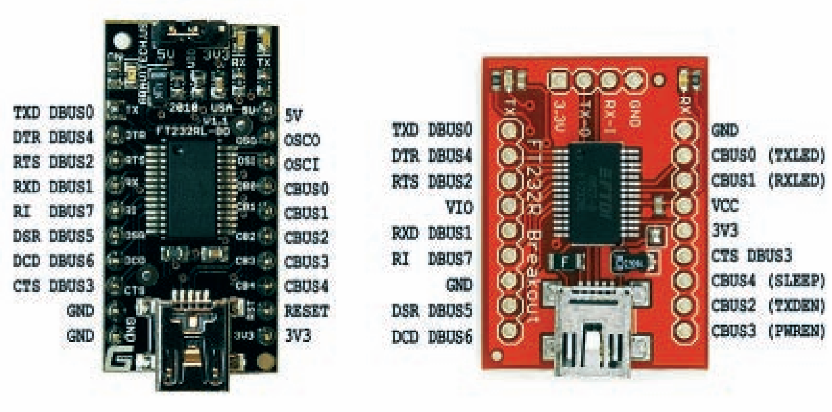
Last month, we got them set up and did a loopback test using a simple terminal program (appropriately named Simple Terminal). Then, we finished with a working serial connection between our PC and a solderless breadboard, ready for doing some electronics prototyping.

Electronics Prototyping?

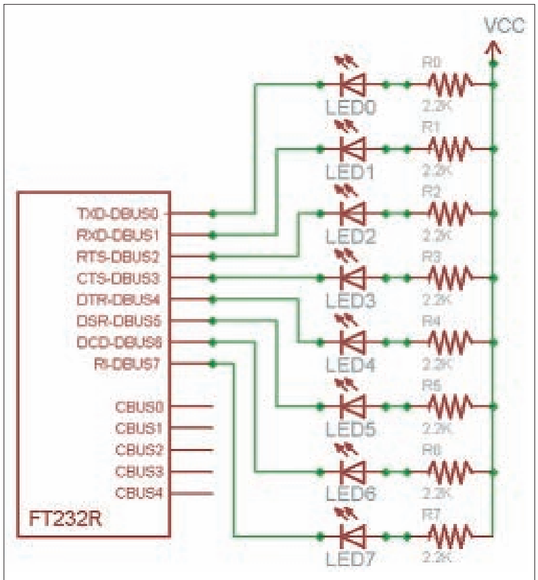
You may have noticed that I used 'Electronics Prototyping' in the title. Is this really **'Electronics'** prototyping when it involves a buried microcontroller on the FT232R? Aren't electronic and microcontrollers really two different things? I think folks tend to think of electronics and microcontrollers as two very different areas of study. Sure, microcontrollers are electronic devices, but there was an analog versus digital mentality that put electronics squarely in the analog arena and microcontrollers in the very different digital arena. But times, they are a changing.

As Moore's Law has made transistors insanely cheap, we can now throw them at analog problems that once would have been far too expensive to handle with digital circuits. One example of this is the LM555 timer 'electronic' device, probably the most venerable circuit employed in every introductory electronics course.

Not long ago, I was designing an IR communications remote control (yeah, like those entertainment center remotes stuck in your couch cushions) and mid design I realized



■ FIGURE 2. Board pin-outs.



■ FIGURE 3. Schematic DBUS to LEDs.

that I could get an eight-pin AVR microcontroller for about the same price as a '555, and that the AVR could do everything a 555 can do and a lot more. Epiphany! Not only is the price for the ICs about the same, but I also didn't need to use the external components for the 555, allowing me to eliminate parts and reduce board space. AND I had the flexibility of a programmable device!

Another example of analog being overwhelmed by digital is a recent project where I wanted to do some radio communications and I started seeing these radio ICs that seem to have all the analog magic hidden under a black blob of epoxy. The interface seemed suspiciously like they had a microcontroller buried in there somewhere. Has computing become so cheap that analog electronics is being subsumed into digital microcontrollers? Frankly, this has kind of snuck up on me so I'll have to do a lot more studying before running around yelling "analog is dead," but I'm pretty sure I can at least mumble "analog ain't as healthy as it used to be."

Where this leads is the concept that contemporary electronics prototyping is no longer as much about analog design as it is about throwing cheap transistors at the problem and purchasing off-the-shelf integrated solutions that mix the analog with digital control in a single chip. So, electronics prototyping now becomes as much about computers as it is about circuits.

Bit-Banging — Hardware Experiments

Despite the pin labels on your FT232R PCB, those pins lead a double life as shown in **Figure 2**.

The D bus pins each have a modem pin alias that they use when sneaking around in the underworld of serial communications — for instance, DBUS0 is also known as TXD.

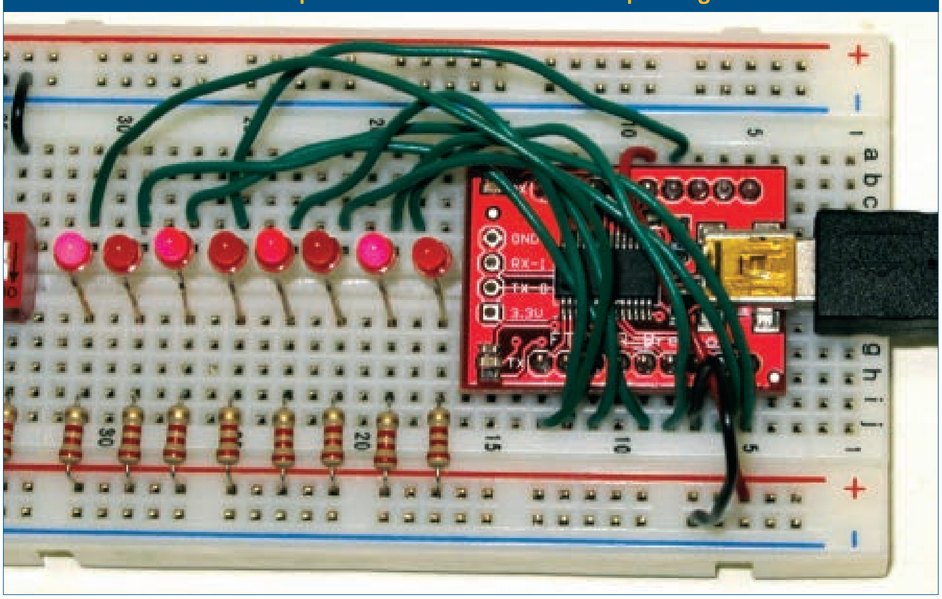
For these bit-bang experiments, we will use the D bus names DBUS0 to DBUS7. Note that the pins are scattered about on the PCBs in no logical order. This wasn't done just to confuse you. (Really.) Do you remember the discussion about Funky Logic? Well, now is when the funk splats on the wall, so be prepared for a mess.

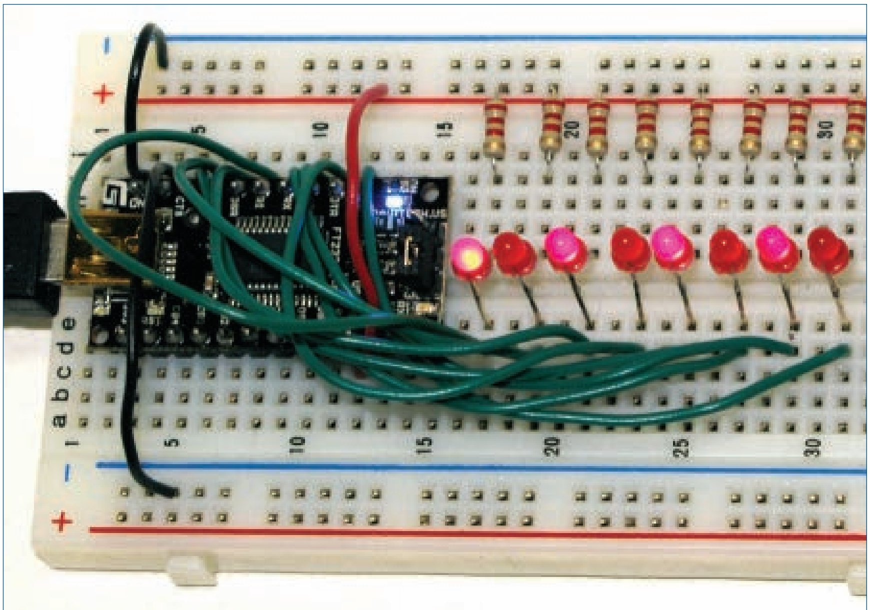
Output

We will test bit-banged output using LEDs that have their anodes tied to Vcc via 2.2K ohm resistors, and their cathodes tied to a FT232R pin as shown in **Figure 3**. When the pin is high, no current flows and the LED is off. When the pin is low, current flows and the LED is on.

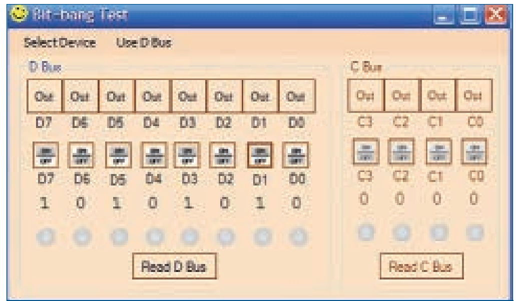
The fun starts when we try to remember the true/false logic of which bit state is low and which is high since it differs for the D bus and the C bus. The D bus On state

■ FIGURE 4. SparkFun FT232R PCB wired up to eight LEDs.

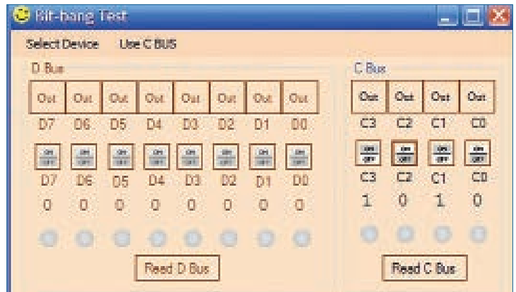




■ FIGURE 5. Gravitech FT232R PCB wired up to eight LEDs.



■ FIGURE 6. Bit-bang Test output 0x55 on Dbus.



■ FIGURE 8. Bit-bang test.

is low and the C bus On bit state is high – confusing, yes, but just remember it.

Output On The D Bus

Wire your FT232R PCB for five volts as shown in Smiley's Workshop 33, then wire up the DIP switch, eight LEDs, and 2.2K resistors as shown in **Figure 3**, depending on which board you are using. **Figure 4** shows the SparkFun unit and **Figure 5** shows the Gravitech setup.

We will test this prototype with a bit-bang test program I wrote in C# .NET that you can get from the article downloads. Open the bit-bang test program and select the FT232R PCB. Now, if you've done everything right (and if you are like me you haven't), when you flip the virtual switches as shown in **Figure 6**, you will output 0xAA which will then light up the LEDs in a 0x55 pattern (extra credit if you remember why).

Output On The C Bus

To demonstrate the C bus, rewire the circuits shown in **Figures 4** or **5** as shown in **Figure 7**.

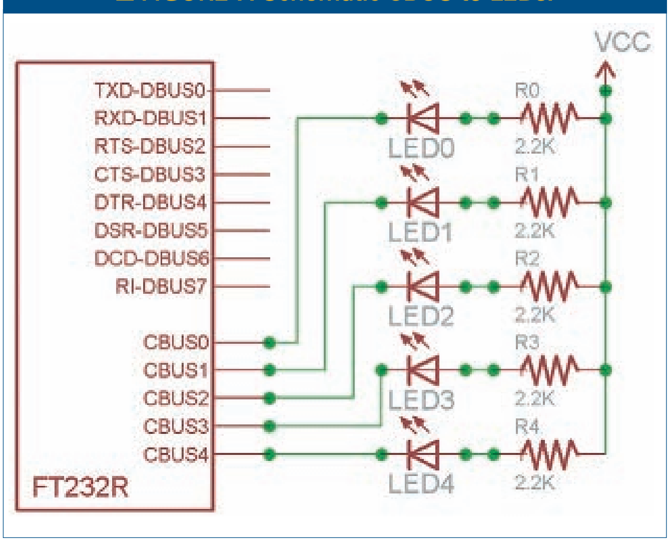
Toggle the 'Use D Bus' menu item so that it reads 'Use C Bus'. The D bus groupBox will be disabled while the C bus groupBox will be enabled, as shown in **Figure 10**. This should behave exactly as the D bus demo.

Input

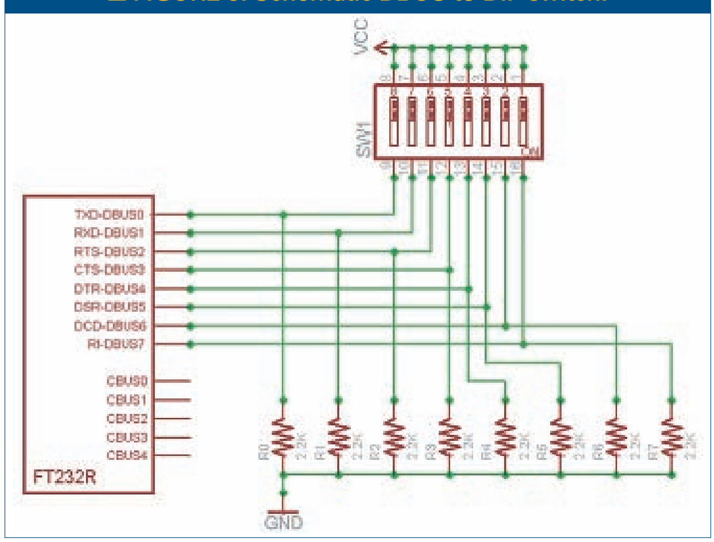
Before beginning this, note that the eight-position DIP switch is numbered left to right (1, 2, 3, 4, 5, 6, 7, 8). We will ignore those numbers and think of it as a binary sequence with the least bit on the right, and thus numbered 7, 6, 5, 4, 3, 2, 1, 0. This will further our confusion, making this experiment even more like the real world.

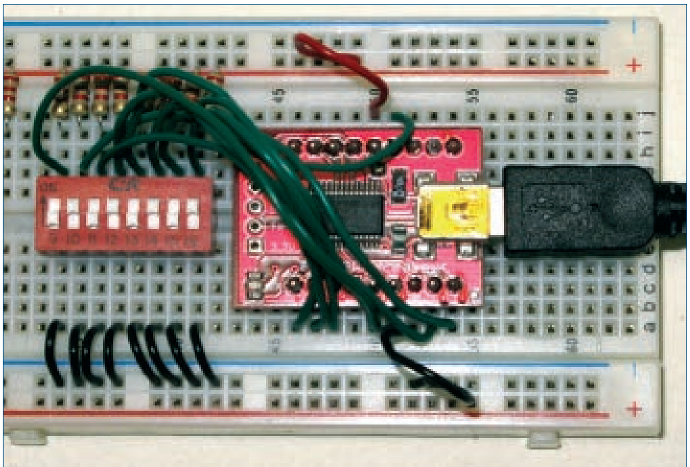
We will wire the pins to a

■ FIGURE 7. Schematic CBUS to LEDs.

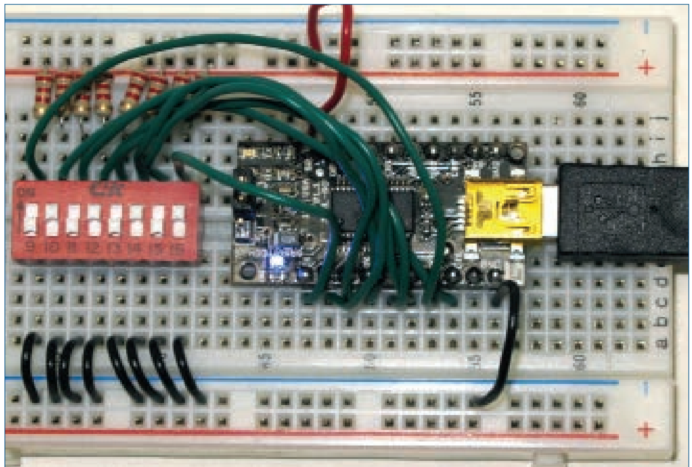


■ FIGURE 9. Schematic DBUS to DIP switch.





■ FIGURE 10. SparkFun FT232R PCB wired up for eight-position DIP switch.



■ FIGURE 11. Gravitech FT232R PCB wired up for eight-position DIP switch.

2.2K ohm resistor to ground and to the switch that when open will connect the pin directly to ground, and when closed will connect the pin to VCC.

Input On The D Bus

Rewire the breadboard according to the **Figure 9** schematic which should look something like **Figures 10** or **11**.

In the bit-bang test program, click on all the buttons on the top row of the D bus groupBox to convert each pin to an input as shown in **Figure 12**.

Input On The C Bus

By now you know the drill, so wire up things for the C bus and run the test as shown in **Figures 13** and **14**.

Instead of showing this for all three FT232R PCBs, we'll just show the BBUSB.

Well, all that was cool, but how about we use all this for something really useful — like a USB based very small scrolling message sign? Okay, coming right up!

Bit-Banging — Seven-Segment LED

You can get the seven-segment test application shown in **Figure 16** from the downloads. This program will allow us to set or clear each segment, select a character to show from a font matrix, show the whole font one character at a time, and output the classic 'HELLO WORLD' at the press of a button.

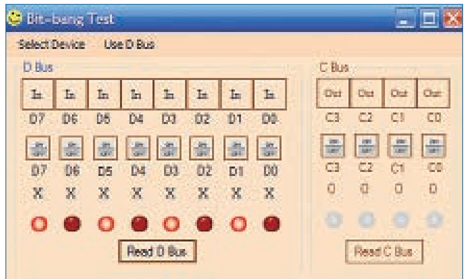
We have a feature that allows us to enter a string of up to 64 characters and have them scroll on the seven-seg LED by flashing each character in sequence. Some folks think you need to show at least six characters or so at one time and to show a longer message, you need to scroll the characters. While that is certainly easier to read, using one seven-seg LED will get the message across if the reader pays attention.

Note that although this is a seven-segment LED, it actually has eight segments when you include the decimal point, so one byte can be used to code each segment on or off.

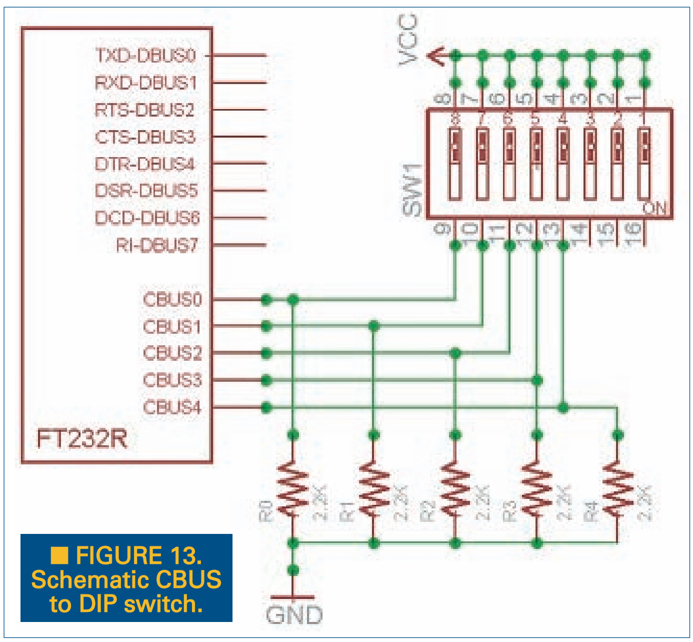
The wiring diagram in **Figure 18** looks much like the one for output to the eight LEDs in the earlier section — and it is — with the main exception that the LEDs have two common resistors between pin 3 and +5 and pin 8 and +5 (**Figure 17**).

■ TABLE 1. DBUS to seven-segment LED pin connections.

DBUS	Seven-seg pin
0	6
1	7
2	2
3	5
4	4
5	9
6	10
7	1



■ FIGURE 12. Bit-bang test read Dbus.



■ FIGURE 13. Schematic CBUS to DIP switch.

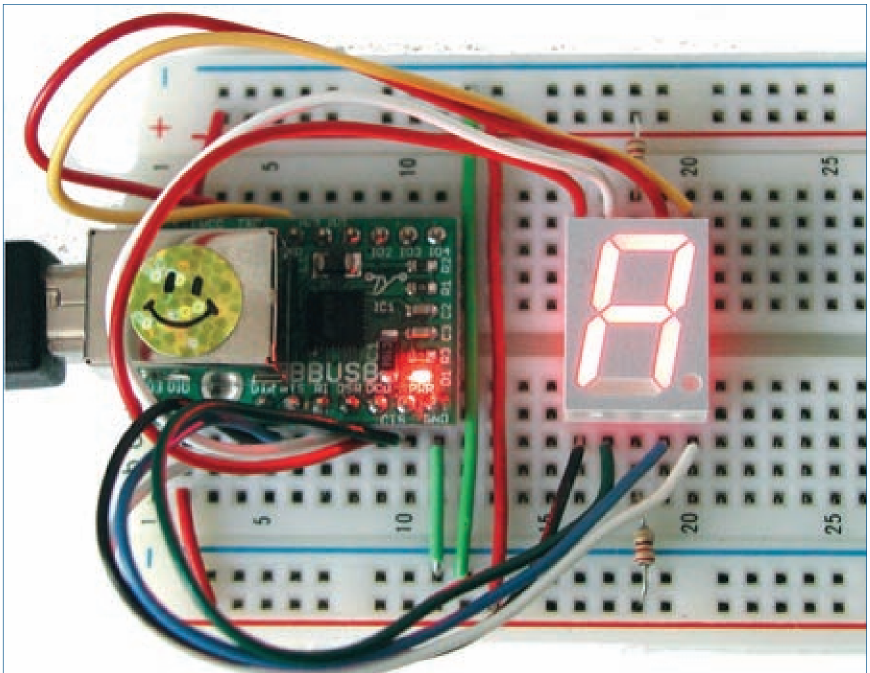


FIGURE 15. World's smallest moving message sign?

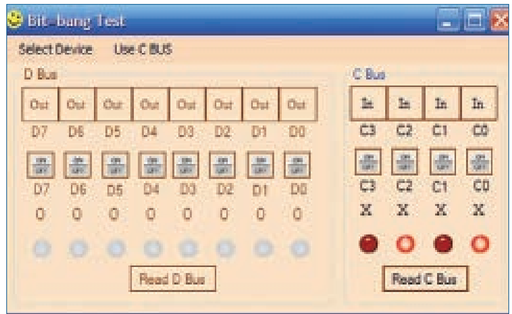


FIGURE 14. Bit-bang test read C Bus.

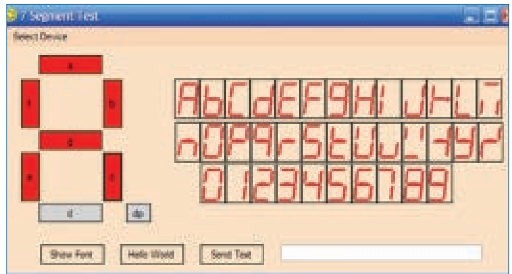


FIGURE 16. Seven-segment test application.

Build An Arduino On A Breadboard

Now for a bonus project not included in the *Virtual Serial Port Cookbook* book. You've heard about the Arduino (unless you've been stuck on the dark side of the moon for the past several years). I've written about it. Heck, everybody has written about it. What you may not know is that the original Arduino used the FT232R chip we've been discussing in these last two articles and since we are learning to use this device on a breadboard, why not just build us an Arduino while we are at it? The official Arduino board is about as low-cost a development board as you could ask for, so the only reason I can imagine that anyone would want to build one on a breadboard out of discrete components is that either they are a bit masochistic [and if you've gotten this far in this article, you may well be] or they really want to have all the pieces available for some serious electronic prototyping.

We discussed another version of the BreadboArduino back in the April '10 *Nuts & Volts*, but in that one we used the SparkFun board. Let's supplement that by rebuilding it with the Gravitech board as shown in **Figure 19** (based on the BreadboArduino schematic shown in **Figure 20**). There is one slight problem with getting the parts on your own though. The ATmega328 must have an Arduino compatible bootloader for it to work with the Arduino IDE.

You can purchase raw ATmega328s and load the bootloader yourself, but that requires programmers that are usually more expensive than apre-built Arduino. You can even convert a regular Arduino so thatyou can use it to program the bootloader onto a raw ATmega328, but that's all kind of a hassle isn't it? So you can get an ATmega328 with a bootloader on it in the BreadboArduino Parts Kit (as listed in **Table 2**)

FIGURE 17. Seven-segment LED pin-out.

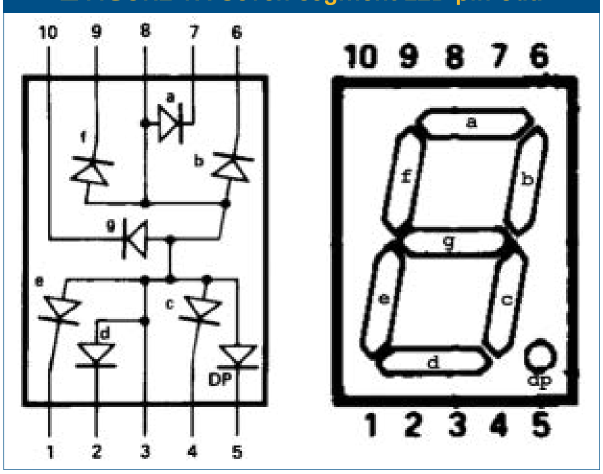
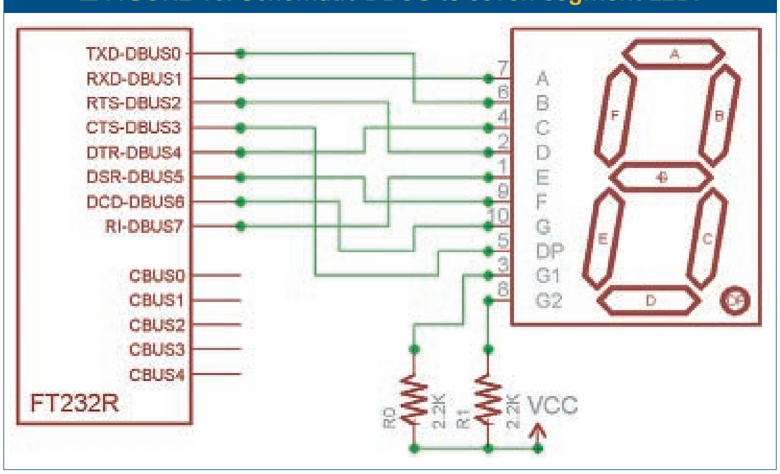
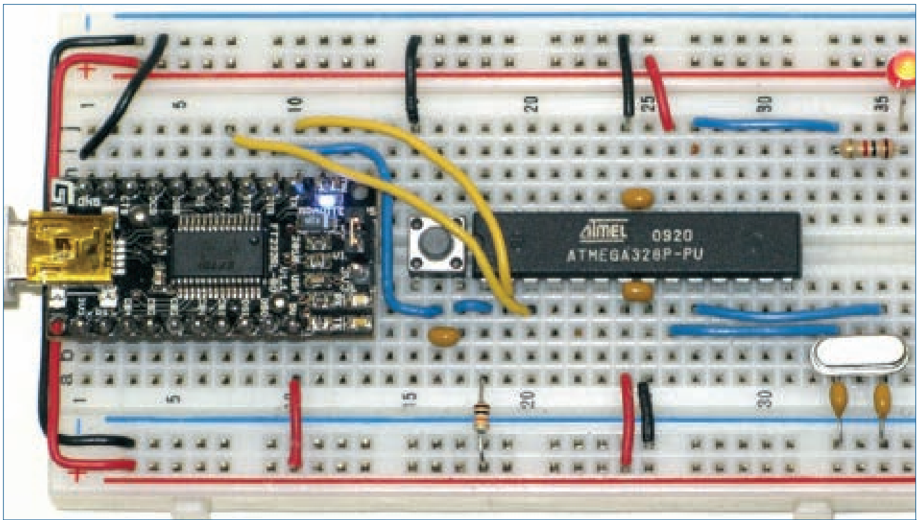


FIGURE 18. Schematic DBUS to seven-segment LED.



■ TABLE 2. BreadboArduino Bill of Materials.

Sch. Part	Description
IC1	ATmega328 with bootloader
Q1	Crystal 16 MHz
S1	Mini Pushbutton
C1,C2	22 pF Capacitor
C3,C4,C5	100 nF Capacitor
R1	10K ohm Resistor
R2,R3,R4,	1K ohm Resistor
L	Red LED
	FT232R Breakout Board
	Break Away Male Headers
	Breadboard
	Hook-up Wire (22 AWG)



■ FIGURE 19. BreadboArduino on a breadboard.

from **www.nutsvolts.com**.

Building The Breadboarduino

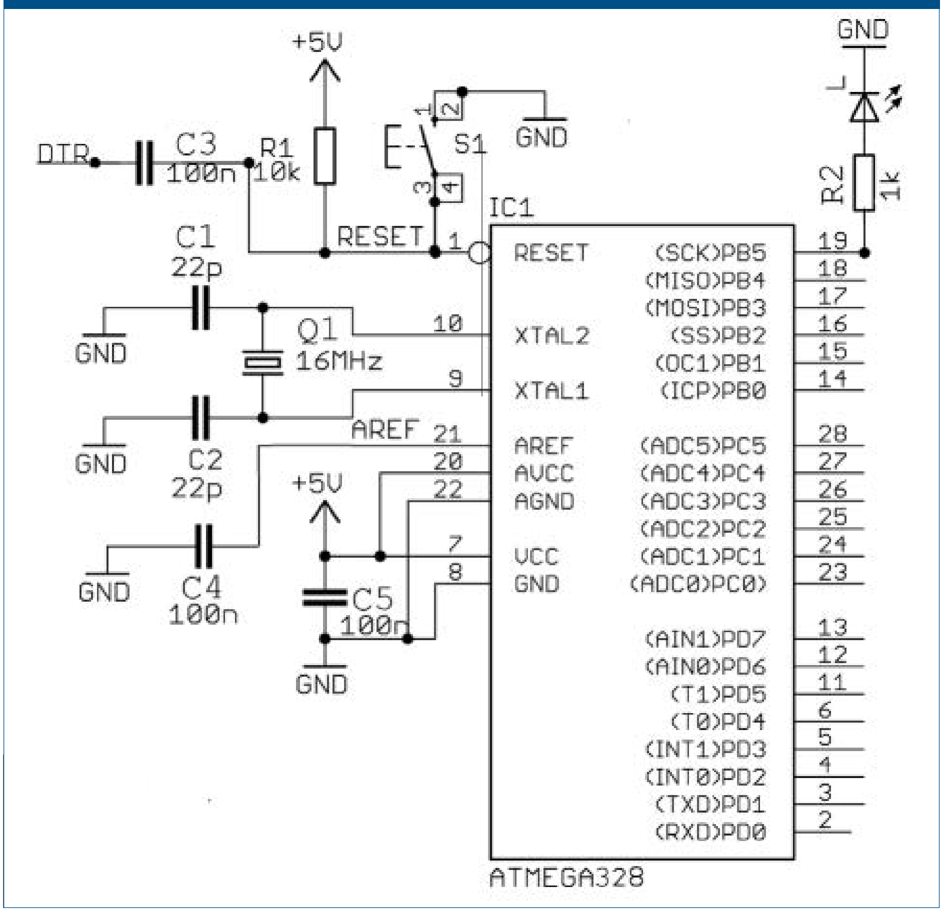
We will simplify our lives by leaving off the Arduino power supply section and using only the power from the USB port. Theoretically, we can take 500 mA from the USB, but there are caveats that cause me to advise using less than 100 mA. This should be enough to do a Cylon Eyes type project, but probably not enough to run motors.

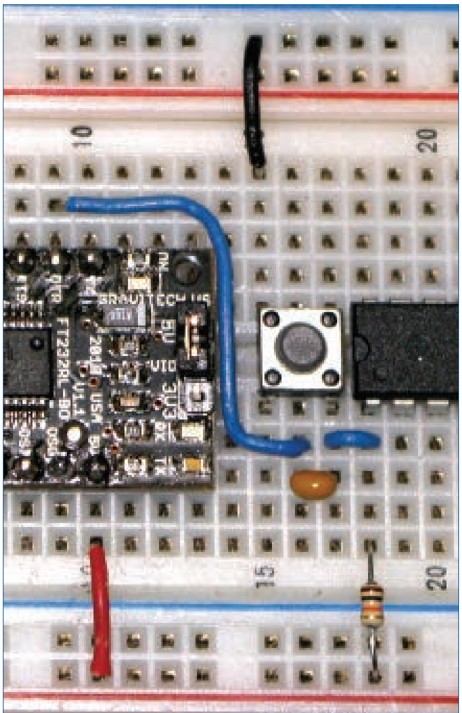
When I built the section shown in **Figure 21**, I had the upper black wire two spaces to the right and nothing worked. Duh, running /RESET to ground tends to create that symptom — it keeps the AVR in reset so nothing happens. I moved it to the position shown and everything worked. NOTE: The switch has short legs and doesn't like to stay on the breadboard, so make sure that it is pushed all the way in and check it after transport. You could fix this by soldering on short pieces of wire.

In **Figure 22**, the serial communication wires are in yellow. You may need to put the paper tent label (from last month's Workshop) on the FT232R breakout board to see where the TxD, RxD, and DTR go. REMEMBER: The TxD on the FT232R board goes to the RxD on the ATmega (pin 2), while the RxD on the FT232R goes to the TxD on the ATmega (pin 3). This confuses a lot of folks, but think about it for a moment. The data being **transmitted** from the PC through to the FT232R is being **received** by the ATmega, while the data being received by the PC through the FT232R is being transmitted by the ATmega. **Figure 23** provides an enlargement of the section containing the crystal and the power — wire this carefully.

In **Figure 19**, you can see an LED on the right of the breadboard. This is connected the same as the built-in Arduino pin 13 LED, so you can test your board by

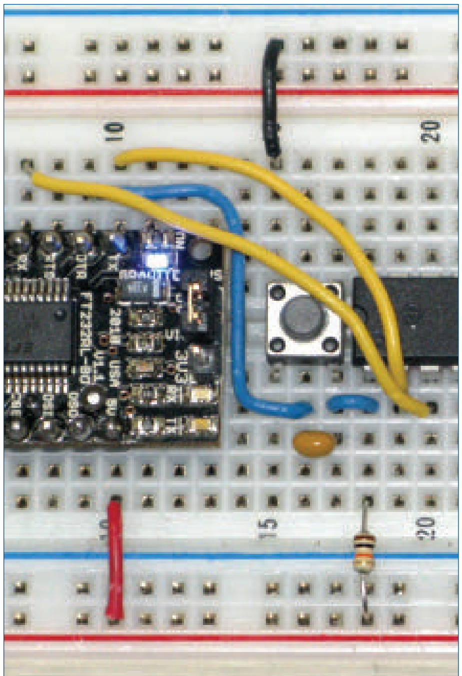
■ FIGURE 20. BreadboArduino schematic.





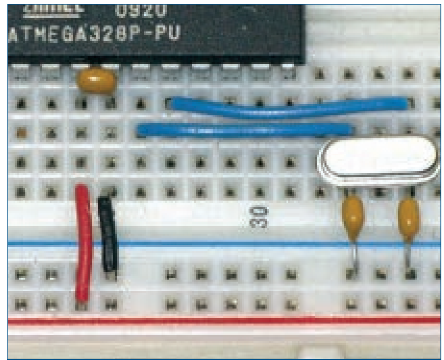
■ FIGURE 21. Automatic and manual reset.

uploading the Blink program from the Examples menu item in the Arduino IDE.



■ FIGURE 22. TxD and RxD.

Hand-building systems like this on a breadboard involve very important electronics prototyping skills you'll want to develop — BUT IT AIN'T EASY. No indeed.



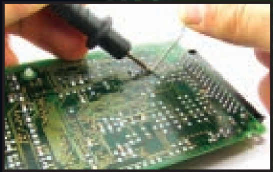
■ FIGURE 23. Crystal and power.

There are many things that can go wrong between good intentions and a working board so be patient and follow the instructions slavishly. If you have a question, start a thread on **www.avrfreaks.net** with BreadboArduino in the title and somebody (maybe even me) will probably have the answer. [And as usual – the warning – before posting your question to lessen the chance of getting flamed (unless you've got asbestos britches) read: How To Ask Questions The Smart Way: **http://www.catb.org/~esr/faqs/smart-questions.html**]

Well, that's all for this two-part series. Remember that the book *Virtual Serial Port Cookbook* and the associated project kits to go along with these two articles are available from **www.nutsvolts.com**.

Next month, we will get back to avrtoolbox and that promised porting of the Arduino serial functions to 'real' C. **NV**

The *Virtual Serial Port Cookbook Revision* and the kits to go with this series of articles can be purchased online from the *Nuts & Volts* Webstore at **www.nutsvolts.com** or call our order desk at **800-783-4624**.

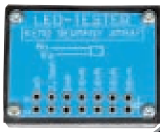


Test & Lighting Kits for Electronic Enthusiasts

LED TESTER MODULE

AA-0272 $11.25 plus postage & packing

This basic but essential tool allows you to check the function, brightness, colour and polarity of all kinds of light emitting diodes (LED). The LED to be tested plugs into the front panel at the current you wish to test it with. Two 10mA positions have been included on this multi-LED tester so that comparisons between two LEDs can be made simultaneously.



- Requires 9V Bolt
- Test currents: 1mA, 2.5mA, 5mA, 10mA, 20mA,50mA
- Dimensions: 58 x 44 x 25 mm

LED BATTERY VOLTAGE INDICATOR

KA-1778 $6.25 plus postage & packing

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED. The LED will be green when above the set point & red when below. The set point is adjustable using a trim-pot. The circuit is suitable for equipment powered from about 6-30VDC. With a simple circuit change, the bi-colour LED will produce a red glow to indicate that the voltage has exceeded a preset value.

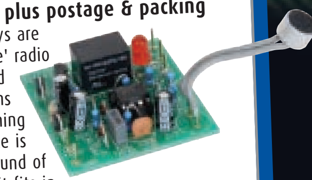
- PCB, bi-colour LED and all specified electronic components supplied

KIT OF THE MONTH

"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, has almost no turn-on delay and can be used to turn on only low power devices. 12VDC @ 35mA required. Kit is supplied with PCB electret mic, and all specified components.



- PCB: 47 x 44mm

Communicate Hands Free!

COURTESY INTERIOR LIGHT DELAY KIT

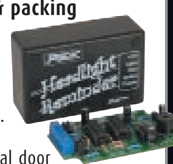
KC-5392 $14.50 plus postage & packing

Many modern cars feature a time delay on the interior light. It still allows you time to buckle up and get organised before the light dims and finally goes out. This kit provides that feature for cars which don't already provide it. It has a soft fade out after a set time has elapsed, and features much simpler universal wiring than previous models we have had.

HEADLIGHT REMINDER FOR CARS

KC-5317 $20.25 plus postage & packing

Nothing is more frustrating than getting into your car early in the morning, only to discover that you had left your headlights on the night before, running your car's battery flat. Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. Build and install this hassle saving kit and enjoy a feature in your car that many luxury vehicle owners have long taken for granted.



LUXEON STAR LED DRIVER KIT

KC-5389 $21.75 plus postage & packing

Luxeon high power LEDs are some of the brightest LEDs available in the world. They offer up to 120 lumens per unit, and will last up to 100,000 hours! This kit allows you to power the fantastic 1W, 3W, and 5W Luxeon Star LEDs from 12VDC. This means that you can take advantage of what these fantastic LEDs have to offer, and use them in your car, boat, or caravan.

- Kit supplied with PCB, and all electronic components

TRANSISTOR TESTER

KA-1119 $17.50 plus postage & packing

Have you ever unsoldered a suspect transistor only to find that it checks OK? Troubleshooting exercises are often hindered by this type of false alarm. You can avoid these hassles with the In-Circuit Transistor, SCR and Diode Tester. The kit does just that, test drives without the need to unsolder them from the circuit! Kit includes a jiffy box, battery, electronic components and a panel showing truth table for device checking.

Don't just sit there BUILD SOMETHING!

5 METRE IR LIGHT BEAM

KG-9094 $11.00 plus postage & packing

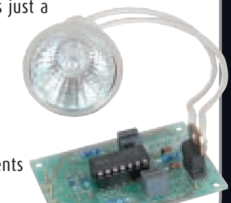
With a range of about 5 metres, this kit will indicate using an LED when a person or object interrupts the infrared light beam. Use it across a doorway or across an assembly line. Kit supplied with Kwik Kit PCB, infrared transmitter/receiver diodes, and all electronic components.

- 9-12VDC operation
- PCB Dimensions: 58 x 45mm

FLICKERING FLAME LIGHTING

KC-5234 $10.75 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 (SL-2735)

DIGITAL MULTIMETER KITS

Digital Multimeter Kits

KG-9250 $15.75 plus postage & packing

Learn everything there is to know about component recognition and basic electronics with this comprehensive kit. From test leads to solder, everything you need for the construction of this meter is included.

- Dimensions: 67(W) x 123(H) x 25(D)mm

Low Capacitance Adaptor for DMM Kit

KC-5493 $22.00 plus postage & packing

Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery and just about any modern DMM.

12V LIGHT OPERATED RELAY

KG-9090 $18.00 plus postage & packing

Operate as a twilight on/off switch or as a light trigger relay from 12 volts, this versatile project triggers a 6 amp relay when the light intensity falls below an adjustable threshold. Turn lights on around the house when it goes dark or trigger an alarm when a light is switched on. Kit supplied with Kwik Kit PCB, relay and all electronic components.

- PCB Dimensions: 55 x 27mm

POST & PACKING CHARGES

Order Value	Cost
$25 - $49.99	$7.50
$50 - $99.99	$20
$100 - $199.99	$40
$200 - $499.99	$60
$500+	$75

Max weight 12lb (5kg).
Heavier parcels POA.
Minimum order $25.

Note: Products are dispatched from Australia, so local customs duty & taxes may apply.
Prices valid until 31/5/2011

HOW TO ORDER

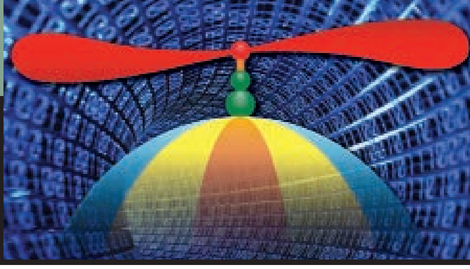
WEB:	www.jaycar.com
PHONE:	1-800-784-0263*
FAX:	+61 2 8832 3118*
EMAIL:	techstore@jaycar.com
POST:	P.O. Box 107, Rydalmere NSW 2116 Australia

- ALL PRICING IN US DOLLARS
- MINIMUM ORDER ONLY $25

*Australian Eastern Standard Time
(Monday - Friday 09.00 to 17.30 GMT + 10 hours)
Note: 10-14 days for air parcel delivery

Order online: www.jaycar.com

Jaycar Electronics



■ BY JON WILLIAMS

WRANGLING THE 1-WIRE BUSS

I have, of late, caught myself saying to friends and customers, "Why don't you just write a custom driver in PASM? It's not that hard." Some scoff, suggesting it's easy for me, but I tend to respond that most projects would be easy for them, too. I have never and will never claim to be the brightest bulb in the box, and I'm certainly no "Propeller guru" — for that, you need to turn to guys like Chip and Beau and Phil and Mike (and others) that assist those of us that frequent the Propeller forum. Still, if I can program straightforward drivers in PASM, you can too, and I intend to show you how.

Those of you that know me from my writing that has appeared in these pages since 1997 (zoinks!) know that I am freakishly sensitive to temperature. For example, I know that my summertime "comfort zone" is between 77 and 78 degrees Fahrenheit — not a big zone. Any cooler and I'm uncomfortable. The same goes if it's any warmer.

Since I do most of my work from home, I have control over the environment and am reasonably comfortable most of the time. Still, when it's hot in the summer or cold in the winter, the HVAC system comes into play and I find myself constantly adjusting it. Here's the problem: The control is too close to an output register and doesn't accurately reflect the rest of my home.

What to do? Same as you would: build my own controller! Now, I'm not going to go into that project this time but what I am going to do is create a 1-Wire object so that I can sense temperature at the controller or within a reasonable distance with a simple setup. If I'm successful this month, you'll be inspired to write your own drivers where timing is critical, hence PASM is required.

1-WIRE REVIEW

The 1-Wire buss — created by Maxim/Dallas — uses a master-slave configuration where all transactions are initiated by the master controller. In our case, the Propeller will be the master and our object will provide control over the buss to communicate with external devices.

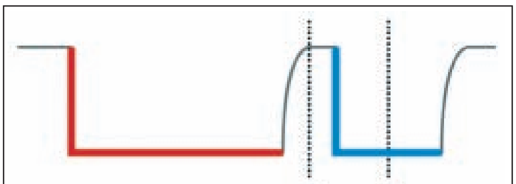
From an electrical standpoint, the 1-Wire buss is an open-collector/open-drain synchronous serial buss. The buss is pulled up to Vcc and all devices — master and slaves — can pull the buss to ground to create a "0" value. This design prevents data collisions from creating an electrical problem since there is no device that can drive the buss high while another is pulling it low.

With just one wire, there is no clock line to keep things in sync (e.g., with the Philips I^2C buss). What this means, then, is that buss timing is critical — you can't do 1-Wire with an RC clock.

All communications are initiated by a master reset pulse which is followed by a "presence" pulse from one or more connected devices. The presence pulse allows the master to know if there is, in fact, something connected to the buss. We can also use the period from the end of the reset pulse to the anticipated start of the presence pulse to detect a buss short.

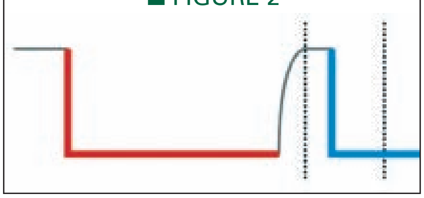
Have a look at **Figure 1** (please note that it is not to scale). The master (red) will pull the buss low for a period of at least 480 microseconds. After releasing the buss, the slave(s) will wait from 15 to 60 microseconds before pulling the buss low to acknowledge presence.

Author's Note: The timing used in my code may be

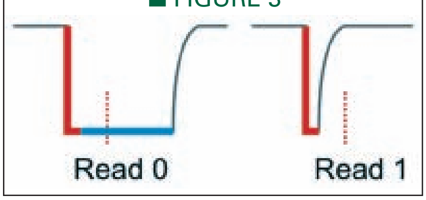


■ FIGURE 1

■ FIGURE 2



■ FIGURE 3



different from what you find in a 1-Wire datasheet. These values, however, come from a Maxim/Dallas support engineer who I worked with while at Parallax when the BS2p series was having some trouble with a particular iButton. That engineer (Ken) gave me these values and he has been correct: I have never had any trouble using 1-Wire devices since. As you'll see, timing values in my code are easily changed should you feel more comfortable with "officially documented" values.

In **Figure 1**, you'll see two points along the diagram: one marked "S" and the other marked "P." The first point is where the master will sample the buss for a short; if that is the case, it will never go back to "1" via the pullup. The second point — always noted in datasheets — is the sampling point of the buss for the presence pulse. By making these two tests after reset, we can determine the state of the buss and if anything is connected.

When we code the reset section, we'll use Ken's numbers:

- Pull buss low for 500 µS
- Release buss to pull-up
- Wait 5 µS
- Sample buss for short (S)
- Wait 70 µS
- Sample buss for presence (P)
- Wait 400 µS (recovery period)

PLAYING THE SLOTS

All 1-Wire signaling is via "slots" that are initiated by the master; there are "write" slots where the master is writing a value to the buss that is sampled by the slave, and there are "read" slots where the master is reading from the currently-enabled slave device.

Figure 2 illustrates the Write 0 and Write 1 slots. The slave will sample the buss about 15 µS after the buss has been pulled low.

Write 0
- Pull buss low for 60 µS
- Release buss to pull-up
- Wait 10 µS (recovery)

Write 1
- Pull buss low for 5 µS
- Release buss to pull-up
- Wait 65 µS (complete slot, recovery)

As you can see, write slots are about 70 µS each.

Figure 3 illustrates the read slots. A read slot is initiated by the master. Within 15 µS of the beginning of the slot, the slave will place its value on the buss for the master to sample.

1-Wire Buss Read
- Pull buss low for 5 µS (critical)
- Release buss to pull-up
- Wait 10 µS
- Sample buss
- Wait 60 µS (complete slot, recovery)

Most 1-Wire datasheets suggest that the master only needs to pull the buss low for a period of greater than one microsecond. However, Ken was adamant that this period should be five microseconds to ensure that the slaves on a long buss would see this pulse and respond properly.

CODING THE 1-WIRE OBJECT

I have seen it suggested that it's possible to code a 1-Wire object in 100% Spin. Bollocks! Each Spin instruction requires at least 5 µS and that does not account for loop overhead where there is more than a single bit to send or receive. Of course, we'll use a Spin interface, but the critical timing required by the 1-Wire protocol will have to be coded in PASM.

Some will remember the framework code from the January article where we connected Spin to PASM. For this object, we'll put it to work — with an improvement, as well. If you're still new to PASM, please hang in with me. I think this is a great demonstrator for simple PASM objects and with just a small amount of study even PASM beginners can master this.

Okay then, let's have a look under the hood. Within the 1-Wire object, there are four variables that serve the interface between the Spin and PASM sections:

```
var
  long  owcmd
  long  owio
  long  owpin
  long  us001
```

The first, *owcmd*, is used to set the command; we'll set this to a [positive] non-zero value and then wait for its return to zero which indicates the completion of the command. Values passed to and from the PASM code are through the variable, *owio*. The pin to use for the 1-Wire buss is passed in *owpin* and, finally, the number of clock ticks per microsecond is passed in *us001*.

Initializing the 1-Wire object is a breeze; we simply pass the desired pin to the **init** method and it takes care of the inside business:

```
pub init(pin)

  finalize

  if (pin => 0) and (pin =< 27)
    owpin := pin
    us001 := clkfreq / 1_000_000
    dira[pin] := 0
    owcmd := 0
    cog := cognew(@onewire, @owcmd) + 1
  else
    cog := -1

  return (cog > 0)
```

If the object was previously started, it gets shut down with **finalize**, and then the pin number is checked. Assuming that's fine, the pin number is copied into the object variable and the ticks per microsecond are calculated from the system clock frequency. The command value is cleared and then we start the 1-Wire cog, passing the address of *owcmd* in the **par** register.

Let's move to the PASM code that gets the 1-Wire object started:

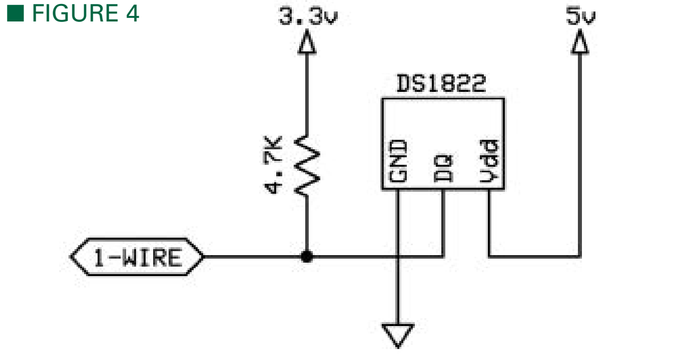
```
dat

                  org      0

onewire          mov      dira, #0
                  mov      outa, #0

                  mov      tmp1, par
                  mov      cmdpntr, tmp1
                  add      tmp1, #4
                  mov      iopntr, tmp1
                  add      tmp1, #4
                  rdlong   tmp2, tmp1
                  mov      owmask, #1
                  shl      owmask, tmp2
                  add      tmp1, #4
                  rdlong   ustix, tmp1
```

At the top, we clear the I/O pins and then move the structural elements from the Spin interface into the cog. The address of *owcmd* (Spin) is transferred through **par** and copied into *cmdpntr* (PASM). Likewise, the address of *owio* (Spin) is copied to *iopntr* (PASM). The values in the next two elements, *owpin* and *us001*, are read from the hub and saved in local variables. The pin number is used to create a mask for the pin that will be used for writing and reading 1-Wire bits.

Now for the command handler which I indicated earlier has an improvement. In my January article, I used a series of stacked comparisons to route the command. That works, and is well-suited for non-contiguous command values. That said, when we have control we can make the command values contiguous to simplify the code. Have a look:

```
owmain           rdlong   tmp1, cmdpntr wz
         if_z     jmp      #owmain
                  mov      bytecount, tmp1
                  and      tmp1, #$FF

                  min      tmp1, #0
                  max      tmp1, #6
                  add      tmp1, #jmptable
                  jmp      tmp1

jmptable         jmp      #cmdexit
do_cmd1          jmp      #owreset
do_cmd2          jmp      #owwrbyte
do_cmd3          jmp      #owrdbyte
do_cmd4          jmp      #owrdbit
do_cmd5          jmp      #owcalccrc

cmdexit          wrlong   ZERO, cmdpntr
                  jmp      #owmain
```

■ FIGURE 4



At **owmain**, we're reading the command value from the hub, initially checking against zero (no command). When a non-zero value is read, we copy the command to a local variable called *bytecount* (more on this later) and then strip off everything except the lower byte, which is where the command value is held.

Next comes error trapping for bad command values. By using the **min** operator, we can convert negative values to zero. By using the **max** operator, we trap command values beyond the legal range. The key is to compare the command value with the number of legal commands plus one. In the 1-Wire object, there are five legal commands, hence the comparison used with **max** is six.

Now for the fun part. The code that follows is the PASM equivalent of **ON X GOTO** in some dialects in BASIC, or the PBASIC **BRANCH** instruction. It works by adding the filtered command value to the address of a jump table that handles the commands. In PASM, values and addresses are longs, so adding the command to the base address gets us to the appropriate **jmp** instruction. Note that the first element in the jump table (for command = 0) jumps to the end of the table — the same place a command that exceeds the legal range will end up. This section of code clears the command without any further hub updates and routes us back to the top of the main loop.

I find this style cleaner and easier to update. And, if you do have a non-contiguous set of commands that don't have large gaps between them, you can set up the jump table to handle the non-command values. They would simply route the code to the exit point.

We know that the 1-Wire buss must be reset before we do anything else; let's have a look at that code:

```
owreset          mov      value, #%11
                  or       dira, owmask
                  mov      usecs, #500
                  call     #pauseus
                  andn     dira, owmask
                  mov      usecs, #5
                  call     #pauseus
                  test     owmask, ina wc
```

```
                    muxc     value, #%10
                    mov      usecs, #70
                    call     #pauseus
                    test     owmask, ina wc
                    muxc     value, #%01
                    mov      usecs, #400
                    call     #pauseus
                    wrlong  value, iopntr
                    wrlong  ZERO, cmdpntr
                    jmp      #owmain
```

In the discussion above, I showed you how the buss can be reset and checked for a short and the presence pulse. We'll capture this two-bit result in a local variable called *value*; this is initialized to %11 (nothing attached to buss). To pull the buss low for the reset pulse, we'll write the pin mask to the **dira** register, making the buss pin an output. We had previously cleared the **outa** register, so this action results in pulling the 1-Wire buss low.

This is important: We only ever want to manipulate the **dira** register to control the buss. When we write a "1" to the bit in **dira**, the 1-Wire pin will go low; when we write a "0" to the bit in **dira**, the pin will become an input and be pulled high by the external pull-up.

You'll recall that Ken told me to use a 500 µS reset pulse. This is accomplished by moving 500 into usecs and calling **pauseus**. Let's have a look at that.

```
pauseus          mov      ustimer, cnt
                  sub      ustimer, #24
                  add      ustimer, ustix
usloop           waitcnt ustimer, ustix
                  djnz     usecs, #usloop
pauseus_ret     ret
```

This subroutine uses a loop to count down the number of microseconds in the delay. One small note: I added a small correction by subtracting 24 from the system count which is moved into *ustimer*. The reason for this is to account for the overhead required for setting up, calling, and returning from the delay. The 1-Wire protocol is all about timing, so we want to keep things tight; this correction helps, especially for short delays.

Back to the reset command. After holding the buss low for 500 µS, it is released and then we wait 5 µS before scanning the buss. At this point, the pull-up should have pulled the buss high, and we'll read a "1" on it. The buss state is captured in the Carry bit written into bit1 of *value* with **muxc**. If we read "0" at this point, the buss is shorted or we neglected to add the pull-up.

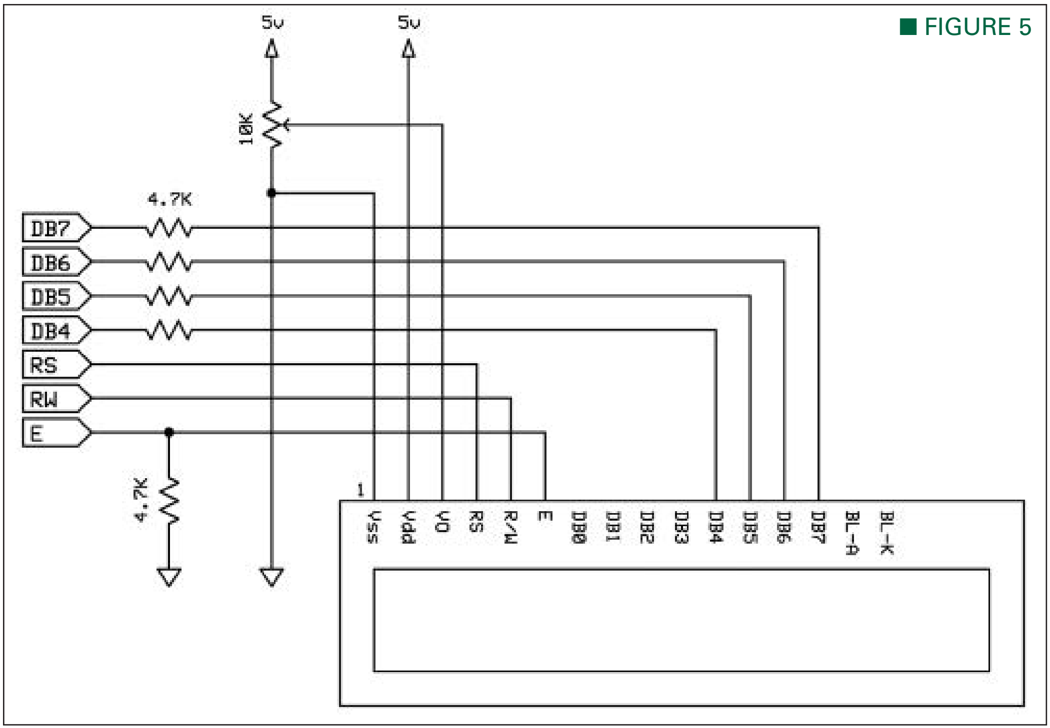
The next step is to wait 70?s; this gives the device(s) on the buss time to pull the buss low to indicate their presence. As before, we capture the buss state in the Carry bit and move it to bit0 of *value* with **muxc**. With a device on the buss we should see "0" at this point, indicating that the device is indeed present.

Finally, a 400 µS delay is inserted to allow the presence slot and buss recovery to take place. The bits in *value* are written to the hub variable called *owio,* and then the program jumps to **cmdexit** which clears the command value in the hub. This is the signal to the mainline code that the command is complete.

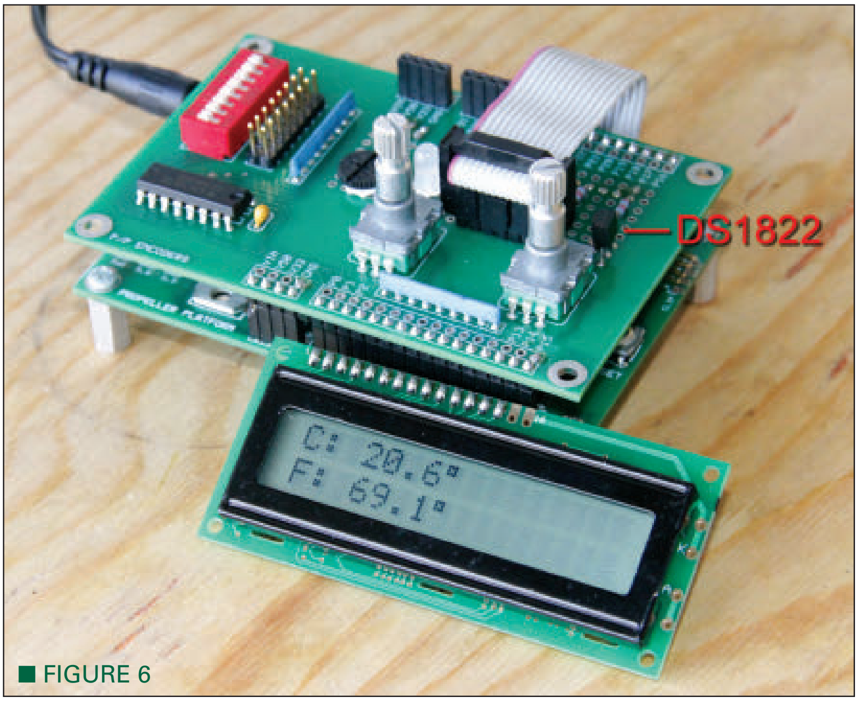
Now let's have a look at the Spin interface:

```
pub reset

  owio := %11
  owcmd := 1
  repeat while owcmd

  return owio
```

The reset method starts by initializing the return value (in *owio*) to the "no device" state — this probably seems overly cautious, but is done to provide a valid return in the event we *erred* on the PASM side and forgot to update the hub. Next, we set the command value; this is the trigger to the PASM code to run the command. When the command is finished, the value of *owcmd* will be zero so a simple **repeat while** loop takes care of the waiting



■ FIGURE 5



■ FIGURE 6

this by shifting that value left eight bits which moves it into byte1 of *owcmd*. You'll remember that we copied the command to a PASM variable called *bytecount* and then stripped off the upper bytes; now you can see why. In the PASM code that handles the CRC, the byte count is reconstituted by shifting it right by eight bits.

Before I run out of space, let's put this dude to use. Since I am the temperature freak I have so often declared, let's measure temperature with a 1-Wire device. My choice this time is the DS1822. I use the TO-92 package with three leads as it's easier to prototype with.

To that end, I soldered the DS1822 and a pull-up to my Encoder Platform module (see *Nuts & Volts*, May '10) which sits on a Propeller Platform (classic). As I've turned this setup into my human controls prototyping platform, I added an LCD using a four-bit interface. In my case, I grabbed the LCD with cable that was part of the StampWorks kit. One off, these LCD/cable combinations can be pricey so you may want to solder the LCD directly to the PCB. An alternative is to use the Propeller Platform LCD UI (available from Gadget Gangster) and connect the DS1822 and pull-up to the expansion buss.

The DS1822 returns temperature as a signed, two-byte value that defaults to 12-bit resolution (the upper four bits are sign bits). In practical terms, this means that each bit in the return value is 0.0625 degrees Celsius. We could argue that this is overboard and configure the DS1822 for lower resolution, but it's simpler to take the value as-is and truncate unused bits later. Yes, it does take longer to convert the higher resolution value, but even at 12 bits of resolution the conversion takes place in well under one second.

As ever, you should consult the datasheet for any device you're using. In the DS1822 datasheet (that was a hint to download it!), there is a flow chart that details the various commands. For our purposes, we're going to assume the DS1822 is the only device on the buss; this allows use of the Skip ROM command ($CC) and simplifies the exchange. Of course, if we decide to add a second sensor then we'll need to know the serial number and access the sensor with it (I've included code that shows you how to do that in my demo).

For now, let's keep it simple — this method will retrieve the temperature in Celsius from the attached DS1822:

```
pub readtc | tc

  ow.reset
  ow.write(SKIP_ROM)
  ow.write(CVRT_TEMP)
  repeat
    tc := ow.rdbit
```

game. At the end, we return *owio* — in this case, indicating the 1-Wire buss reset state — to the caller.

The other 1-Wire methods work in exactly the same manner and follow the timing guidelines discussed above, so I won't put you through the drudgery of an explanation. As ever, the download files are completely annotated should you want further details.

There is an exception that I promised to cover. One of the methods in the PASM code is used to calculate the CRC8 value of a block of bytes in the hub. Let me be honest, I didn't write this code. I "liberated" ("steal" is such an ugly word) it from a program written by Propeller and math guru, Cam Thompson. Here is the Spin interface to that code:

```
pub crc8(pntr, n)

  owio := pntr
  owcmd := (n << 8) + 5
  repeat while owcmd

  return owio
```

This method requires the address of the byte array and the number of elements to check. We pass the address to the PASM code in *owio* and embed the number of bytes in the array into the command — we do

BILL OF MATERIALS

Item	Description	Supplier/Part No.
LCD	2x16 w/cable	Parallax 603-00006
R1-R6	4.7K	Mouser 299-4.7K-RC
Q1	DS1822	Mouser 700-DS1822
X1	2x8 male header	Mouser 517-836-01-04

```
    until (tc == 1)
    ow.reset
    ow.write(SKIP_ROM)
    ow.write(RD_SPAD)
    tc := ow.read
    tc |= ow.read << 8

    tc := ~~tc * 625

    return tc
```

This method, in fact, takes us through two paths in the flow chart; the top instructs the DS1822 to do a temperature conversion. While the DS1822 is busy with that, it will output "0" when a read bit command is executed. By putting this in a loop, we can move on as soon as the conversion is complete.

The next section reads the first two bytes from the DS1822 scratchpad — this is where the temperature from the last conversion is stored (Little Endian). As the 1-Wire buss is byte oriented, it takes two reads to retrieve the temperature.

The value returned is a signed value, but it's only 16 bits. Thankfully, Spin has a cool operator (~~) that will extend the sign of a 16-bit value; this lets us do math without errors. After extending the sign, we multiply by 625 to convert the raw reading into units of 1/10,000.

For the LCD demo, I decided to display values with a single decimal point. Here's that code:

```
pub show_temp(t)

    if (t < 0)
      lcd.out("-")
      ||t

    lcd.dec(t / 10_000)
    lcd.out(".")
    t //= 10_000
    lcd.out((t / 1_000) + "0")
    lcd.out(223)
    lcd.out(" ")
```

If the temperature is negative (the DS1822 can measure down to -67 degrees Fahrenheit), then we'll print the negative sign and remove the sign from the value with the absolute (||) operator. The whole degrees are extracted by dividing the input value by 10,000 and printing with the **dec** method. We remove the whole part with the modulus (//) operator and then print just the most significant digit by dividing that by 1,000. Adding "0" converts the digit to ASCII for use with the **out** method.

There you have it: A 1-Wire object and some practice connecting to a common device. To be fair, there are not nearly as many 1-Wire devices in the world as there are I²C devices, but 1-Wire can be useful, especially in local temperature sensing. Another benefit to adding any 1-Wire device to your project is that it now has a serial number, even if you don't use it to access the device.

Last Christmas, a new friend was telling me about a style of cooking called Sous Vide (soo veed) where food is sealed in bags that have had the air removed (think "seal-a-meal"). The bags are placed in a hot water bath to cook "low and slow." So, before I tackle a custom rework of my HVAC system, I might start in the kitchen. My thought is that I can mount a DS1822 in the end of some aquarium tubing — sealed with silicone — to make it submersible. Now I just need to find an inexpensive SSR to control the crock pot! I guess I'd better pop in to see my friends at All Electronics.

That's what I've got in mind. What are you going to do? Until next time, keep spinning and winning with the Propeller! **NV**

JON "JONNYMAC" WILLIAMS
jwilliams@efx-tek.com

PARALLAX, INC.
Propeller C3
www.parallax.com

GADGET GANGSTER
Propeller Platform kits and accessories
www.gadgetgangster.com

READER FEEDBACK

continued from page 11

upper cylinder lubrication to last.

Having worked with the design and programming of steam generators in the oilfields for over 25 years (which output 50 million BTU of live steam), I am a qualified expert in that arena. Steam is incredibly dangerous and I see no mention of Personal Protective Equipment (PPE) such as safety glasses or gloves to protect again burns with steam use. There really should have been a sidebar emphasizing safety! Not to mention the engine seizing if someone is foolish enough to use steam without proper lubrication. Whenever rotating equipment seizes, it often fragments, throwing pieces of debris in all directions. Please understand that I'm not trying to tear the author apart, I'm simply trying to help others from getting hurt!

There's lots of self-imposed "experts" out there taunting alternate energy solutions. Solar, wind, gravity fed water power generation, etc., are alternate energy solutions. Since the source of the air and/or steam has their prime movers (energy source) in petroleum, I don't think this qualifies as alternative energy. I appreciate the many interesting articles and the talented engineers (such as Jon Williams and Fred Eady) teaching the ropes to the younger and less experienced readers. I felt a moral obligation to clarify some issues I believe were overlooked. Please consider my comments in that light.

Dennis Shepard

Response: Yes, your comments regarding safety are well founded! I intentionally did not mention boilers, etc., except in passing at the foot of the sidebar, and then only the so-called monotube design. I guess I assumed that any reader of N&V *would generally realize that steam is hot. I think I did use the words "potentially dangerous." I will re-emphasize that point here.*

I understood going into the article that it was very unlikely that many readers would progress from compressed air to actual steam and those that did would have some pre-understanding of the pitfalls. The real intent of the article was intended to illustrate how current microcomputer technology can be applied to problems associated with "obsolete" technology.

Again, due to limitations in space for the article I did not address lubrication. In the air engine — as the lower end is open and at atmosphere — I simply grease the crank pin and rod end with lithium grease, and prior to a run inject some 50 weight oil into the exhaust port. Again, I may have incorrectly assumed that folks interested in actually persuing the engine would have pre-existing knowledge (re: oil and grease) ... my bad! For steam, I built a larger version of the model engine displacement lubricator which is fine for saturated steam use ... again space limitations.

However, I should mention that petroleum is NOT the prime mover in many small scale energy projects, by design. The old standby wood and wood byproducts, as well as methane produced from manure and landfills/garbage can and do produce many BTUs on a smaller scale worldwide.

John Molnar

ELECTRONET

■ BY L. PAUL VERHAGE

PROGRAMMING THE NEARSPACE ULTRALIGHT

Now that the UltraLight flight computer is complete, you're ready to start creating a near space mission. Therefore, this month we'll delve into programming the UltraLight's PICAXE-28X1 and how to download mission data.

The UltraLight has two microcontrollers, but you program them two different ways. The first is the PICAXE-28X1 and it's responsible for operating experiments and collecting data. Since it is mission specific, it gets a new program for each mission. The Tiny Trak, on the other hand, is responsible for generating position reports and you normally program it once. Both use free software that is available over the Internet. The PICAXE Editor is available from Revolution Education (**www.rev-ed.co.uk**) and the Tiny Trak configuration editor is available from Byonics (**www.byonics.com**).

The PICAXE-28X1 has 4K of EEPROM for programs (data can be stored in EEPROM, but the UltraLight carries a memory chip for this purpose) and 28 bytes of RAM for variables (named B0 to B27). The UltraLight takes advantage of the analog-to-digital conversion channels and hardware serial port built into the PICAXE. The UltraLight configures the remaining PICAXE pins for digital I/O and servo control.

The microcontroller in the Tiny Trak is preprogrammed to collect GPS data and transmit position reports over a radio. All the configuration editor does is set its parameters of operation which includes information like your callsign and the digi-path for transmissions.

The rest of this article describes how to program the UltraLight to collect sensor data, operate servos and cameras, and how to store results. The next article closes this series on the UltraLight with programming the Tiny Trak.

READING THE COMMIT PIN

After starting the UltraLight, its GPS receiver requires a few minutes to get a satellite lock. To prevent the UltraLight from wasting memory recording data while you wait for the GPS LED to stop blinking and go solid, add a routine to the flight code that keeps the UltraLight in a wait loop until someone removes the commit pin (be sure to remember to pull the commit pin just before liftoff). The following code will do the job:

```
Commit:
IF PIN6 = 0 then Commit
```

READING THE ANALOG PORT

The analog port is where you'll interface most of the sensors. Its function is to convert analog voltages into digital values that can be stored in memory. The analog conversion takes place within the PICAXE and all four of the PICAXE's ADC channels (ADC0 through ADC3) are accessible. There are two commands that read analog voltages: READADC for eight bits of resolution and READADC10 for 10 bits of resolution. At eight bits, a voltage from zero to five volts gets divided into 256 bins (19.5 mV per bin). At 10 bits, the same voltage gets divided into 1024 bins (4.9 mV per bin) or with four times the resolution. The eight-bit result can be stored within a byte of memory but a ten-bit result must be stored within a word. This means the UltraLight can only store half as many readings at the higher resolution. This limitation is not a serious issue as long as the memory is large enough for the amount of sensor data collected. The format for both commands is the same:

```
COMMAND, I/O Channel, Variable
```

An example subroutine to collect all four analog sensor voltages at eight bits of resolution looks like this:

BalloonSat

In March, I completed the oral exam for my Ph.D., so now I just need to complete the dissertation. I plan to research the effects of a BalloonSat project on middle or secondary students. The effect I'm looking for is changes in student attitudes and beliefs about science, math, and engineering. I'm now looking for volunteer classrooms. If you have a class or know of a class that might be interested in building a BalloonSat and having the University of Kansas launch it for them (the BalloonSat will be sent back after recovery so the students can analyze the results), then please contact me. My email address for this study is nearsys@ku.edu. Thanks.

```
FOR B0 = 0 to 3
READADC, B0,B1
NEXT
```

In this example, variable B0 points to the ADC channel that the UltraLight is currently converting and variable B1 is the variable where the result of the conversion will be stored. To make this code more meaningful, consider using symbols to replace variable names. For example:

```
SYMBOL Index = B0
SYMBOL Result = B1
```

Each conversion of a sensor reading must be stored in memory before the next conversion takes place. You'll find the subroutine for storing data later in this article.

USING THE DIGITAL PORT

The channels of the digital port are PICAXE-28X1 PortC pins. By default, they are inputs to the PICAXE, however, software can redefine them as outputs. As inputs, the digital port is good for Geiger counters and detecting switch closures.

The example below illustrates the UltraLight collecting data from a Geiger counter. Upon each detection of ionizing radiation, the output of the Aware Electronics RM-60 Geiger counter goes from +5V to ground. The example below counts the number of times the voltage drops to zero on digital pin 0 for 10 seconds (10,000 milliseconds) and stores the result in a variable called Result.

```
COUNT 0,10000,Result
```

In the next sample code, the UltraLight is detecting when a digital high (a voltage above 1.4V) occurs on pin IN2 (D2 on the UltraLight):

```
IF PIN2 = 1 THEN Detected
```

When connecting a relay, SCR, or LED to the digital port, the PICAXE must reconfigure an input pin to an output pin. The next example configures UltraLight channel D1 as an output:

```
HIGH PORTC 1        'set D1 to +5V

LOW PORTC 1         'set D1 to ground
```

USING THE GPS PORT

The GPS connects to the UltraLight through the PICAXE's hardware serial port. Doing so permits the GPS to dump data into the PICAXE's 256 bytes of scratch pad memory. Afterwards, the flight code can parse the data for the desired information. GPS data is 4800 baud, N81, inverted. However, the PICAXE hardware serial port cannot read inverted data, so a MAX232 IC is a part of the UltraLight. The following command prepares the hardware serial port for GPS data, but only records it to the scratch pad when the HSERIN command is given (it's possible for the scratch pad to update constantly):

```
HSERSETUP B4800_4,%00
```

Once the hardware serial port is set up, the following command dumps GPS data into the scratch pad memory:

```
HSERIN [4000,Bad_GPS],0,60,("W")
```

Now a few words of explanation:

[4000,Bad_GPS] indicates the PICAXE is to jump to the label **Bad_GPS** if no GPS data is received within four seconds of the command being issued. Always include the wait parameter; that way, if something goes wrong with the GPS, at least the flight computer doesn't lock up.

0,60 instructs the PICAXE to begin storing data at scratch pad address 0 and to store the next 60 bytes of GPS data.

("W") tells the PICAXE not to store data until it sees the letter W in the text.

After storing a stream of GPS text into scratch pad memory, the following code will walk through it looking for a specific character (in this case, the letter M):

```
FOR Index = 0 to 60
GET Index,B0
IF B0 = "M" THEN Confirmed_Good_GPS
NEXT
```

USING THE SERVO PORT

Use the **SERVO** command to position servos and be sure to give the servo enough time to position itself (one second is usually long enough) before going to the next command:

```
SERVO 0,125
PAUSE 1000
```

The range of motion for most servos is 75 to 225. Do not exceed these values without gradually testing the servo at greater values.

USING THE CAMERA PORTS

The UltraLight operates Canon cameras running CHDK or standard cameras with modified shutters. A Canon camera running the remote USB script needs to see +5V on its USB port before taking a picture. A camera with a modified shutter needs its relay onboard the UltraLight to close. Both conditions occur when Output 4 or Output 5 is set to five volts. Give a camera about a second to operate the shutter as shown below:

```
HIGH 4
PAUSE 1000
LOW 4
```

STORING DATA

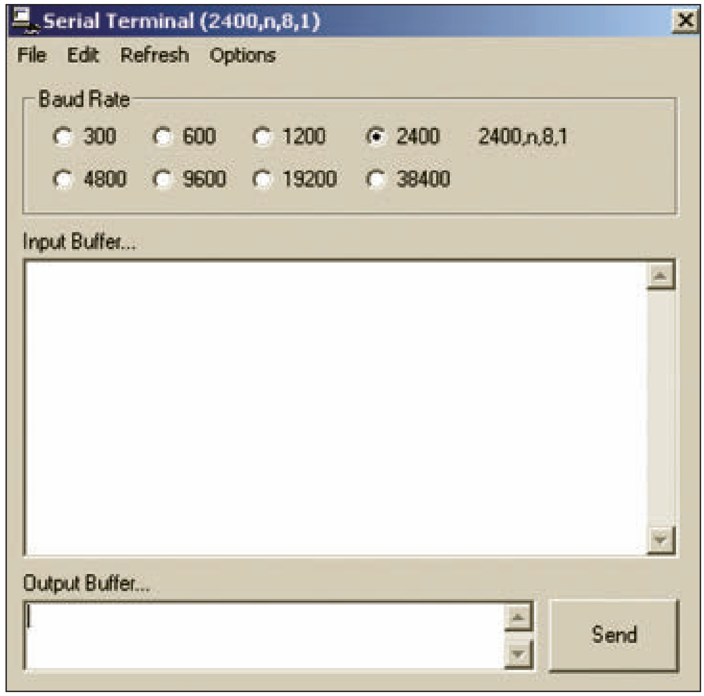
The UltraLight's mission memory is a 24LC128 or similar IC. This is an I^2C EEPROM that interfaces to the PICAXE's built-in I^2C circuitry. Before using the I^2C memory, the PICAXE-28X1 must have its I^2C pins properly configured with the following command:

```
I2CSLAVE %10100000,I2CFAST,I2CWORD
```

This command sets the PICAXE to communicate at 400 kHz and send data in one word lengths.

After configuring the I^2C channel between the PICAXE and EEPROM memory, the following code writes two bytes (one word) to successive EEPROM memory locations:

```
Store_Data:
LOW 2             ' un-write protect memory
WRITEI2C Record,(B6,B7)
PAUSE 10
Record = Record + 2
HIGH 2            'write protect memory
```



■ If the data looks garbled, check the baud rate setting in the terminal window. The data from the UltraLight shows up in the input buffer.

After completing the near space mission, you download mission data with the following code:

```
Download:
SERTXD ("Start,")
FOR Record = 0 to 4091 STEP 2
READI2C Record,(B6,B7)
SERTXD (#Reading, ",")
NEXT
```

I recommend using the terminal program that's included with the PICAXE Editor. You start the terminal program by clicking **PICAXE** at the top menu and then **Terminal**.

The proper baud rate for the SERTXD command is 4800 baud (it can't be changed). After downloading data from the UltraLight, click **Edit** in the Terminal's top menu and then **Copy Input Buffer**. Then, start up a text editor (like Notepad) and paste the text into it. From there, you can add any commas needed to properly format the data before opening it in a spreadsheet for final processing.

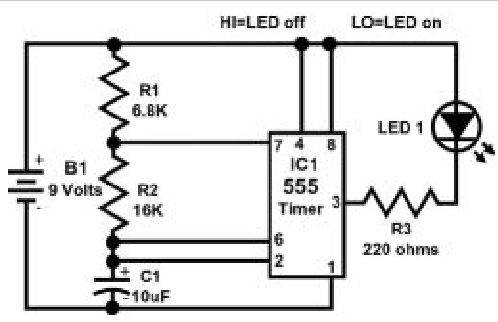
That is most of the programming information you need to fly a mission with the UltraLight. The challenge is adding all the pieces together to create a seamless program. Next time, we'll go over programming the Tiny Trak onboard the UltraLight. As you will see, the Tiny Trak is normally only programmed once and it's a whole lot easier.

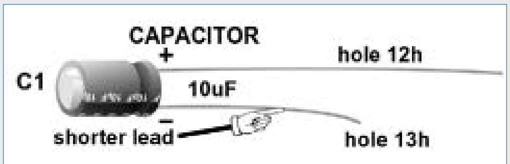
Onwards and Upwards,
Your near space guide **NV**

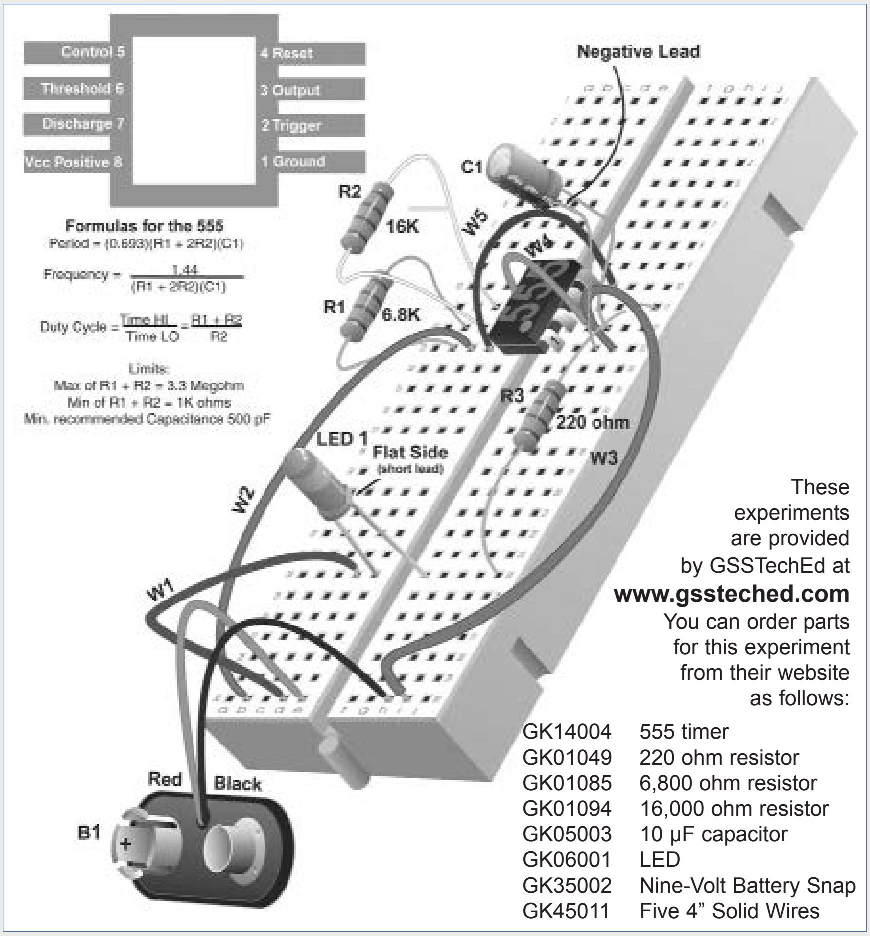
FUNDAMENTALS FOR THE BEGINNER

How a 555 Timer Works

A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at **www.nutsvolts.com** or call us at **800-783-4624**.







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

GK14004	555 timer
GK01049	220 ohm resistor
GK01085	6,800 ohm resistor
GK01094	16,000 ohm resistor
GK05003	10 µF capacitor
GK06001	LED
GK35002	Nine-Volt Battery Snap
GK45011	Five 4" Solid Wires

In this experiment, we will build a simple circuit to observe the operation of a 555 timer circuit.

1. Build the Circuit.

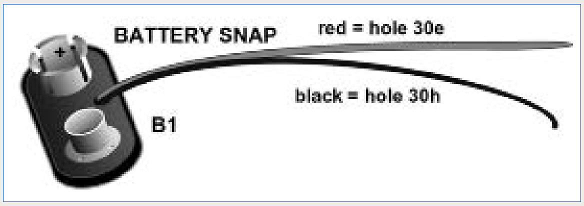
Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

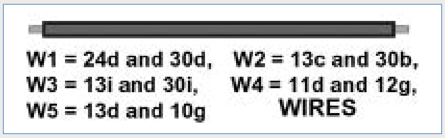
2. Do the Experiment.

__Theory:__ The 555 timer chip is commonly used as an astable or free-running multivibrator. Astable or free-running means that it will continue putting out pulses until you remove the battery. The ubiquitous 555 timer is a two-state device which means its output (pin 3) can only be high or low. Its state — HI or LO — and how long it remains with one of the two states on its output depends on external components (i.e., resistors and capacitors) connected to the pins of the 555. The square wave pulses emitted by pin 3 are called clock pulses. Digital circuits need these kind of clock pulses.

The circuit presented here is designed to make the outputs change from one state to another about once a second at one pulse per second. You can experiment with changing the values of R1, R2, and C1 and observe how the LED blinks at different rates.

Procedure: Connect a nine-volt battery to the battery snap. The LED should blink on and off at a frequency of about one time per second.





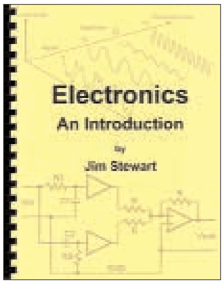
For a complete product detail visit our webstore!!

The Nuts & Volts WEBSTORE

ELECTRONICS

Electronics An Introduction
by Jim Stewart

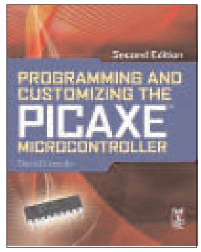
NEW!



This book is designed as an in-depth introduction to important concepts in electronics. While electronics can be highly mathematical, this text is not about calculations. It is about how electronic equipment is able to extract, process, and present information held in electrical signals. If you are in — or studying to be in — a profession that requires the use of electronic equipment, then this book will provide the insight necessary to use such equipment effectively. **$39.95***

Programming and Customizing the PICAXE Microcontroller 2/E
by David Lincoln

UNLEASH THE POWER OF THE PICAXE!

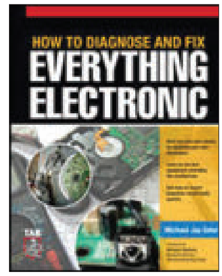


The PICAXE is a powerful and easy-to-use processor, capable of highly sophisticated projects, without the complexities and high costs of alternative chips. Beginners can produce tangible results within minutes, and experienced users can achieve truly professional results. This Second Edition has been fully updated for the latest hardware and software upgrades, and shows you step-by-step how to take full advantage of all the capabilities of the PICAXE and build your own control projects.
$49.95*

How to Diagnose and Fix Everything Electronic
by Michael Jay Geier

NEW!

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.

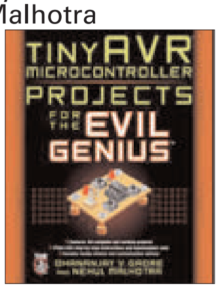
About the Author

Michael Jay Geier began operating a neighborhood electronics repair service at age eight that was profiled in *The Miami News*.
$24.95

---

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

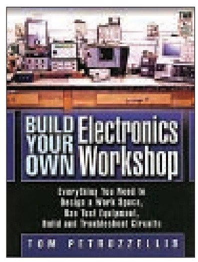
NEW!



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

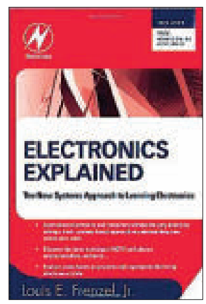
BUILD YOUR OWN DREAM ELECTRONICS LAB!



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

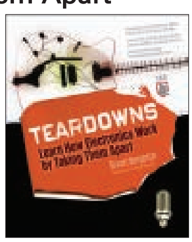
Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists
by Dustyn Roberts

NEW!

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*

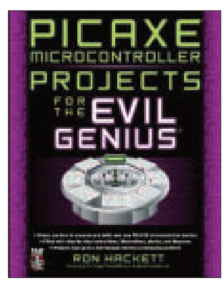
TEARDOWNS
by Bryan Bergeron

Learn How Electronics Work by Taking Them Apart



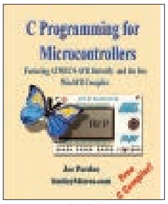
Amp up your knowledge of electronics by deconstructing common devices and analyzing the revealed components and circuitry. *Teardowns: Learn How Electronics Work by Taking Them Apart* contains 14 projects that expose the inner workings of household appliances, workbench measuring instruments, and musical 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

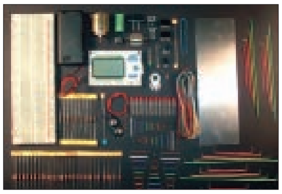


This wickedly inventive guide shows you how to program, build, and debug a variety of PICAXE microcontroller projects. *PICAXE Microcontroller Projects for the Evil Genius* gets you started with programming and I/O interfacing right away, and then shows you how to develop a master processor circuit.
$24.95

BOOK & KIT COMBOS



From the
Smiley Workshop
C Programming for
Microcontrollers
by Joe Pardue

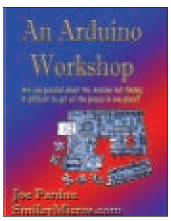


Book **$44.95**

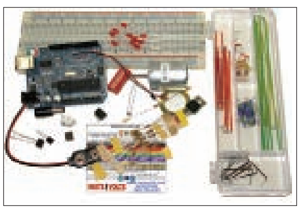
Kit **$66.95**

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

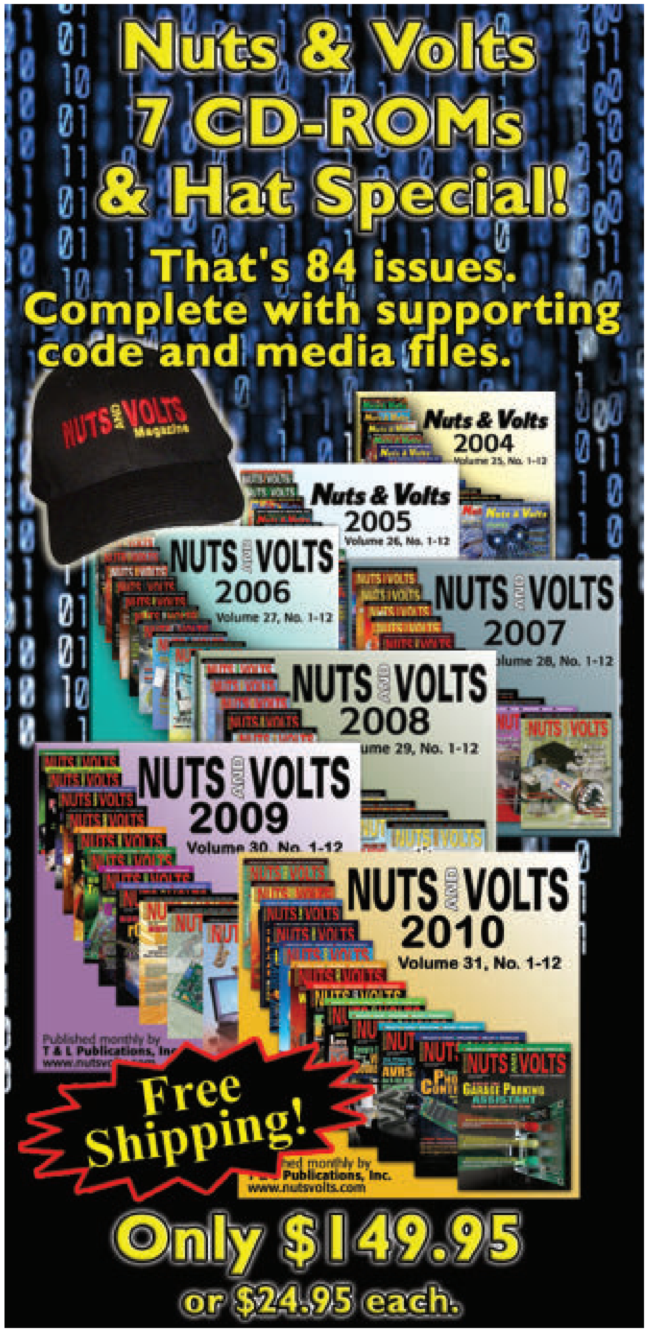


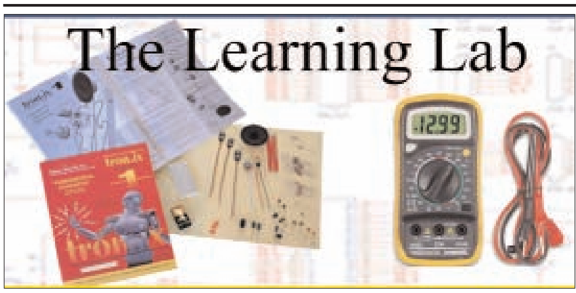
The book *An Arduino Workshop* and the associated hardware projects kit bring all the pieces of the puzzle together in one place. With this, you will learn to: blink eight LEDs (Cylon Eyes); read a pushbutton and 8-bit DIP switch; sense voltage, light, and temperature; make music on a piezo element; 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





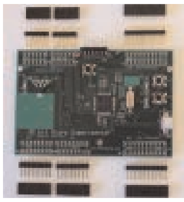
This lab — from the good people at GSS Tech Ed — will show you 40 of the most simple and interesting experiments and lessons you have ever seen on a solderless circuit board. As you do each experiment, you learn how basic components work in a circuit. Along with the purchase of the lab, you will receive 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!

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.

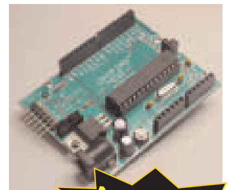
Subscriber's Price **$89.95**
Non-Subscriber's Price **$93.95**

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



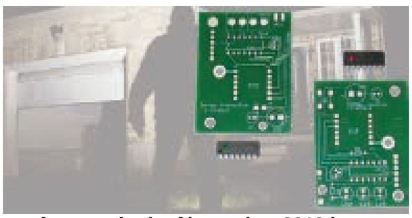
Assembled units $29.95!

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**

Garage Door Alarm PCB & Chips



As seen in the November 2010 issue.
Is Your Garage Door Open?

This project uses the latest in wireless technology, and is a fun and easy project to build. We provide the difficult parts: the transmitter and receiver PCBs with their matching programmed MCUs. The other components can be found at your favorite parts house.

Includes an article reprint.

Subscriber's Price **$29.95**
Non-Subscriber's Price **$31.95**

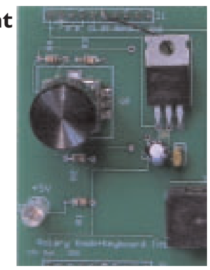
Mini-Bench Supply Complete Kit

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



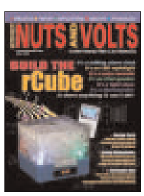
The best experiment yet for the 16-Bit Experimenter Board.

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**

rCube Talking Alarm Clock Kit

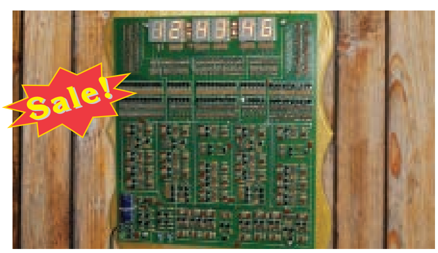
As seen on the May 2009 cover



Available in blue, black, red, and green. All components are pre-cut and pre-bent for easier assembly and the microcontrollers are pre-programmed with the software. Kits also include PCB, AC adapter, and instructions on CD-ROM.

Subscriber's Price **$49.95**
Non-Subscriber's Price **$54.00**

Transistor Clock Kit



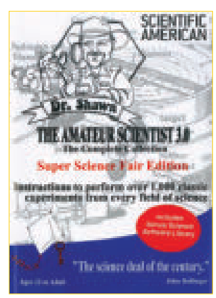
If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

Reg $225.95
Sale Price $199.95

PCBs can be bought separately.

The Amateur Scientist 4.0 The Complete Collection

by Bright Science, LLC



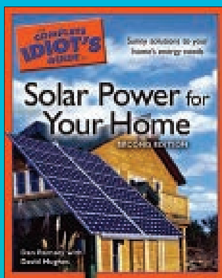
There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of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

Reg $26.95 Sale Price $23.95

WE ACCEPT VISA, MC, AMEX, and DISCOVER. Prices do not include shipping and may be subject to change.

ALTERNATIVE ENERGY SECTION

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

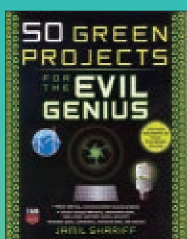


The perfect source for solar power — fully illustrated. This book helps readers understand the basics of solar power and other renewable energy sources, explore whether solar power makes sense for them, what their options are, and what's involved with installing various on- and off-grid systems.
$19.95

NEW!
Green Lighting
by Brian Clark Howard, Seth Leitman, William Brinsky
Flip the switch to energy-efficient lighting!

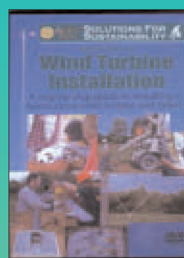
This do-it-yourself guide makes it easy to upgrade residential and commercial lighting to reduce costs and environmental impact while maintaining or even improving the quality of the lighting. Filled with step-by-step instructions and methods for calculating return on investment, plus recommended sources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

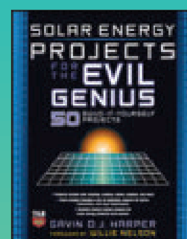
NEW!
Wind Turbine Installation DVD



Manuals can sometimes 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.

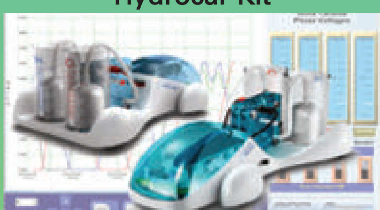
$19.95*

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**

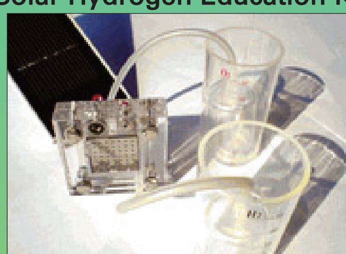
Hydrocar Kit



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.

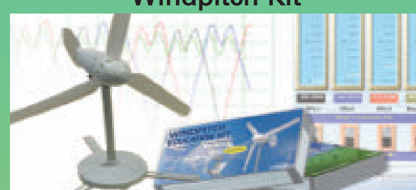
Subscriber's Price **$79.95**
Non-Subscriber's Price **$84.95**

Solar Hydrogen Education Kit



The Solar Hydrogen Education Kit includes a solar cell, a PEM reversible fuel cell, oxygen and hydrogen gas containers, and more! The set only needs pure water to create hydrogen and produce electricity. Perfect for science labs, classroom use, or demonstration purposes.
Subscriber's Price **$56.95**
Non-Subscriber's Price **$59.95**

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.
Subscriber's Price **$94.95**
Non-Subscriber's Price **$99.95**

ROBOTICS

MaxSonar
Ultrasonic Ranging is EZ

LV-MaxSonar-EZ
- Power-up calibration
- Smallest MaxSonar
- Low power, 2.5V-5.5V
- $29.95 USD qty. 1

MaxSonar-WR (IP67)
- Industrial packaging
- Weather resistant
- Standard ¾" fitting
- $99.95 USD qty. 1

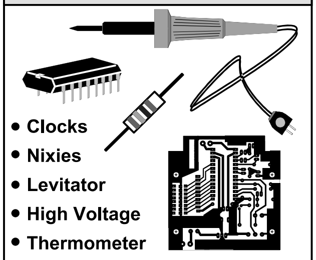
XL-MaxSonar-EZ
- Beam pattern choice
- Real-time calibration
- High acoustic power
- $39.95 USD qty. 1

MaxSonar-WRC (IP67)
- Compact packaging
- Weather resistant
- Quality narrow beam
- $99.95 USD qty. 1

www.maxbotix.com

KITS/PLANS

AMAZING KITS!



- Clocks
- Nixies
- Levitator
- High Voltage
- Thermometer
- Stepper Motor Drivers

www.TECHKITS.com

SAM-III Geomagnetometer Kit
- 3-Axis – N-S, E-W, Vertical
- ±50,000 nT, 1-2 nT resolution
- 12 Vdc
- Complete kit includes software
- Logging with PC or standalone
- Join worldwide magnetometer network
- Starting at US$199.95

www.reeve.com/SAM3.htm

Electronic Kits
- Fun and Educational
- Discount White and Blue LEDs
- Quantity Discounts

www.bakatronics.com

QKITS.COM

Qkits Ltd
50 AMP PWM
1-888-GO 4 KITS

High Quality
Electronic Kits & Modules

$59.95
UK1133
50 AMP DIGITAL PWM
(OPTIONAL DISPLAY)

FM Transmitters
Timers
Audio Amplifiers
Motor Controllers
PIC Programmers / Arduino
••• Custom Designs •••

www.canakit.com

POOR MANS SPECTRUM ANALYZER
Turns any oscilloscope or PC into a 2MHZ to 2.15GHZ RF Spectrum Analyzer.
Available as a kit
or kit with built and tested boards.
science-workshop.com

COMPONENTS

RF PARTS™ CO.
Tubes, Transistors, Power Components
Email: rfp@rfparts.com • Web: www.rfparts.com
800-737-2787 Fax 888-744-1943

uM-FPU V3.1
Floating Point Coprocessor

32-bit IEEE 754
SPI or I2C
DIP-18, SOIC-18

New full featured Compiler
Extensive floating point support, GPS input, FFT, 12-bit A/D, matrix operations, user-defined functions.

www.micromegacorp.com

LEDs
Super Brights from 20¢
RGB Color Mixing 30 Pack $6.99
Assortment 120 Pack $24.99
Shipping from $3.00
Alan-Parekh.com/Store

Magnet Wire
adapt

www.adaptwire.com

www.nutsvolts.com

PCB SOFTWARE

EXCLUSIVE U.S. DISTRIBUTOR

YOUR COMPLETE SOLUTION!
- PCB Design
- PCB Simulation
- CAD/CAM Menu

121747, Hobby Vers., $175
121743, Pro. Version, $275

www.KELVIN.com

HARDWARE WANTED

DEC EQUIPMENT WANTED!!!
Digital Equipment Corp.
and compatibles.
Buy - Sell - Trade
CALL KEYWAYS 937-847-2300
or email buyer@keyways.com

DESIGN/ENG SERVICES

* Circuit board layouts
* Prototype assemblies

WWW.OSPREYELECTRONICS.COM
Convert your sketch or print into a quality pcb for a reasonable price. Visit us on the web or call Osprey Electronics at (208) 664 1089 (USA)

FLEXREV China Direct Manufacturing
Turn Key or Subassemblies
Components, Enclosures, Keypads
$0.007 per soldering point
2 layer PCBs $0.14/in2
Small jobs welcome
FLEXREV.COM

MISCELLANEOUS FOR SALE

ESTATE LIQUIDATION!
ELECTRONIC WORLD STORE CLOSED! $250,000 INVENTORY: NOVELTY TELEPHONES, WATCHES, CLOCKS, BUTANE LIGHTERS, POCKET KNIVES, SWORDS, THROWING KNIVES, CALCULATORS, WIRELESS HEAD PHONES, SUNGLASSES, PEN AND PENCIL SETS, READING GLASSES, STROBES, SECURITY CAMERAS AND MONITORS.
ISE PH: **956-444-0004**;
888-351-5550
DETAILS AND PICTURES
WEB: **www.iseliquidator.com**

ENERGY SOLUTIONS

Save Money On
Your Electric Bill
www.sunny-solutions-shop.com
800-315-0309

SURPLUS

SURPLUS ELECTRONIC PARTS & ACCESSORIES

Over 18,000 Items in Stock.

Cables, Connectors, Displays, Fans
Hardware, LEDs, Motors, Potentiometers
Relays, Semiconductors, Service Manuals, Speakers
Switches, Test Equipment, Tools, VCR Parts

Surplus Material Components
SMC ELECTRONICS
www.smcelectronics.com

No Minimum Order.
Credit Cards and PAYPAL Accepted.
Flat $4.95 per order USA Shipping.

continued from page 32

instrumentation products, industrial control, health products, exercise equipment, etc.

The HT67Fxx series is composed of four MCU devices (HT67F30, HT67F40, HT67F50, and HT67F60) encompassing a full range of multiple functions. These include a core with 2K~12K words of Flash program memory, 128~640 bytes of data memory, 64~256 bytes of data EEPROM, and 4~12 stack levels.

Regarding peripheral functions, all devices contain an internal R-type and power-efficient C-type LCD driver to support applications with display requirements. The internal 12-bit high speed analog-to-digital converter is on hand to measure external environmental signals from sensors such as temperature, humidity, etc.

An internal comparator and two independent SPI and SPI/I²C interfaces are also included, while the whole series uses Holtek's new Timer Modules offering five different timer operating modes: Input Capture, Compare, Timer/Event, Single Pulse Output, and PWM. These features combine to offer a device series that can implement a full MCU system with a minimum of external components.

Holtek fully supports these devices with its comprehensive hardware and software development tools. Known as the HT-IDE3000, these development tools provide features such as real time emulation, memory and register access, hardware breakpoints complete with logical setups, full trace analysis, etc.

This range of development tools ensure that designers have all the resources at hand to provide for rapid and efficient design and debug of their microcontroller-based new product applications.

For more information, contact:
Holtek Semiconductor, Inc.
Web: **www.holtek.com**

UNDERSTANDING SIGNALS WITH THE PROPSCOPE PARTS AND TEXT KIT

This new Propscope Parts and Text kit from Parallax, Inc., includes the PropScope USB, electronic components for breadboard circuits, and a printed text that guides you step-by-step from the basics through advanced electronic measurement techniques.

All the circuits and design technique examples measured in the book are standard ingredients in electronic product designs, and are also widely used in science and industry. This kit is an excellent resource that can be applied in many ways to science, technology, engineering, or mathematics (STEM) programs. It begins with an overview of the PropScope's electronic test-bench tools.

Features:

- DC voltmeter — measures voltage levels.
- Oscilloscope — measures and plots voltages that vary with time.
- Logic analyzer — measures and plots digital signal levels.
- Spectrum analyzer — measures and plots sine wave components in signals.
- Function generator — synthesizes signals for testing circuits.

Visit the website listed and search "Understanding Signals Kit" (32225). The retail price is $229.00.

For more information, contact:
Parallax, Inc.
Web: **www.parallax.com**

WIXEL PROGRAMMABLE USB WIRELESS MODULES

Pololu announces the release of the Wixel, a general-purpose programmable module with integrated full speed USB and a 2.4 GHz radio. Users can load their own custom

continued on page 81

TECH FORUM
READER-TO-READER

>>> QUESTIONS

Toying With Tektronix Scope

I have some internal parts to an old Tektronix oscilloscope that I would like to "light up" but have no technical manual. I would love to see a trace on the scope tube. I am now working on a scheme to light up the 20K volt power supply. The scope tube is direct-connected on the Y axis through a delay line such as was used on old radiation detectors at Argonne and elsewhere. I have no idea about the pin-out but some resistors are still attached as a starter. I don't hope to restore it (as I just did on an old Sylvania), but would like to have one hell of a toy.

#5111 **Robert Gibson**
via email

1.5 VDC Motor On 1.5 VDC Battery

If I ran a 1.5 VDC motor continuously off of a 1.5 VDC battery, how do I figure the approx. life expectancy of the battery (in hrs)?

#5112 **Valerie St-Hilaire**
Canada

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.

#5113 **Alan Slate**
via email

MOVs

Is there any advantage (or disadvantage) to putting decreasing valued MOVs across power lines? Ex: My power (16.8 kV) comes across the yard to a pole with a transformer. At the bottom of the pole is the meter, followed by a 400A disconnect which kills the entire farm power. Each building has a disconnect; the house one is 200A. This goes to the house service entrance panel with 200A main and 40 slots for circuit breakers. My thought is to put 500 V. MOVs at the 400A box, 400V MOVs at the 200A box, 250V MOVs at the service entrance panel, and 130V MOVs at the surge/spike protector feeding the computer. The idea here is to clip the spike several times to a safe level.

#5114 **Robert Krieger**
Lost Nation, IA

DC-DC Voltage Booster

I need to get 48V DC at around 350 mA from a battery pack. A 40 cell battery pack is a bit much, so I was thinking of boosting a 12V or 18V pack. Would something simple like a 555 driving a power FET into a step-up transformer with the usual rectification/smoothing circuit on the output work? The load should be fairly constant and regulation not too stringent (.5V either way).

#5115 **Larry Thrasher**
Flora, MS

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

#5116 **Richard Seabrease**
Biglerville, PA

Need To Transmit From Laptop To FM

I use my laptop to play MP3s through my stereo. Right now, I have to use a cable to connect the two. 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 to power the transmitters I already have.

#5117 **Derek Tombrello**
Shelby, AL

>>> ANSWERS

[#2114 - February 2011]
Incandescent Panel Lamp To LED

I need to change a 10 watt 230 volt panel lamp to an LED lamp.

A few years ago, someone showed how to use an LED and capacitor on the AC line to show it was energized. I used it as an on/off switch indicator and later as a nightlight. Unfortunately, I found that the diode would die after a number of times turning the switch on and off. So, I modified the simple circuit **(Figure 1)** with a resistor and a diode. The resistor limits the curent, just in case, and the diode keeps the reverse voltage off the LED; again, just in case.

I then changed the LED to an ultra-bright LED and fit the entire circuit into two things:

1. A dead nightlight lamp base.
2. A replacement non-polarized AC plug.

I call #2 my traveler's nightlight and #1 I fit back into my granddaughter's nightlight.

With my protections added, I haven't had any LEDs die yet. My

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving technical problems. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals.

Always use common sense and good judgment!

Send all questions and answers by email to **forum@nutsvolts.com**
*Check at **www.nutsvolts.com** for tips and info on submitting to the forum.*

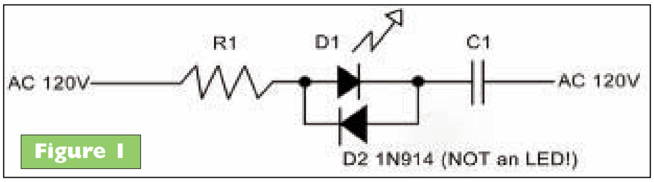


Figure 1

original nightlights were built ~ Sept. 2009. Previously, LEDs would die in less than a year and sometimes on the first or second usage.

For a 230V version, I would assume we need to cut down the value of the cap that was suggested for 120V AC.

D2 - CanNOT be an LED.

C1 - Use a .01 (103) AC cap for normal LEDs. You can use a .10 (104) AC cap for 3V ultra bright LEDs (1.7V on LED).

Better: Use a .47 (474) AC cap for 3V ultra bright white LEDs (2.2V on LED).

R1 of 470 ohms works well, limiting the in-rush so as not to kill the LED.

Approx. power used is ≤ 250 mW R! ~ 8.8 V LED ~ 2.2 V = ~11 V 11 * .02 A ~ 220 mW.

Please get a few extra LEDs and give it a try with smaller caps. If you've saved the dead lamp, I'd break the glass such that you save the wire connections inside, then see if you can place two or three LEDs in it like I did for my granddaughter's nightlight. I only used one ultra bright LED for all the nightlights I built.

Hint: If you want the light to scatter, buff the LEDs with fine grit sandpaper or a sponge. I've also ground down the lens end with a file to make it flat and then buffed the end to scatter the light even better.

Phil Karras KE3FL
Mount Airy, MD

[#3111 - March 2011]
Phone Fails To Answer Via VOIP

Our phone service is by a cordless phone connected to a VOIP box, to a router, to a cable modem. Much of the time the phone works well, but sometimes when the phone rings, it is dead; no voice, no dial tone.

There are a couple things that could be happening. **1)** When the phone registers with the provider, the router has to put the route in its addressing table. That table has a finite time to live. If there is no activity, the router will forget the route and move on to other things. In order to resolve the problem, there should be a "keep alive" setting in the telephone. This will send a request to the VoIP provider through the router to keep the channel alive. **2)** Depending on the provider, the problem may be resolved by providing static port forwarding to your phone. Any info that comes in on the VoIP port should be directed to the phone. Port 5060 is usually used for VoIP. You can always ask the provider if there is a port that should be directed to your phone. Your phone would also need a static IP address for this to work.

Chris McCune
Hampstead, NH

[#3113 - March 2011]
AC-to-DC

Why do most laptops, cell phones, etc., have relatively large transformers to convert AC power to the proper DC voltage, but the Amazon Kindle only has a small adapter that seems to have no space for the traditional transformer?

#1 The Kindle is a very low power device since the e-ink only requires power when the page changes. The power adapter of my third generation Kindle states an output of 4.9 VDC and 0.85A which is a little over 4W. Transformers are large and tend to be expensive compared to the other parts in a power supply, so many consumer devices use power supplies without them.

Microchip (the manufacturer of the popular PIC microcontrollers line) describes resistor and capacitive transformerless power supplies in application note AN954 (**ww1.microchip.com/downloads/en/AppNotes/00954A.pdf**). In the first method, a resistor is in series with a zener diode to set the output voltage (**Figure 2**). A capacitor in series with a diode is parallel to the zener diode. The capacitor supplies DC power to the load. The capacitive method replaces the resistor with a smaller resistor and capacitor in series, resulting in lower wasted power.

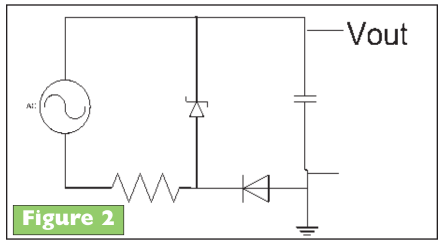


Figure 2

The August '04 *Nuts & Volts* had a project "A White LED NightLight" that used the capacitive technique. Please note: These techniques can be very dangerous since the circuit is directly connected to the AC main voltage which can result in a nasty shock or fire.

William Wagner, Ph.D.
Fort Washington, PA

#2 It all has to do with design power requirements. Transformers maintain higher power levels as they bring voltages close to needed levels. In an ideal transformer with no losses, Vin/Vout = Iin/Iout. An input voltage of 120 VAC @ 1A would have an output current @ 12 VAC of 10A. This allows more power to be sent to the final device. When high power requirements are not needed, a transformer can be removed, saving several downstream costs — monetary, as well as efficiency.

Returning to your original question, my laptop charger label states a power rating of 90W where the charger for my Kindle is a USB powered device, so is limited to approximately

2.5 watts (5V @ 500 mA per USB specifications), so components were matched to development needs.

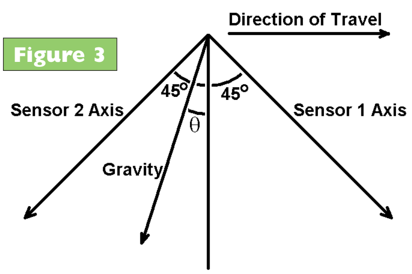
Tom Homan
Globe, AZ

[#4111 - April 2011]
Detecting Vehicle Deceleration

I want to use an accelerometer to control a 12V vehicle stop light. A mercury switch is influenced by the angle of the surface the vehicle may be located on.

I will not attempt to offer a full, completed circuit, but I can outline an approach. In general, you cannot tell the difference between the pull of gravity and an acceleration. Since the angle of the car and the acceleration are both unknown, you will need two measurements. Using a two axis accelerometer (of any kind) will allow you to get the desired result.

Figure 3



By orienting the two axis as shown in **Figure 3**, the acceleration along the direction of travel can be deduced with a few mathematical operations. The calculation can be implemented using a microcontroller and software or, in this case, analog multiplying ICs, (such as the AD633) and some op-amps.

As described in the datasheet, the AD633 is capable of producing squares and square roots. Some approximations can be made if the angle θ is not too large.

The acceleration is computed as follows.

Designating the reading from accelerometer sensors 1 and 2 as Y1 and Y2 respectively, combine them together to get Z1 = Y1+Y2 and Z2 = Y2-Y1. To remove vertical accelerations (due to potholes), a long time constant (a few seconds), low pass filter should be applied to Z1, since Z1 should change only as fast as the road grade changes, while a less aggressive filter can be applied to Z2 where vertical motion should cancel. The value of Z1 when the car is on level ground (θ = 0) and stationary is saved as Z0. The acceleration, a, of the car is given by the formula:

$$a = \left(Z2 - \sqrt{Z0^2 - Z1^2}\right) / \sqrt{2} .$$

As long as the incline is less than about ±30 degrees, the following simpler formula can be used to compute the car's acceleration to reasonable accuracy:

$$a = 0.71 \cdot Z2 - \sqrt{Z0^2 - Z0 \cdot Z1}$$

where most of the calculation can be done using well-known op-amp circuits (i.e., sum, difference, and multiplication by a constant). If a is negative, the car is decelerating.

Bryan Suits
Houghton, MI

[#4112 - April 2011]
Remote Generator Start By Phone

I need a method to remote-start a generator by calling it.

Try the VDA2Plus from Broadcast Tools. You have full dial up and dial out, relay control, temp monitoring, and with a small audio amp hooked to it, you can also hear your generator run. It can be programmed to call out if the room goes silent or gets a relay closure that the generator has stopped. Circuitwerks sells a similar unit. For control over the Internet, try the devices from Control by Web. These are a web page based control box and I have used them at my solar FM transmitter site for remote control.

Mark Parthe
Prescott, AZ

[#4114 - April 2011]
Water Level

I need to come up with an inexpensive solution to determine the depth of the keel of a boat. Nothing can be attached to the boat because it will be used on other vessels. Mechanical solutions don't work because of the various sizes and shapes of the keels. One idea I had was a simple pressure measurement where a diver would take a measurement probe to the keel and the depth would depend on the water pressure at that level.

It sort of works, but the keel depth can be from two feet to five feet, and the pressure difference is very small.

Accurate pressure transducers are expensive. A simple solution might be to have your diver take down a plumb line with a scuba laser pointer (available starting around $25) mounted perpendicularly to sight the keel. This website gives some ideas for mounting lasers to a metal yardstick for underwater use: **www.personal.umich.edu/~lpt/yardstick.htm**. You would only need to mount one and mark off the line for depth.

Jin Choi
New Jersey

[#4116 - April 2011]
Scanner Mod

I have had a police scanner from RadioShack for many years. My brother is a police officer, so I sometimes listen to it. The scanner went bad and I purchased a new one at RadioShack [model #PRO2018] that looks the same as the old unit. However, I cannot get the lower frequencies any more. Someone told me it's simple to install low frequencies on this scanner. How do I do it?

For the RadioShack PRO-2018 and many other scanners, the easiest way to add additional frequency coverage is by the use of a special software program: ***Scancat Lite Plus Public Safety Combo***.

You can get it from this website at a cost of $50 USD. It covers many makes and models of scanners and is very easy to use: **www.bearcatwarehouse.com/scancat_lite-plus_public_safety_combo_software.aspx**.

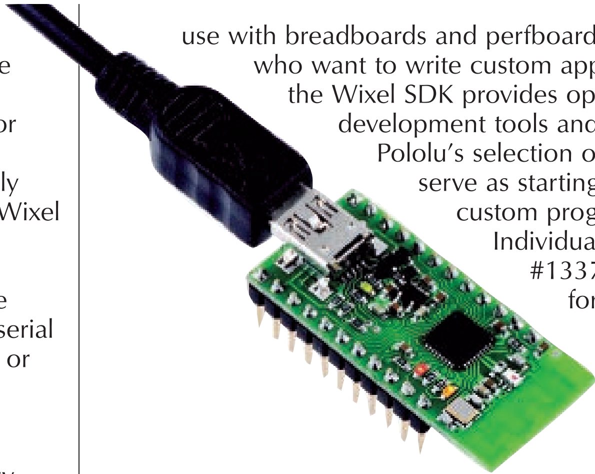
Bruce
Wayne, NJ

continued from page 77

programs or pre-compiled, open-source apps to enable wireless control of a robot, create a wireless microcontroller programmer, establish a wireless sensor network, and more. No programming experience is required to get started with the Wixel. Users can simply download an app from the Web and upload it to the Wixel using its built-in USB bootloader and Pololu's free configuration software (no external programmer is required). For example, the Wireless Serial App can be used to turn a pair of Wixels into a wireless USB/TTL serial link for communication between two microcontrollers or between a PC and a microcontroller.

The Wixel is based on the versatile CC2511F32 microcontroller from Texas Instruments which has an integrated radio transceiver, 32 KB of program memory, 4 KB of RAM, and a USB interface. The Wixel makes a total of 15 general-purpose I/O lines available, including six analog inputs, and the 0.1" pin spacing makes it easy to use with breadboards and perfboards. For those who want to write custom applications in C, the Wixel SDK provides open-source development tools and libraries, and Pololu's selection of apps can serve as starting points for custom programs.

Individual Wixels (item #1337) are available for $19.95 each.



For more information, contact:
Pololu Corporation
Web: **www.pololu.com**

■ LOOK FOR ■ SEARCH FOR ■ FIND

ADvertiser INDEX

Find your favorite advertisers here!

BlackJack SolderWerks Inteligent Preheating System

The BK7000 & BK7050 from *BlackJack SolderWerks use a highly efficient quartz infrared heater system that provide fast heat up and utilizes a feedback control circuit to optimize the PCB pre-heat operation.

They are designed to aid the reworking operation for large and multilayer PCBs (such as game consoles and motherboards) that use either traditional or lead free solder.

Both systems have three modes of operation.
Type 0: for single temperature heating using an internal temperature sensor.
Type 1: for more precise temperature control using the supplied external temperature probes.
Type 2: for a fully automated time and temperature based profile mode.

Once again Circuit Specialists brings you a quality product at a great price!

Item# **BK7000** **$288.00**

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

www.CircuitSpecialists.com/BK7000

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.

Deluxe Hot Air Rework Station with 70 Watt Soldering Iron

Includes Digital Display & Mechanical Arm

The BlackJack BK5050 Repairing System is a multipurpose reworking station that incorporates a Hot-Air gun and a 70 watt soldering iron which is appropriate for traditional solder or lead free solder. The hot-air gun is equipped with our BlackJack Solderwerks hot-air TRIPLE PROTECTION SYSTEM which provides (1) System Cool Down, (2) Auto System Sleep, and (3) Overheat Protection.

Item# **BK5050** **$169.00**

www.CircuitSpecialists.com/BK5050

lead-free

3 Channel Programmable Regulated DC Power

Check out our new programmable hi preformance 3 channel power supplies. Featuring both USB & RS232 interfaces, Overload Protection, Auto Fan Control, and Series or Parallel Operation. Both units feature a Large LCD display panel with simultaneous output and parameter view and a keypad for control. They are ideal for applications requiring high resolution, multiple output, and automated operation such as in production testing. There are both fine and coarse controls via the shuttle knob and 90 memory settings. Software included.

Reliable, Highly Stable, Fan Cooled.

FEATURES

* Full digital programmable interface
* High resolution 10mV , 1mA
* Compact and lightweight package
* Alterable display mode
* Intelligent window interface Facilitate user operation
* Supports multiple immediate buttons
* Automatic parallel function
* High stability, low drift
* Over-voltage, over-current, over temperature protection
* Intelligent fan control (Changes with output power)
* Warning Alert Buzzer
* 100 memory locations
* RS-232 & USB interfaces standard

Model	CSIPPS33T	CSIPPS55ST
DC Voltage	0-32V x2 0-6V x1	0-32V x2 0-6V x1
DC Current	0-3A x3	0-5A x2 0-3A x1

Item # **CSIPPS33T** **$399.00**

www.circuitspecialists.com/CSIPPS33T

Item # **CSIPPS55T** **$499.00**

www.circuitspecialists.com/CSIPPS55T

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 & automatically 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

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**

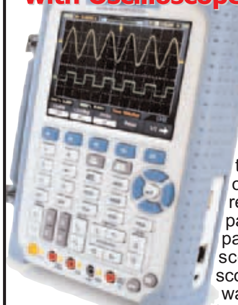
www.circuitspecialists.com/csi-station1a

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 **$739.00**

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 **$529.00**

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 **$659.00**

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.

Full specifications at www.CircuitSpecialists.com/aardvark

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**

Hot New Product!!
$99 Low Cost Aardvark Jr Inspection Camera

Full details At:
www.CircuitSpecialists.com/AardvarkJr

0-30V / 0-5A . DC Power Supply

The CSI530S is a regulated DC power supply which you can adjust the current and the voltage continuously. An LED display is used to show the current and voltage values. The output terminals are safe 4mm banana jacks. This power supply can be used in electronic circuits such as operational amplifiers, digital logic circuits and so on. Users include researchers, technicians, teachers and electronics enthusiasts. A 3 ½ digit LED is used to display the voltage and current values.

www.circuitspecialists.com/csi530s

Item # CSI530S **$84.95**

PROPELLER MULTICORE STARTUP SPECIAL!

$79.99

A great way to play with the multicore Propeller P8X32A microcontroller at a great price! This open-source, made-in-the-USA, limited-time-only kit includes a Gadget Gangster Propeller Platform USB, a ProtoPlus module, and a cool pinstriped acrylic enclosure to house your completed project!

Combining a 64 KB EEPROM, 5 MHz removable crystal, 1.5 A power regulation, USB, and a microSD card slot on a compact, breadboard and protoboard friendly module, the Propeller Platform USB is an easy-to-use development tool for the multicore Propeller microcontroller. All 32 Propeller I/O are available via pin sockets, along with 5 and 3.3 V regulated power. The ProtoPlus module adds video and audio to your Propeller Platform and includes a prototyping area. Traces in the prototyping area are also marked in the silkscreen, so it's easy to see how the traces are connected. **We have several tutorials available online to get you started.**

MADE WITH PRIDE IN THE USA

open source™

Order the **Propeller Multicore Starter Special** (#910-32316; $79.99) at www.parallax.com or call toll-free at 888-512-1024 (M-F, 7AM-5PM, PDT).

Friendly microcontrollers, legendary resources.™

PARALLAX INC

www.parallax.com

"ParallaxInc" on Twitter, Facebook, and YouTube