PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

NUTS AND VOLTS

EVERYTHING FOR ELECTRONICS

www.nutsvolts.com
November 2011

Don't get caught with your battery down!

Build The BATTERY MARVEL

✦ **Digilent Electronics Explorer *Review***
All-In-One Analog Circuit Design Station

✦ **Design Cycle**
You *CAN* Create An Arduino-Compatible Controller Area Network Using The ChipKIT And Its Network Shield

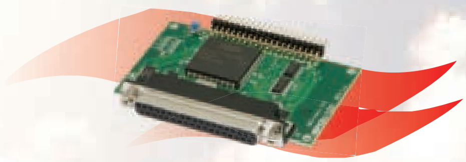
U.S. $6.50 CANADA $7.50
11
0 71486 02421 7

The easiest finished product you will ever create

Start with the PK70 EX

+

Design your own, or use a NetBurner Personality Blade



=

Add your label to get a finished product

Personality Blades

Prototype Blade *(P/N NBPKBP-100CR)*.............................. **$25 ea.**
Create your own Personality Blade

CPLD Digital I/O Blade *(P/N NBPKD-100CR)*...................... **$59 ea.**
Programmable Xilinx CPLD
32 digital I/O

Multi-I/O Blade *(P/N NBPKM-100CR)* .... **$99 ea.**
Eight 12-bit analog-to-digital inputs
Two 16-bit digital-to-analog outputs
16 digital I/O

FPGA Digital I/O Blade *(P/N NBPKX500-100CR)* .... **$169 ea.**
Programmable Xilinx Spartan 3E FPGA
High-density 62-pin connector

NTP Server with GPS Blade *(P/N NBPKX500-100CR)*.......... **$99 ea.**
Network Time Protocol (NTP) server
Precision GPS time reference

Quad UART Blade: RS-232 Version
(P/N NBPKBU-232CR).. **$99 ea.**
Network enable up to 4 RS-232 serial devices

Quad UART Blade: RS-422/485 Version
(P/N NBPKBU-485CR).. **$119 ea.**
Network enable up to 4 RS-422/485 serial devices

Quad UART Blade: RS-232/422/485 Version
(P/N NBPKBU-MMSCR) .... **$245 ea.**
Network enable up to 4 RS-232/422/485 serial devices

PK70 EX & Development Kit

PK70 EX *(P/N PK70EX-100IR)* .... **$199 ea.**
32-Bit Freescale ColdFire 147 MHz CPU
8MB SDRAM • 4MB Flash Memory
SD/MMC Flash Card Support • I2C • SPI • Address and Data Bus
10/100 Ethernet • 2 UARTs

PK70 EX Development Kit
(P/N NNDK-PK70EX-KIT) .... **$299 ea.**
The Development Kit features NetBurner's Eclipse, an enterprise level professional IDE that provides editing, downloading and debugging in one environment.

NetBurner
Networking In One Day!

Information and Sales | sales@netburner.com **Web** | www.netburner.com **Telephone** | 1-800-695-6828 the best place for microcontroller community projects and libraries

LIBSTOCK®

A PLACE FOR CODE™

DOWNLOAD FREE PROJECTS AND LIBS

Get all kinds of cool ideas. Download free, functional and working libraries and projects, including schematics, documents and tutorials, and install them with a single click. Everything you need is in one place.

SHARE YOUR CODE WITH THE COMMUNITY

Do you want to share your work with the rest of the world, and get community feedback on your projects? This website gives you the best infrastructure a programmer can have for sharing the code.

IT'S A FACEBOOK FOR CODERS

With personalized accounts, you can connect with other programmers, share experiences, and learn more about yourself too. Social interaction brings a new dimension to the world of programming.

ALL COMPILERS SUPPORTED

mikroC, mikroBasic and mikroPascal for PIC, dsPIC, PIC32, AVR and 8051 are all natively supported by Libstock.

PACKAGE MANAGER SOFTWARE

With free Package Manager software, you can make one-click extractable packages of your libraries and projects.

EXCLUSIVE MIKROE LIBRARIES

TCP/IP stack, FAT16 and FAT32 are just part of the libraries that mikroElektronika will exclusively share only on Libstock website.

MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS

www.libstock.com

community

BitScope

Digital + Analog

Mixed Signal Oscilloscopes

100 MHz Digital Oscilloscope

✓ Dual Channel Digital Storage Oscilloscope with up to 12 bit analog sample resolution and high speed real-time waveform display.

40 MSPS x 8 Channel Logic Analyzer

✓ Captures eight logic/timing signals together with sophisticated cross-triggers for precise multi-channel mixed signal measurements.

Serial Logic and Protocol Analyzer

✓ Capture and analyze SPI, CAN, I2C, UART & logic timing concurrently with analog. Solve complex system control problems with ease.

Real-Time Spectrum Analyzer

✓ Display analog waveforms and their spectra simultaneously in real-time. Baseband or RF signals with variable bandwidth control.

Waveform and Logic Generators

✓ Generate an arbitrary waveform and capture analog & digital signals concurrently or create programmable logic and/or protocol patterns.

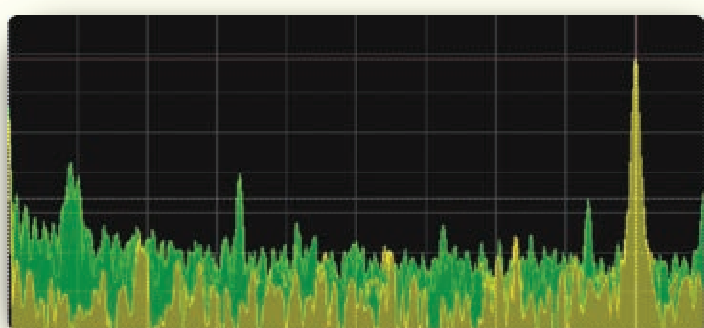
Multi-Channel Chart Recorder

✓ Record to disk anything BitScope can capture. Allows off-line replay and waveform analysis. Export captured waveforms and logic signals.

Protocol Analyzer

Digital Oscilloscope

Spectrum Analyzer

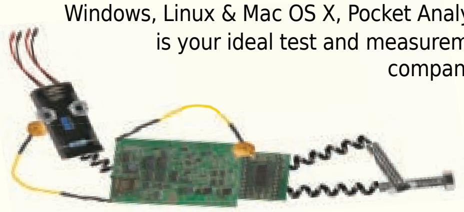


Everything in one tiny package !

BitScope Pocket Analyzer is the world's first Mixed Signal Scope to include a powerful Logic Protocol Analyzer, Waveform & Pattern Generator, Spectrum Analyzer and Chart Recorder in one ultra-portable **USB powered** package.

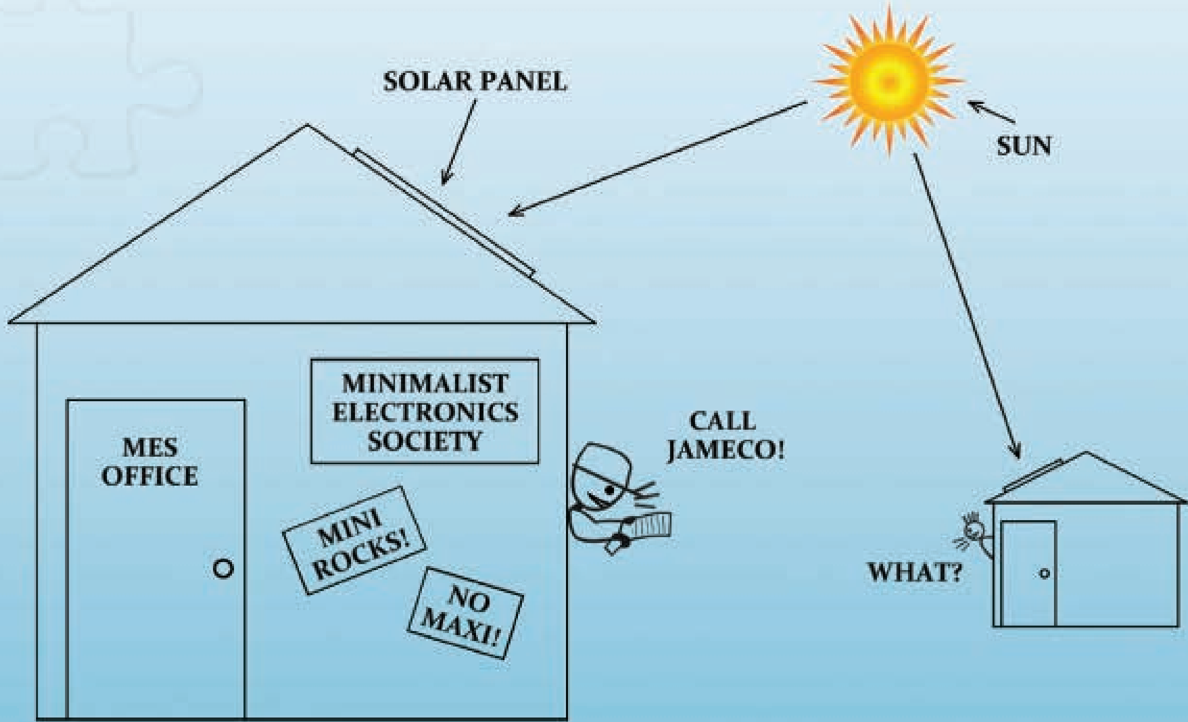
Pocket Analyzer is fast, displaying up to 100 frames per second with up to 12kS per frame. Alternatively stream data direct to disk for replay and analysis.

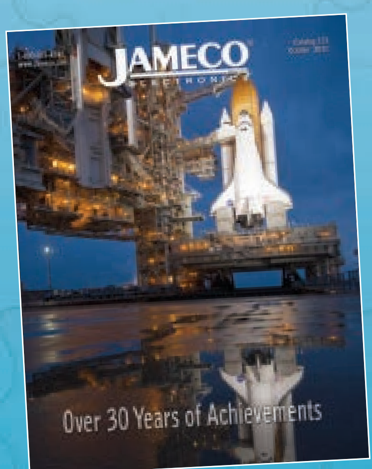
Compatible with major operating systems including Windows, Linux & Mac OS X, Pocket Analyzer is your ideal test and measurement companion.



bitscope.com/nv

Can You Solve This?





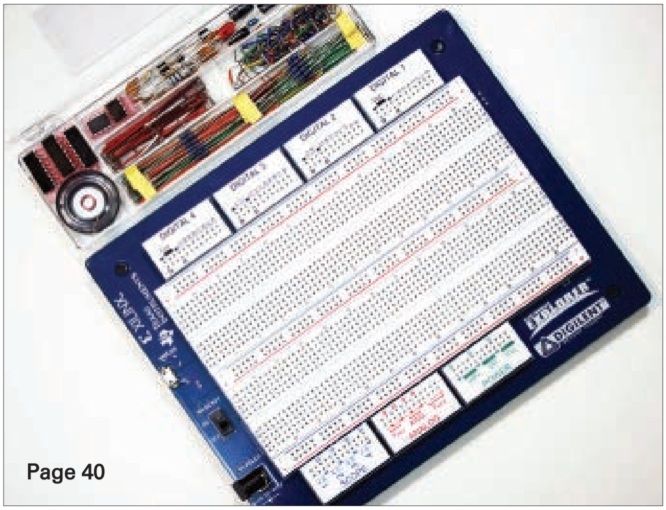
Consultant Ed Brown was retained by the Minimalist Electronics Society (MES) to design an electronic intercom that would allow the group's president and secretary to speak to one another between the two tiny structures that served as their offices. The only condition was that the intercom must be as minimalist as possible. A conventional intercom would require a pair of conductors, which was one too many. The soil under the offices was desert gravel and much too dry for linking the offices with a single wire and a ground at each end. Cell phones or radio? No way. Their signals would be sprayed everywhere, thereby violating minimalism. Power line link? No. Each office was powered by its own roof top solar panel. Brown finally thought of a solution. What's yours? Go to Jameco.com/search12 to see if you are correct.

Order Your Free Jameco Catalog!
Jameco.com/catalog

JAMECO® ELECTRONICS Since 1974
1-800-831-4242

Nuts & Volts November 2011

www.nutsvolts.com


Page 40

Interact With Writers and Other Readers at the NV Forums!

Now you can discuss all your favorite articles in the magazine at our newly redesigned forums. Just point your browser to **http://forum.servomagazine.com** where you can post comments, engage with other readers, ask questions, and talk to the writers.

Projects & Features

30 Replace Incandescent Lighting with LEDs
This project shows how to use Texas Instruments products to change the incandescent light bulbs in a curio cabinet to energy-efficient LEDs.
By Michael Day

34 Build the Battery Marvel
This easy-to-build 12V battery monitor will alert you well before your car, truck, boat, or motorcycle battery fails.
By Dave Decker

40 *REVIEW* The Digilent Electronics Explorer
See if this all-in-one analog circuit design station is for you.
By Bryan Bergeron

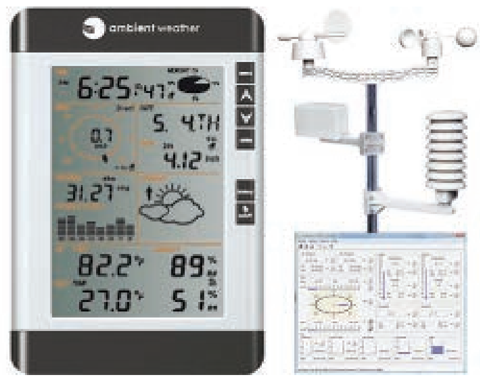
44 LED Madness Contest Winners
See who took home the gold from *Nuts & Volts* first Facebook contest.

Departments

08	DEVELOPING PERSPECTIVES	67	ELECTRO-NET
28	NEW PRODUCTS	76	CLASSIFIEDS
29	SHOWCASE	78	TECH FORUM
64	NV WEBSTORE	80	AD INDEX

Columns

10 TechKnowledgey 2011
Events, Advances, and News
Read up on things like doubling wireless capacity, a sauna in your pants, a new laptop, and HP calling it quits ... plus some other items of interest.



14 The Spin Zone
Adventures in Propeller Programming
Big Fun With Small LEDs.

22 Q & A
Reader Questions Answered Here
Some of the answers this month deal with a high power LED flasher, a solar controller, an LED flashlight, and a Lithium-Ion battery charger to name a few.

48 Smiley's Workshop
Programming • Hardware • Projects
Digital I/O — Part 2.

54 Near Space
Approaching the Final Frontier
An Antenna for Near Space.

68 The Design Cycle
Advanced Techniques for Design Engineers
You *CAN* Do It With the chipKIT MAX32.

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.

Global Specialties
www.Globalspecialties.com
Phone: 1-800-572-1028

DL-020 Sequential Logic Trainer

PB-503 Desktop Analog & Digital Design Workstation

The **DL-020 Sequential Logic Trainer** introduces concepts of sequential logic design, which is the final basic elements to understanding microprocessor and microcontroller logic. The ***PB-503 Desktop Analog & Digital Design Workstation*** is a robust electronics trainer suitable for all levels of electronics instruction and design.

Most Popular Breadboards EXP-300 & EXP-350

The EXP-300 has 550 tie points and EXP350 has 270 tie points that offers unlimited circuit design expansion through its unique molded-in interlocking edge rails prototyping applications.

Digital Electronics Courseware

This book is meant to serve as the text/lab manual for a first course in digital electronics. Comprehensive 204 page book of the most contemporary topics in digital electronics are referenced.

Digital Multimeter Pro-1000

NEW

Model ***PRO-1000*** is a highly versatile, economically-priced, portable, bench type digital multimeter with a 4 1/2 digit LED display that can measure diodes, frequency, current, voltage, resistance, as well as test continuity.

DEVELOPING PERSPECTIVES

Thoughtful Repurposing

Teardowns of electronics devices can be an excellent means of learning how to design circuits for the real world, as well as an inexpensive source of parts for your construction projects. In these times of economic constraints, it's tempting to simply go for the parts and bypass the time-consuming circuit analysis. Armed with an old toaster oven, it's relatively easy to heat circuit boards and knock off dozens of components with a tap.

However, if you invest just a few minutes trying to understand the circuit on each board, you'll likely learn a few construction tricks, and save both time and money in the long term. Pay attention to the circuit layout on your next teardown. Are components bolted, glued, or simply friction fit? What's the spacing? Are fuses on both the input and output? How are cables run and fished? More importantly, are there sub-circuits that can be repurposed *in situ*? That is, let's say you're preparing to harvest the components from a shortwave receiver. Why simply remove the transistor or IC, electrolytic caps, and resistors, only to have to recreate an audio amp circuit later? Better to keep the circuit intact, perhaps by cutting away and saving that section of the printed circuit board.

If harvesting part of the circuit board isn't practical, then at least consider extracting the components of the audio amp and storing them separately, together with a schematic of the original circuit. Then, when it's time to add an audio amp to your next project, you have a proven design and components to work with. I've found that power supplies tend to be easily reclaimed intact, and they're also the most likely sub-circuit to be useful in future projects.

Another way to save on the cost of experimentation is to be on the lookout for boards and circuits that use leaded components. SMT components are nice and compact, but they're very difficult to repurpose without resoldering. Leaded components, on the other hand, lend themselves to solderless breadboard circuit designs. Even if you reclaim sub-circuits, it's often a simple matter to add either short lengths of solid wire or stiff 0.1" headers to make the section of board 'plug and play' with solderless breadboards.

Back to the topic of component removal. I've found an old toaster oven is the fastest, most economical means of harvesting components from a circuit board. I say old because the oven is dedicated to heating solder to the melting point. The solder fumes — together with the gassing of components — leaves unhealthy residues inside the oven. No point in exposing yourself or your family to extra doses of heavy metals.

The trick with using a toaster oven is knocking the components out of the board as soon as possible. I use a silicon baking sheet to catch hot components, but you can use an old pizza pan. Consider grounding the pan if you're working with sensitive components. Toaster ovens vary in temperature, but I've had luck with the oven set to 450°. Solder begins to flow in about three minutes.

Barring use of an oven, a hot air pen is very effective, but time consuming. It's my tool of choice for delicate, multi-legged ICs. That said, I've harvested components from dozens of boards using an old-fashioned pencil soldering iron pen. Just keep a used tip handy to use for desoldering — no need to sacrifice a new tip for old parts. **NV**

RS485/422/232/TTL

Converters / Repeaters
Multi-Repeaters / Hubs
Fiber Optics / Isolators
Extended Distance Units
Serial to Digital I/O
Large Multi-Drop Networks
Custom Units & Smart Units
Industrial, 3.0 KV Isolation
Call the RS485 Wizards
513-874-4796

RES R.E. Smith Inc.
www.rs485.com

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, Michael Day, Dave Decker, Jon Williams, Paul Verhage

CIRCULATION DIRECTOR
Tracy Kerley
subscribe@nutsvolts.com

SHOW COORDINATOR
Audrey Lemieux

MARKETING COORDINATOR WEBSTORE
Brian Kirkpatrick
sales@nutsvolts.com

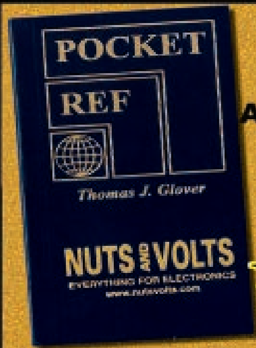
WEB CONTENT
Michael Kaudze
website@nutsvolts.com

ADMINISTRATIVE ASSISTANT
Debbie Stauffacher

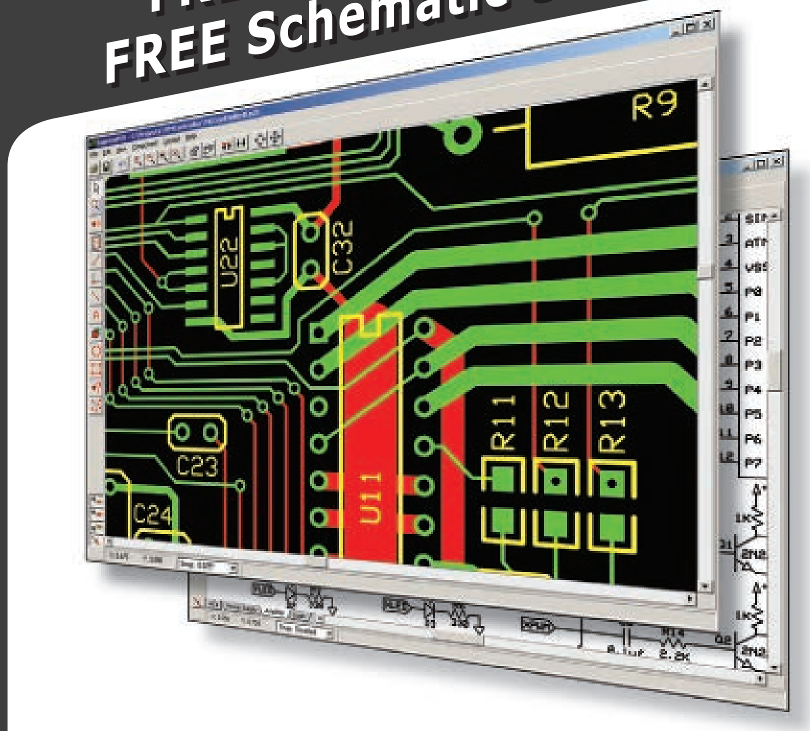
PRODUCTION/GRAPHICS
Shannon Christensen

Copyright © 2011 by T & L Publications, Inc.
All Rights Reserved
All advertising is subject to publisher's approval. We are not responsible for mistakes, misprints, or typographical errors. *Nuts & Volts Magazine* assumes no responsibility for the availability or condition of advertised items or for the honesty of the advertiser. The publisher makes no claims for the legality of any item advertised in *Nuts & Volts*. This is the sole responsibility of the advertiser. Advertisers and their agencies agree to indemnify and protect the publisher from any and all claims, action, or expense arising from advertising placed in *Nuts & Volts*. Please send all editorial correspondence, UPS, overnight mail, and artwork to: 430 Princeland Court, Corona, CA 92879.

Printed in the USA on SFI & FSC stock.

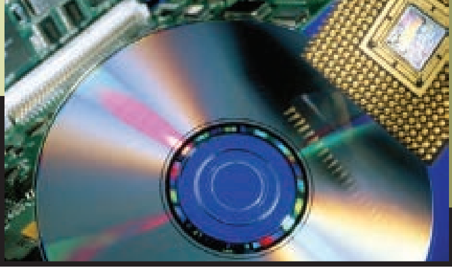


The Nuts & Volts Pocket Ref
All the info you need at your fingertips!
This great little book is a concise all-purpose reference featuring hundreds of tables, maps, formulas, constants & conversions.
Only $12.95
AND it still fits in your shirt pocket!
Visit http://store.nutsvolts.com or call (800) 783-4624

$51 For 3 PCBs
FREE Layout Software!
FREE Schematic Software!


01 DOWNLOAD our free CAD software
02 DESIGN your two or four layer PC board
03 SEND us your design with just a click
04 RECEIVE top quality boards in just days

expresspcb.com



TECH KNOWLEDGEY 2011

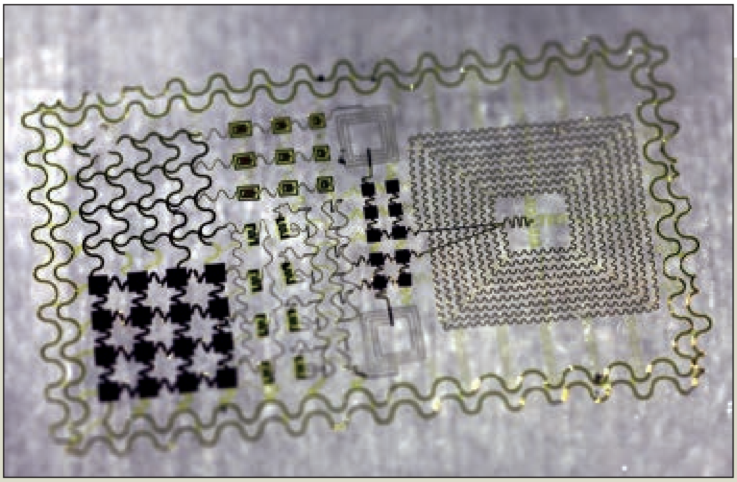
EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

THIS AIN'T NO TRAMP STAMP

Even if you find today's profusion of tattoos, piercings, and other "body art" to be regrettable, be forewarned: The day may come when you will sport a tat of your own. The good news, though, is that it won't be permanent and won't require you to get polluted enough to let some creepy guy in a strip mall inject ink into your skin. What we're talking about is a set of ultra-thin, self-adhesive electronics that can collect data about your heart, brain waves, and muscle activity. As revealed in a recent issue of *Science Magazine*, a group of researchers from the University of Illinois (**illinois.edu**) and some other institutions in the USA, China, and Singapore have created a new class of microelectronics that they call an epidermal electronic system (EES). An EES basically consists of a collection of miniature sensors, LEDs, transmitters, and receivers, all connected via a network of wire filaments. Much like a stick-on tattoo, the device can be applied to the skin on most locations (other than elbows, knees, and so on), and because it has almost no weight, no external connections, and negligible power requirements, it is held in place entirely by van der Waals forces, so requires no adhesive.



■ Epidermal electronic system created by an international team of engineers and scientists. *Credit: J. Rogers, University of Illinois.*

According to lead research engineer Yonggang Huang, "The mechanics behind the design for our serpentine-shaped electronics make the device as soft as the human skin. The design enables brittle, inorganic semiconductors to achieve extremely vast stretchability and flexibility. Plus, the serpentine design is very useful for self-adhesion to any surface without using glues." Much farther down the road, the researchers hope to incorporate microfluidic devices into this technology which could lead to advanced electronic bandages and enhanced-functioning skin — potentially accelerating wound healing or treating burns and other skin conditions. ▲

DOUBLING WIRELESS CAPACITY

In case you weren't aware of it, your cell phone is a half-duplex device. In a way, that makes it as primitive as the 300 baud modem that you attached to the old RadioShack Trash-80 back in the 1980s. Because it can't transmit and receive simultaneously on the same frequency, each cell phone has to eat up two different frequencies to allow a two-way conversation. If someone could figure out how to make it operate in full-duplex mode, carriers could achieve nearly double the network throughput without adding any new towers or frequencies.

Well, some folks at Rice University (**www.rice.edu**) have figured it out. By employing an extra antenna and "some computing tricks," they have achieved what was once believed to be impossible on wireless networks. According to Prof. Ashutosh Sabharwal, "We send two signals such that they cancel each other at the receiving antenna — the device ears. The canceling effect is purely local, so the other node can still hear what we're sending. We repurposed antenna technology called MIMO, which is common in today's devices. MIMO stands for multiple-input multiple-output, and it uses several antennas to improve overall performance. On the device side, we've shown that we can add full duplex as an additional mode on existing hardware. Device makers love this, because real estate inside mobile devices is at a premium, and it means they don't have to add new hardware that only supports full duplex."

Sabharwal noted that just about every wireless company in the world has expressed interest in the concept. As soon as appropriate standards for full duplex can be developed, we may expect to see its implementation beginning. The Rice researchers expect to see that in just a few years, as carriers upgrade to 4.5G or 5G networks. ▲

COMPUTERS AND NETWORKING

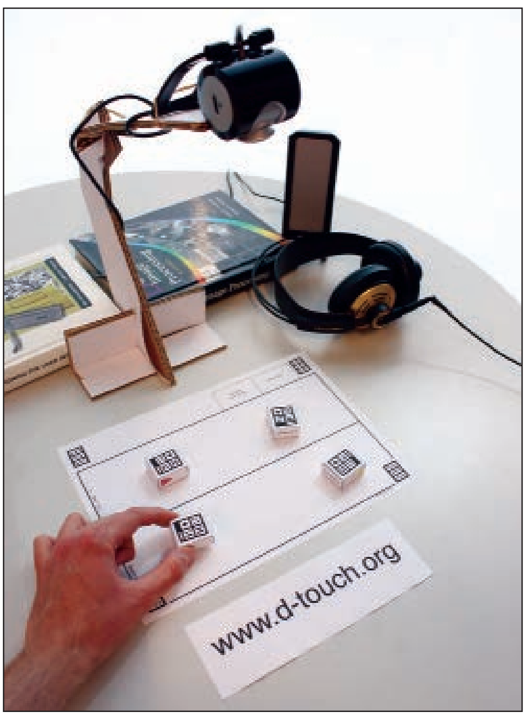
NEW LAPTOP TRIO

When there isn't much going on in terms of technology, you have to rely on style to sell computers. Hence, we have Lenovo's new trio of "luxury laptops," the IdeaPad U300s Ultrabook™, and the U300 and U400 models. "The new IdeaPad U Series laptops provide style mavens everything they need in a slender, mobile, and super chic package," said Yao Yingjia, VP of the company's Innovation Design Center. "The U300s, U300, and U400 laptops are the perfect luxury accessory this season, liberating consumers on the go to combine productivity and entertainment in one stylish device."

It appears that the IdeaPad is intended to challenge Apple's MacBook Air on a dimensional level. The machine has a 13.3 inch display, is 0.59 in (1.49 cm) thick, and weighs 2.2 lbs (1 kg), whereas the 13 in Air is 0.68 in (1.73 cm) thick and comes in at 2.96 lbs (1.34 kg). You get a choice of graphite gray or "clementine orange" shell colors, applied electrolytically and sandblasted to create a scratch-resistant coating.

Other features include a chicklet-style breathable keyboard which allows cooling air to flow through and around it, while maintaining a level of spill resistance. Getting down to the guts, you can choose between two Intel Core processors: the Core i7 2677M (1.8 GHz, 4 MB of cache) or the Core i5 2467M (1.6 GHz, 3 MB of cache). The U300s has 4 GB of DDR3 memory and up to 256 GB of SSD storage. The U300s and U400 start at $1199.99 and $849.99, respectively. ▲

■ Lenovo's IdeaPad U300 laptop.



■ The unique tangible user interface for the d-touch sequencer.

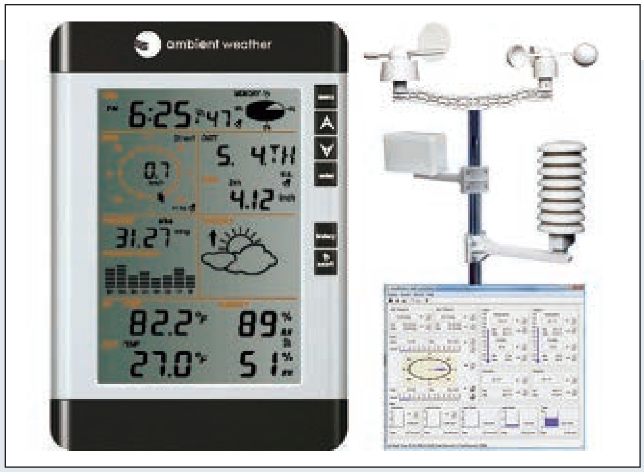
FREE DRUM MACHINE AND SEQUENCER

Once in a while, you see something that makes you scratch your head and wonder, "How the heck did someone come up with this?" Such is the d-touch sequencer and drum machine, downloadable for free at **www.d-touch.org/audio**/. For the non-musician, we note that a sequencer is simply a program that — within a computer or stand-alone unit — allows you to assemble stored digital sounds into a sequence for playback. While audio sequencers have been around for decades, the weird thing about this one is the user interface. Developed by Dr. Enrico Costanza at the University of Southampton (**www.soton.ac.uk**), it is referred to as a tangible user interface (TUI) which "gives physical control in the immaterial world of computers."

Probably the best description of the concept is provided on the d-touch website, where it is explained, "Audio d-touch is a collection of applications for real time musical composition and performance, with very special user interfaces. The collection includes a drum machine and a sampling sequencer; both are controlled by spatially arranging physical objects on an interactive table surface. Each object represents a sound, and its position with respect to the surface is mapped to certain playback parameters. For example, the horizontal position of an object represents the timing of the sound. All that is needed to get audio d-touch to work is a standard computer (PC or Mac) with a webcam and a printer."

If that explanation leaves things a bit unclear, you can log onto the website and view the video. It will still be unclear, but maybe not quite so much. The best solution is probably to just download it, hook up your webcam, and try it out. Even if you don't know much about music, it still looks like fun. ▲

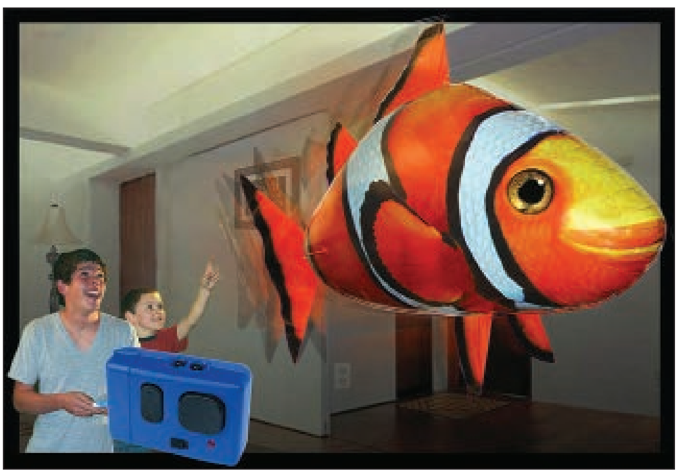
CIRCUITS AND DEVICES



■ The Ambient WS-2080 weather station.

CAN THE WEATHERMAN

With the holidays sneaking up on us again, it might be useful to consider some devices for the techno-geeks on your list (such as yourself). One possibility is the WS-2080 Wireless Home Weather Station from Ambient Weather (**www.ambientweather.com**) which is as much a hobby as an appliance. The station measures wind speed, wind direction, temperature, inside and outside humidity, and barometric pressure, plus it keeps track of rainfall. Weather parameters are displayed on a wall-mounted or desktop LCD screen, and the console includes a USB port for connection to your PC. It comes with EasyWeather software (apparently for Windows only) that allows real time monitoring, and can be used to program station parameters and alarms. It also provides data logging capability. An interesting (free) add-on is Cumulus software from Sandaysoft (**sandaysoft.com**) which allows you to become an official monitoring station for Weather Underground (**www.wunderground.com**). Cumulus is not Mac friendly, but it appears that Mac users can accomplish the same thing using WeatherSnoop software available from Ambient (requires OS X 10.5.8 or higher), or wview that's available at **www.wviewweather.com**. Weather Underground doesn't actually pay you anything for your efforts, but they will give you a free membership which usually costs $10. That gets you ad-free screens when you log on and ad-free forecasts and alerts via email. The system runs a somewhat modest $109.95. ▲



■ The Air Swimmers remote control clownfish.

RC AIR SWIMMERS

For the kids, it's always nice to find something that's exciting, harmless, and relatively cheap, which brings up the "air swimmers" remote controlled fish from William Mark Corp. (**www.airswimmers.com**). Available in shark or clownfish versions, they are 57 in (1.45 m) long and 3 ft (0.9 m) tall, with climb, descend, and tail fin controls. Powered by four AAA batteries, they have a range of up to 40 ft. The only caveats are that (1) you have to get your own helium from a supermarket, florist, or party store, and (2) it's highly inadvisable to fly them outside, where a wind gust could take them to Oz. They're available from M and M Toys (**www.mandmtoys.com**) for $42 each or $79.80 for the combo pack. Replacement balloons will only run you $5, so don't worry if the cat gets to it. ▲

A SAUNA IN YOUR PANTS

Hereby nominated for the worst gift idea of 2011 are Sauna Pants, imported from the folks at Wellmax Industrial Co (**www.wellmaxchina.com**) and sold through Amazon and other retailers for about $40. You might need to be retailed after you burn your tail off at temperatures up to 160°F (71°C). According to product literature, the pants take excess weight off by allowing you to focus heat on your "trouble spots," which leaves too much to the imagination. You just strap the things on to any waist up to 54 in (137 cm) in diameter, affix them with the velcro straps, and sweat your — well, you know — off. Don't forget to pick up an inverter unit so you can wear them as you drive to work! ▲

■ Sweat yourself thin in Sauna Pants from Wellmax Industrial.

INDUSTRY AND THE PROFESSION

HP TO CALL IT QUITS

Hewlett Packard's roots in the personal computer business go way back to 1968, when it rolled out the 9100A which some credit as being the first mass-marketed, mass-produced PC. HP marketed it as a desktop calculator, but it did have a CPU, a CRT display, magnetic card storage, and a printer. In fact, Steve Wozniak designed the Apple I while working there and offered it to them, but they declined, eventually becoming a giant in the "IBM-compatible" world. As of 2010, HP still had a 17.9 percent share of the global PC business, but with a shrinking share of a shrinking market and profit margins increasingly skinny, the company recently made it known that it is exploring "the separation of its Personal Systems Group (PSG) into a separate company through a spin-off or other transaction." According to Leo Apotheker, HP president and CEO, "We believe exploring alternatives for PSG could enhance its performance, allow it to more effectively compete and provide greater value for HP shareholders." HP also reported that it plans to discontinue operations for webOS devices, specifically the TouchPad and webOS phones. Apparently, it's time to follow in the footsteps of IBM, which sold its PC unit to Lenovo in 2005. **NV**

■ HP's 9100A desktop calculator, regarded as the first mass-marketed PC.

PICOLOG

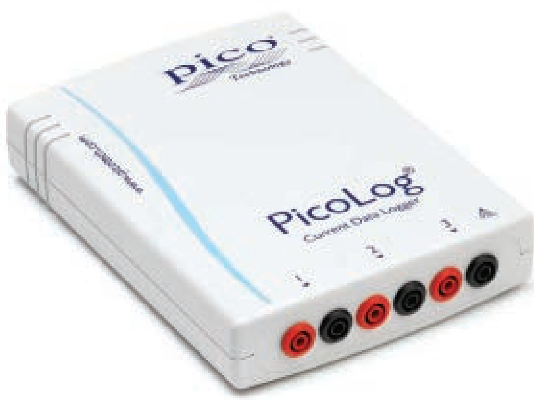
5 YEAR WARRANTY

PICO TECHNOLOGY 1991 - 2011 20 YEARS

PicoLog® CM3

CURRENT DATA LOGGER

HIGH ACCURACY THREE PHASE



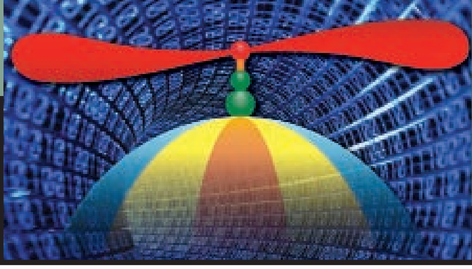
- 0 to 200 A
- Multiple units can be run on a single PC
- 3 Current Clamps Supplied
- Data Logger has 24 Bit Resolution ensuring 1% Accuracy
- Realtime remote monitoring
- Supplied with PicoLog data logging software
- USB or Ethernet, with PoE

The new PicoLog CM3 USB/Ethernet Current Data Logger is a compact, easy-to-use instrument for measuring the power consumption of buildings and machinery. With three channels, high accuracy and low noise, it is ideal for recording data from both single-phase and three-phase AC supplies. The logger is supplied complete with three AC current clamps and all necessary software.

www.picotech.com/pco461

Give Us A Call At: 1.800.591.2796

pico Technology



■ BY JON WILLIAMS

BIG FUN WITH SMALL LEDs

There are times when my friends comment that I lead a "charmed" life, and there are many days that I agree. This summer, for example, was a hoot. I had the honor of being invited to participate in DEFCON 19 — a blast in itself — but even better was getting to spend time with old friends (and uber-hackers), Ryan Clarke and Joe Grand. My job at DEFCON was to play "the Spy" — the human element of a cryptography game set up by Ryan. When not providing clues or misleading players, I spent time in the Hardware Hacking village and taught three standing-room-only classes on Propeller programming. Parallax very generously provided QuickStart boards for participants, and as the boards have built-in LEDs, we used them in the training.

Of course, it happened. When I explained that we would learn how to control LEDs, a few participants — not thinking I noticed — rolled their eyes. Let me tell you, LEDs are cool; if you do things well, that is. In this article, I'm going to show how to create a simple, multi-output LED modulator, and how I put it to use to make cool displays. With the holidays upon us, this is a good time to grab a Propeller and add cool lighting effects to your own projects.

SIMPLE LED MODULATION

Some time back, I explained a driver that used a methodology called BAM (bit angle modulation) for driving LEDs. I've used it. Note the past tense. For simple LED modulation, I have trashed BAM. Why? Well, at the mid-point of the duty cycle, that is, the transition from 127 to 128, and vice versa, there can be a dip or spike in apparent brightness. While working on a display for a gaming company, I just found I'd had enough of this abhorrent behavior. If I noticed, the client would, and that was not acceptable. The problem can be overcome when using just one output and tricks in code, but I never do that. I'm routinely doing four to eight — and sometimes more — dimming channels in my projects.

So ... back to the beginning. Even the plain Jane BASIC Stamp I has a PWM command that works well for LED modulation and for charging RC circuits; in fact, that's what this type of PWM is best at. Let me clarify.

Most of the time when we describe PWM, we think of a duty cycle (ratio of "on" time to period) and frequency (based on the period). The duty cycle changes per the requirements of the output while the frequency remains fixed. This PWM is really good for motor control where we can set the frequency best suited to the motor construction, and vary the duty cycle to change speed (see my column in the May '11 issue for more on this).

It can take a bit of work to create a fixed frequency PWM output, something not necessary for LEDs or charging an RC circuit (to create an analog voltage). A simpler strategy is what some call "accumulator-divider." The process is simple: We add the desired output level to an accumulator and then copy the carry of this accumulator to the output. This is how the Stamp I does it, in fact, this is how the Propeller counter works when set to PWM/NCO mode. The problem is that we only have two counters per cog and when using byte values, we have to scale them for application in the 32-bit counter. If you're interested in exploring this, the *Propeller Education Kit* manual — written by Andy Lindsay of Parallax — has a nice example.

As I stated, I tend to use four to eight LEDs in my projects and I don't want to use more than a single cog for brightness control. Using accumulator-divider code, it's really easy and I'm going to show you how. We haven't worked with PASM for a while, so here's a good opportunity — especially as this object demonstrates using an array in PASM.

The object, jm_ezmod_8x.spin, is started by passing the number of outputs to use (1 to 8) and the base pin of a group. Note that when using more than one pin, the outputs will be contiguous and the base pin is the LSB. If P0 is the base pin, P1 will be the next, and so forth:

```
var

  long  cog
  long  pincount
  long  basepin
  byte  dutycycle[8]
```

```
pub start(n, p) | ok

 ok := false

 if ((n => 1) and (n =< 8))
   if ((p => 0) and (p =< (28-n)))
     stop
     pincount := n
     basepin  := p

     ok := cog := cognew(@ezmod8, @pincount) + 1

 return ok
```

The VAR section holds parameters used by the object, including the cog used for the PASM code, the pin count, the base pin, and the byte array for output duty cycle. We're using a byte array to make things easy, especially with lighting protocols like DMX. These variables are placed into the global variable area of the object, so we can pass a pointer to them to the PASM code.

The start() method takes care of qualifying the parameters; we want to ensure a valid pin count, as well as the base pin. What this does is prevent us from using the programming/debug and I²C pins as modulation outputs. With good values, the global variables are updated and the PASM cog is launched. The first parameter required for the PASM code is the address of the pin count variable, so we pass that in the cognew() call; this will be passed to the PASM code in the par register.

Let's jump into the PASM code that handles the modulation:

```
ezmod8          mov       tmp1, par
                rdlong    chcount, tmp1
                add       tmp1, #4
                rdlong    ch0pin, tmp1
                add       tmp1, #4
                mov       hub0, tmp1

                mov       outa, #0
                mov       tmp1, #%1111_1111
                mov       tmp2, #8
                sub       tmp2, chcount
                shr       tmp1, tmp2
                shl       tmp1, ch0pin
                mov       dira, tmp1
```

At the top, we copy par into tmp1 (so it can be modified — par is read-only). The first thing we read is the channel count. Most of the hub parameters are longs, so we add four to tmp1 to point to the next which is the base (channel 0) pin for the group. After reading the base pin, we add four to tmp1 again and we have the hub address of the duty cycle array. This value is saved into hub0 for use in the main program loop.

The next section sets the required I/O pins to output mode in prep for the modulation loop. We start by moving %1111_1111 into tmp1; this is the mask for eight bits. Since eight is the maximum channel count, we move that into tmp2. The channel count is subtracted from tmp2 (8) to create a right shift value for the mask which corrects the mask for the number of channels used. The corrected bit mask is then shifted left to align its LSB with the base pin for the group. This value is written to outa to set the pins as outputs. Now for the loop that reads the channel levels and handles the output modulation:

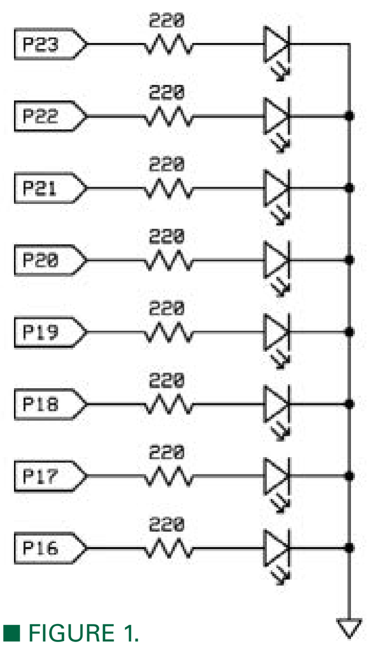
```
mod_main        mov       hubpntr, hub0
                mov       cogpntr, #chacc
                mov       count, chcount
                mov       chmask, #1
                shl       chmask, ch0pin

:loop           movd      :update_acc, cogpntr
                movd      :check_acc, cogpntr
                movd      :clear_c, cogpntr

                rdbyte    tmp1, hubpntr
                cmp       tmp1, #255 wz
  if_e          mov       tmp1, C_BIT

:update_acc     add       0-0, tmp1
:check_acc      test      0-0, C_BIT wc
:clear_c        and       0-0, #$FF
                muxc      outa, chmask

                add       hubpntr, #1
                add       cogpntr, #1
                shl       chmask, #1

                djnz      count, #:loop
                jmp       #mod_main
```

At the top, we copy the hub address of the duty cycle array (saved in hub0) to a working variable called hubpntr. The address of the local (cog) accumulator array is copied to cogpntr. Note that the hash symbol (#) is used to designate a cog address. Both variables will be modified through the loop. The number of channels to process is moved into count and, finally, a mask is created for the LSB pin of the designated outputs.

The next section is where we do a bit of magic. You see, one way to use an array in PASM is to modify the code as it runs. This is possible in the Propeller as all code and data exists in the same RAM space. Note the three lines at the start of the inner loop; each uses the movd instruction. This instruction copies the source value from that instruction into the destination field of the target register. In this case, we're specifying those registers by referring to local labels. In the destination field at each of those labels, you'll see 0-0 which is a programmer's reminder that this element will be modified by other code. This is self-modifying code. In each case, we are moving

BILL OF MATERIALS

Item	Description	Supplier/Part No.
R1-8	220 ohms	Mouser 299-220-RC
LED1-8	Red, 5 mm	Mouser 859-LTL-4224



■ FIGURE 1.

cogpntr (the local array pointer) to the instruction so we can work on an element of that array.

The first time through the loop, we're writing the cog address of the channel zero accumulator to those instructions. After reading the channel duty cycle from the hub, we add that into the current accumulator, then test the accumulator carry bit by comparing it to a mask. In doing this, we will set or clear the Propeller's Carry flag. After clearing the accumulator carry bit, we update the output by using the muxc instruction to copy the Propeller Carry flag to the current output pin. In short, when adding the duty cycle to the accumulator causes a carry, the output for that channel will be on. The larger the duty cycle, the more frequently this will happen.

The end of the inner loop updates the hub pointer. As we're using bytes, we add one to point to the next. The following line updates the cog pointer. You may be wondering why we're using one when all cog variables are longs (four bytes). Well, here's why: We can only treat cog variables as longs, so adding one to cogpntr will point to the next accumulator address. The channel mask is updated by shifting it to the left.

After all the channels have been processed, we start over. The code runs constantly — as fast as it can — given the crystal input, PLL setting, and number of channels used. To give you an idea of the frequency variability, the worst case on the low end is when the duty cycle is set to one. With a typical system (80 MHz), I measured the modulation frequency at about 575 Hz. The fastest frequency comes when the modulation is set to 128 because this will cause the output to toggle every cycle. On the same board, I measured the modulation frequency at about 73 kHz for a duty cycle setting of 128.

There are two lines of code that I skipped over, so I'll go back to those now. What I don't like about general accumulator-divider code is that there is a periodic low output — even when the input is set and maintained at the maximum level. To save paper, let's look at a three-bit level with the duty cycle set to seven (maximum value for three bits):

```
Acc = %0_000 + %111 = %0_111 : Carry = 0
Acc = %0_111 + %111 = %1_110 : Carry = 1
Acc = %0_110 + %111 = %1_101 : Carry = 1
Acc = %0_101 + %111 = %1_100 : Carry = 1
Acc = %0_100 + %111 = %1_011 : Carry = 1
Acc = %0_011 + %111 = %1_010 : Carry = 1
Acc = %0_010 + %111 = %1_001 : Carry = 1
Acc = %0_001 + %111 = %1_000 : Carry = 1
Acc = %0_000 + %111 = %0_111 : Carry = 0
```

As you can see, we get a zero output every 2^channels bit, even when we maintain the maximum duty cycle input. This is easy to correct in code. After reading the channel duty cycle, we compare it to the maximum for the values we're using (255 for a byte in our case). If this is true, then we preset the modulation carry bit by writing the carry value into the working duty cycle variable. When this is added to the accumulator, it will force the modulation carry to be set and the output to be on — without periodic dips — when the duty cycle is set to maximum.

Okay, we have another way to control LEDs, so let's put it to work. As a kid, one of my favorite '70s TV shows was Battlestar Galactica. As an adult, I like the new version even more. An icon of BSG (and later, Knight Rider, also created by Glen Larson) is what's known as the "Larson Scanner" — a string of lights/LEDs where one lit element is "ping-ponged" back and forth in a scanning motion. The Cylon eye from BSG is a Larson scanner.

Most of the time we simply turn on an output and use left and right shifts inside a time loop. Yes, everybody has done this with every processor you can imagine. While working with an FX crew over the summer, I was approached about building a circuit for a Cylon helmet from the original series. Having recently written the object we just worked through, I decided to use that instead of taking the easy route. For convenience, we'll use just eight elements in the demo program which will let you run the program (jm_cylon_8x.spin) on a QuickStart board, a demo board, or the Propeller PDB. If you don't have one of these, connect eight LEDs to your Propeller as shown in **Figure 1**.

I enjoy small lighting projects, and something I often do is embed lighting sequences right into the code. We can do this with the Propeller by using a DAT section; this allows us to embed raw data into the program that we can access at will. Here's the data for the Cylon eye animation:

```
cylon  byte   $00, $00, $01, $08, $FF, $00, $00,
              $00
       byte   $00, $00, $00, $01, $08, $FF, $00,
              $00
       byte   $00, $00, $00, $00, $01, $08, $FF,
              $00
       byte   $00, $00, $00, $00, $00, $01, $08,
              $FF
       byte   $00, $00, $00, $00, $00, $00, $FF,
              $08
       byte   $00, $00, $00, $00, $00, $FF, $08,
              $01
       byte   $00, $00, $00, $00, $FF, $08, $01,
              $00
       byte   $00, $00, $00, $FF, $08, $01, $00,
              $00
       byte   $00, $00, $FF, $08, $01, $00, $00,
              $00
```

```
        byte   $00, $FF, $08, $01, $00, $00, $00,
                   $00
        byte   $FF, $08, $01, $00, $00, $00, $00,
                   $00
        byte   $08, $FF, $00, $00, $00, $00, $00,
                   $00
        byte   $01, $08, $FF, $00, $00, $00, $00,
                   $00
        byte   $00, $01, $08, $FF, $00, $00, $00,
                   $00
```

If you look very closely, you'll see that one element of each line is full bright ($FF), and the position in the table creates the scanning effect. Now look again. Here's where we can make things cool by using a dimmer instead of straight shifts of a single LED. If you look, you will see the values $08 and $01 adjacent to the lit LED. Once you see it in action, the values will make sense. What's happening here is that we're creating a motion trail on the downstream side of the moving element. This gives a richer look to our version of the Larson Scanner, and is one of those subtle details that people appreciate — even if they don't know exactly why.

Let's have a look at the demo program. In keeping with the new version of BSG, when the program starts the center element will fade on. This is easily handled with a loop:

```
  repeat level from 0 to 255
    bright := leds.ezlog(level)
    leds.set(3, bright)
    pause(7)
```

This is simple. We're looping through the brightness of the LED to create a fade on effect. Note, though, that we're using a method called ezlog() to modify the value. A friend showed me this trick for "bending" a linear set of LED values into a quasi-log curve. What this does is provide a more natural fade effect when looking at the LED. The set() method moves a value to a dimmer channel. After a short hold, we drop into the program main scanner loop.

```
  repeat
    repeat row from 0 to 13
      bytemove(leds.address, @cylon[row*8], 8)
      pause(100)
```

The outer repeat causes this loop to run forever; the inner repeat loops through the DAT table. The only tricky aspect is moving the table to the modulation object. One of the methods in that object is called address() which provides the hub address of the duty cycle array. By knowing this address, we can use bytemove to copy eight bytes from the table directly into the duty cycle array. A short pause is used to control the speed of the animation. That's it; a cooler version of the ubiquitous Larson Scanner.

GAME ON!

Now, if you still don't think LEDs are cool, let me tell you about another aspect of my busy summer. In August, I traveled to Seattle for the PAX Prime gaming convention. Honestly, I'm not very much of a gamer, but I love the technology and programming used in online and console games. In fact, a lot of the disciplines used in the gaming industry were born in the visual effects world of the movie industry.

So, why did I go? Well, I had the incredible good fortune to be asked by Hollywood FX master, Steve Wang, to do lighting in characters that he was building for a display. Steve and his massively talented team took two characters from the new game, Firefall (from Red 5 Studios), and made them full sized and unbelievably lifelike. They are so realistic, you expect them to walk off the platform. **Figure 2** is a photo of Steve (lower left with big brown dog) and most of the build crew. Can you find me? With us real humans in the photo you get a sense of the scale of this display; and it was built in just six weeks!

The characters are phenomenal but can't move, so Steve asked me to provide lighting control that let us easily animate the lights on the character for extra pizazz. This is where the Propeller really shines — no pun intended. When Steve has a lighting change request, it doesn't take long to implement using Spin.

To give you an idea, each character controller's master cog launches the dimmer cog (PASM) and up to four animation cogs which are all written in Spin. The state of each of these Spin cogs is stored in a global hub variable so that the master cog, "listens" for a start signal from the project master controller. On receiving the start signal, the master cog runs the show by changing the various states of the other lighting control cogs. The neat part is that the lighting cogs are written in Spin (easy) and as they are, they can access the methods of the dimmer object that was started by the master cog. That's right, the dimmer object is being accessed by up to five cogs.

Figure 3 shows the male character, Typhon, all lit up. Most of the front lighting pulsates up and down in a smooth pattern, though the white headlights have an occasional "twitch" as if there was a loose wire while moving. **Figure 4** is a close-up of Typhon's back. In the image, you'll see that there are two cylindrical protrusions

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

PARALLAX, INC.
Propeller chips and programming tools
www.parallax.com

PULSAR PRO FX
PCB Fab-In-A-Box
www.PulsarProFX.com

■ FIGURE 2.

that each have three windows. Each window is on its own circuit — again from their own Spin cog — to create a spinning effect in the windows. I did this by dimming one window (on each side) down to about 10%. By running this in a loop, it creates the illusion of motion inside the machine — similar to what we did with the Larson Scanner.

As a final bit of fun, I added another cog to each character which uses Morse code and a rear-facing LED module to emit, "Red 5 Studios Firefall" which is followed by the name of the character (the female is called Morningstar). Thankfully, everyone loved the effect and as these are military characters, we explained it as their IFF (Identification, Friend or Foe).

The Firefall display was a tremendous hit with the employees of Red 5 Studios and the thousands of participants at PAX. I really enjoyed sharing how we built the display. With sound (using the Propeller-powered AP-16+), pneumatic motion in the "thumper" machine, smoke effects, and fully lit characters, it was quite a spectacle.

See? LEDs are totally cool! Unfortunately, I cannot give you the character control code (it's owned by the client), but I have added a demo (jm_led_show.spin) to the downloads file that will illustrate the technique I used in the character lighting controllers. The demo has the same circuitry as the Cylon program and two lighting

■ FIGURE 3.

■ FIGURE 4.

control cogs: 1) runs a menu-selected mini light show; and 2) when active, sends a message via Morse code using one of the LEDs. Have a look. I think that once you see how simple it is, you'll be very excited about doing big things with small LEDs.

PDBS IN A HURRY

The display that went to PAX was actually the second of two. Having been through one grueling build where I hand-wired hundreds of LEDs, I helped myself the second time by using PCBs instead of perfboard (which I could do now, knowing the size of each LED panel). The problem was cost; sending out for prototype PCBs would have been really expensive, and we had already set a budget for materials.

My good friend Peter suggested that I have a look at a product called PCB Fab-In-A-Box from Pulsar Pro FX — and man, am I glad I did. With this system, you can output your PCB design using a laser printer onto special paper that comes in the kit. The toner on the paper is transferred to the PCB (also in the kit) using a modified laminating machine. The laminator ensures proper heating and pressure to do a good transfer — something that's tough to get right with an iron.

There is another step before etching which is what allows this system to create such high quality boards: The board is run through a second time, this time with a green sealer. Toner is somewhat porous, so the sealer fills any pores which is what allows the system to create high quality traces, even when the line pitch is very fine.

Etching is handled as with any other home-etched PCB, and toner removal is easy with a bit of acetone. It took a bit of time to cut and drill the boards, but this was less time and far less expense than waiting on prototype PCBs from a traditional board house. **Figure 5** shows one of my spare PCBs. After rough cutting the boards from the 8" x 10" master PCB, the shapes were refined and holes drilled using a Dremel tool. Finally, the boards were chemically tinned to prevent oxidation prior to soldering on the resistors, LEDs, and wires.

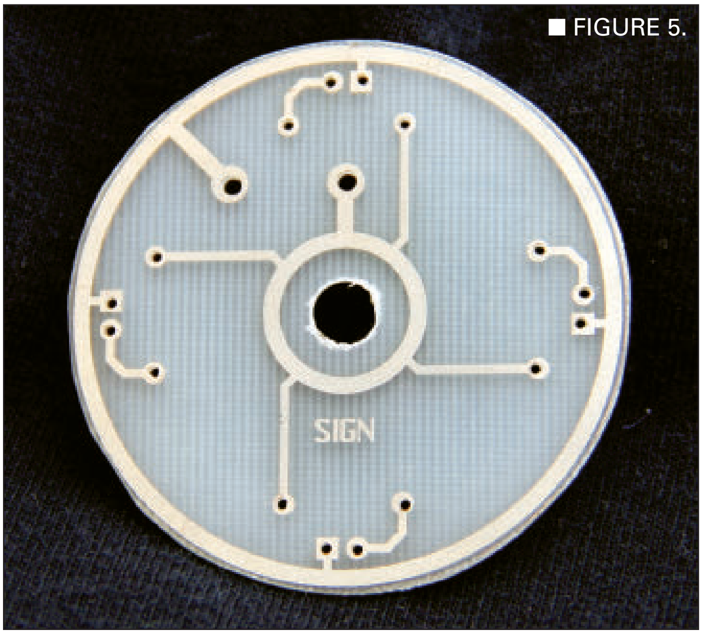
The other great aspect of this system is customer service. I didn't have time to make errors, so I was quick to pick up the phone and call company owner, Frank Miller, for guidance. He was fantastic. At every turn, he was there with good advice and support. I'm looking forward to trying his labeling product which uses similar processes and — he told me over the phone — he's working on a flexible PCB material that works with his system. For the kinds of things I do around the film industry — especially with costumes — building flexible PCBs at home will be fantastic.

Have a look at PCB Fab-In-A-Box — it can be a lifesaver. The great thing is I can now build PCBs over a weekend, especially for my quick-turn, small scale, and one-off projects.

Happy Holidays!

You know what? This is my final column for the year, so let me bid you and yours the very best for the season and the coming new year. As ever, I am appreciative for my friends at Parallax and at *Nuts & Volts* for all their support for me and for The Spin Zone.

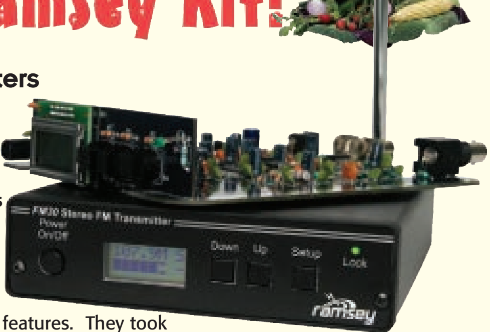
Enjoy the holidays, and keep spinning and winning! See you next year. **NV**



■ FIGURE 5.

Get Ready For The Holidays With a Ramsey Kit!

Digital Controlled FM Stereo Transmitters



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

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

The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting.

Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power. A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use!

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish black metal case measures 5.55"W x 6.45"D x 1.5"H. *(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)*

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

Electrocardiogram ECG Heart Monitor

- ✔ Visible and audible display of your heart rhythm!
- ✔ Bright LED "Beat" indicator for easy viewing!
- ✔ Re-usable hospital grade sensors included!
- ✔ Monitor output for professional scope display
- ✔ Simple and safe 9V battery operation

Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while, at the same time, covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The documentation with the ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hook-ups. In addition, a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see on ER... or in the ER! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Safe 9V battery operation.

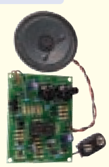
ECG1C **Electrocardiogram Heart Monitor Kit With Case & Patches** **$44.95**
ECG1WT **Electrocardiogram Heart Monitor, Factory Assembled & Tested** **$89.95**
ECGP10 **Electrocardiogram Re-Usable Probe Patches, 10-Pack** **$7.95**

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.

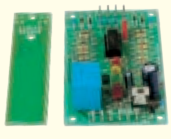
MK134 **Steam Engine & Whistle Kit** **$11.95**

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**

Liquid Level Controller



Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.

K2639 **Liquid Level Controller Kit** **$21.95**

The Holiday Spotlight!

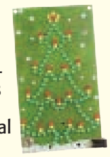
LED Animated Santa

This animated Santa and reindeer display has been our most popular holiday display for years! It contains a whopping 126 dazzling colored LEDs which make it a great holiday sign that is guaranteed to draw attention!

LED animated motion makes it come alive. Runs on standard 9V battery or 9-12VDC external power supply. Dazzle your friends this great display!

MK116 **LED Animated Santa Kit** **$16.95**

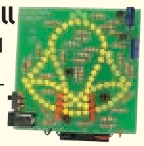
LED Christmas Tree



Electronic Christmas tree features 134 bright colored LEDs in the shape of a gorgeous holiday Christmas tree. Includes 18 random flashing blinking "candles" on the PC board! Runs on a 9V battery or external 9-12VDC power supply.

MK117 **LED Christmas Tree Kit** **$18.95**

LED Animated Holiday Bell



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

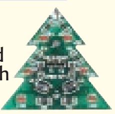
MK122 **LED Animated Bell Kit** **$16.95**

3D LED Christmas Tree

Not your average LED display! 4 branch sections give this tree a true 3D look! 16 red LEDs light it up with yellow LED's for you to customize your tree! The base of the tree is actually the 9V battery acting as a self supporting base! Now that's pretty neat!

MK130 **3D LED Christmas Tree Kit** **$7.95**

SMT LED Christmas Tree



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

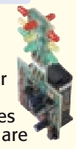
MK142 **SMT LED Christmas Tree Kit** **$10.95**

SMT LED Smiley Face

This is a great attention grabber and also teaches you the basics of SMT construction! Perfect to wear through the holiday season or to hang on your tree as an attention getting ornament! ! Extra parts included! Runs on Li-Ion cell.

MK141 **SMT LED Smiley Kit Kit** **$9.95**

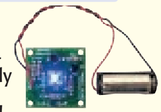
LED Traffic Signal



Not exactly a holiday theme, a real attention getter for this time of the season! Impress your friends with this neat 4-way traffic signal! Operates just like a standard signal, and features adjustable delay. Red, yellow, and green LEDs are used just like the real thing! Runs on 9V battery.

MK131 **LED Traffic Signal Kit** **$7.95**

LED Switcher Blinkey



Wait, an LED that runs on 3VDC running on 1.5VDC? Learn power supply switching and end up with a super bright Telux LED blinking at 140 kHz! Great to light up your ornaments! Runs on a single standard AA battery (not included).

LSW1 **LED Switcher Blinkey Kit** **$14.95**

ramsey
www.ramseykits.com

Where Electronics... Is Always Fun!

✔ 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!

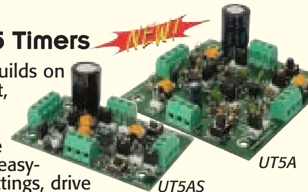
Four-Mode Keyless Entry Test Set
NEW!

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. Until now there was no way to determine where the system was failing.

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! Runs on a standard 9V battery. Also available factory assembled & tested.

WCT3	Four-Mode Keyless Entry Test Set Kit	$59.95

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.

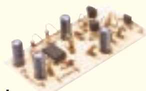
UT5A	Through Hole 555 Timer/Osc Kit	$24.95
UT5AS	SMT 555 Timer/Osc Kit	$26.95

Passive Aircraft Monitor
PATENTED!

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

Voice Activated Switch



Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1	Voice Switch Kit	$9.95

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.

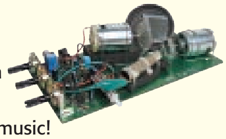
TS1	Touch Switch Kit	$9.95

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.

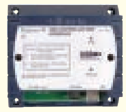
LLS1	Laser Light Show Kit	$49.95

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.

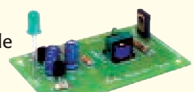
K8062	USB DMX Interface Controller Kit	$67.95

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.

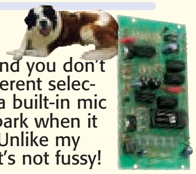
TS4	Tickle Stick Kit	$12.95

Tri-Field Meter Kit
THE GHOST DETECTOR!

"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

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 my Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655	Electronic Watch Dog Kit	$39.95

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!

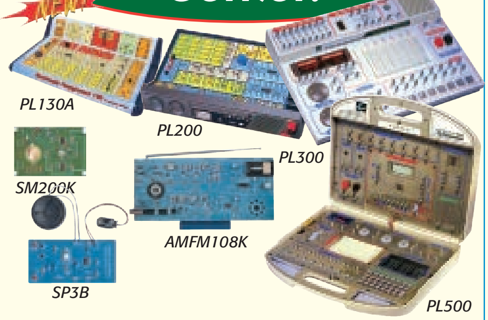
MC1	Mini Electret Condenser Mic Kit	$3.95

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

The Learning Center!
NEW!



Fun Electronic Learning Labs

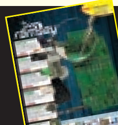
- ✔ **Learn and build!**
- ✔ **130, 200, 300, & 500 in one labs!**
- ✔ **Practical through hole and SMT soldering labs!**
- ✔ **Integrated circuit AM/FM radio lab!**
- ✔ **Super comprehensive training manuals!**

Starting out our "All in One" series, the PL130A, gives you 130 different electronic projects, together with a comprehensive 162 page learning manual. A great start for the kids...young and old! Next, check out the PL200, that gives you 200 very creative and fun projects, and includes a neat interactive front panel with 2 controls, speaker, LED display and a meter. From there, step up to our PL300, which gives you 300 separate electronic projects along with a 165 page learning and theory manual. The PL300 walks you through the learning phase of digital electronics. If you're looking for the ultimate lab kit, check out our PL500. It includes a whopping 500 separate projects, a 152 page starter course manual, a 78 page advanced course manual, and a 140 page programming course manual! The PL500 covers everything from the basics to digital programming!

If you are looking to either learn or hone up on your through hole or SMT soldering skills check our SP3B and SM200K Practical Soldering Labs. You will be a soldering master in no time!

We make it easy to learn IC's while at the same time, building a neat AM/FM radio with our AMFM108K AM/FM IC lab kit. You will have a blast AND learn!

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 Hold Soldering Lab	$9.95
SM200K	SMT Practical Soldering Lab	$22.95
AMFM108K	AM/FM IC Lab Kit & Course	$34.95



Get the latest 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

Prices, availability, and specifications are subject to change. According to Robin we are not responsible for typos, stupids, printer's bleed, or tryptophan sleep comas from the turkey, and she certainly writes the rules! Visit www.ramseykits.com for the latest pricing, specials, terms and conditions. Copyright 2011 Ramsey Electronics®... so there!

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

Q&A

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

- ✔ Solar Controller
- ✔ Lithium-Ion Battery Charger
- ✔ High Power LED Flasher

■ 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**

QUESTION ABOUT LED PROJECT

Q I'd like to know what PIC compiler you used to complete the LED flasher project that was published in the August '11 issue.

— Sassan Amjadi

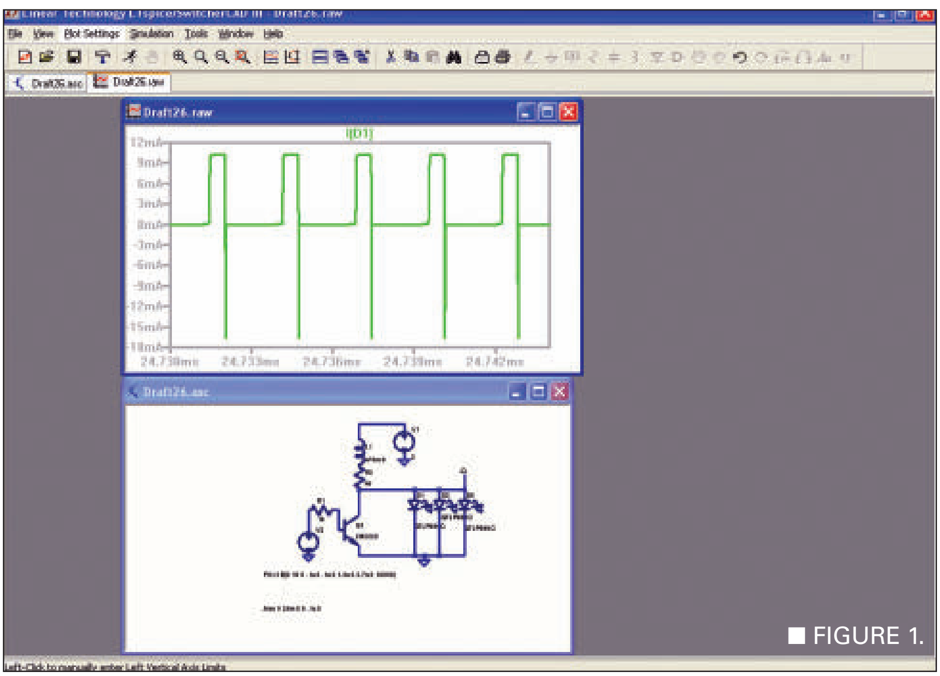
A I used the PICBASIC PRO compiler from microEngineering Labs and MicroCode Studio from Mecanique — it's a program editor and Windows interface that greatly simplifies the programming chore. Microcode Studio is bundled with the free version of PICbasic (**http://melabs.com**). Check it out.

LED FLASHLIGHT

Q I picked up an interesting LED flashlight at the 99 Cent Store. It is housed in rubber, uses only two AA cells, and is very bright. I took it apart and inside are three white LEDs, one 47 ohm resistor, and what I presume is an IC. It is in a three-lead TO-92 package. One lead goes to battery negative; the center lead goes to positive. The third lead goes to three LEDs in parallel, and the 47 ohm resistor goes from the LEDs to battery positive. The LEDs are connected to the negative rail. If you measure the LEDs, there is about 2.5 VDC across them. On a scope, however, there is a 4.5V p-p distorted square wave. The period is about 2.6 µS, so the frequency is about 385 kHz. The IC is marked N8 10229. I am curious to know what it is but have been unable to find it listed in any of the online component databases. I think the flashlights were there because they have a strong odor similar to kerosene, but that will dissipate in time. They are definitely well worth a dollar. Would you have any idea what the device is?

— Bill Lahr

A Since you can't get more than the supply voltage without an inductor, I suspect that the 47 ohm resistor is actually an inductor, possibly 47 mH or 470 mH. The IC consists of an oscillator and switch which I have simulated in **Figure 1**. The switch charges the inductor when it is on, then when the switch turns off, the inductor discharges through the LEDs. This allows the circuit to work even when the battery voltage falls below the turn-on voltage of the LEDs. It would be a lot more efficient if the inductor resistance was not so high, but it was no doubt a tradeoff for size and cost.



■ FIGURE 1.

PIR CONTROLLED IR ILLUMINATOR

Q I'd like to use a 24-IR Illuminator in conjunction with a PIR module (Passive Infra-Red) from **www.**

Parallax.com (#555-28027) from a 12 VDC-100 mA power supply, but don't know how to connect the two together.

Can you create a schematic on how to turn on the IR Illuminator whenever the PIR module detects any heat/movement and turn it off when no heat/movement is detected?

Please indicate whether I should use a 12 VDC-500 mA rather than a 12 VDC-100 mA power adapter.

— Don Franklin

A The IR illuminator has six diodes in series which each drop 1.5 volts plus 78 ohms in series; there are four strings in parallel. With 12 VDC applied, there are three volts across 78 ohms which gives a current of 38.5 mA and 154 mA total; therefore, you need a power supply rated at least 200 mA or 500 mA.

The sensor operates on three or five volts, so you need a regulator. In **Figure 2**, I show an LM2931 five volt regulator which is in a TO-92 package. The sensor output goes high when movement is sensed, which turns on the logic level FET to power up the illuminator. The ZVN4210A is also in TO-92 packages.

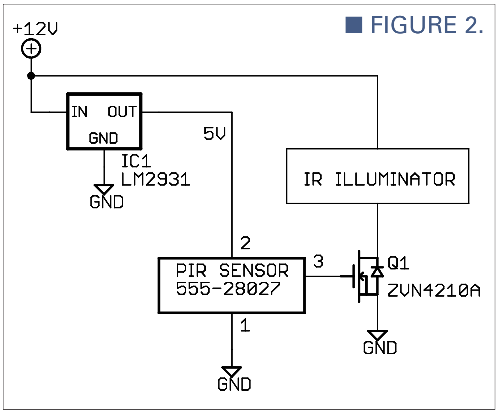


FIGURE 2.

CONVERT LOGIC CIRCUIT TO MICROPROCESSOR

Q Can the circuit in **Figure 3** be converted to use a PIC? I'm sure all these chips can be substituted with a microcontroller of some kind.

U1 is for sequel output.
U2 is a divide by two.
U3 seems to be two slaves.
U4 is a modulator of some kind, I think PWM.
U5 is logic combiner possibly.
U6 is a dual clock using 556.
One other thing ... the two transistors go to another part of a circuit off this circuit.

— Craig Kendrick Sellen

A A microcontroller can only do one thing at a time and this circuit has two independent oscillators, so it is not possible to directly translate this circuit to a microcontroller. However, if the inputs and outputs are described

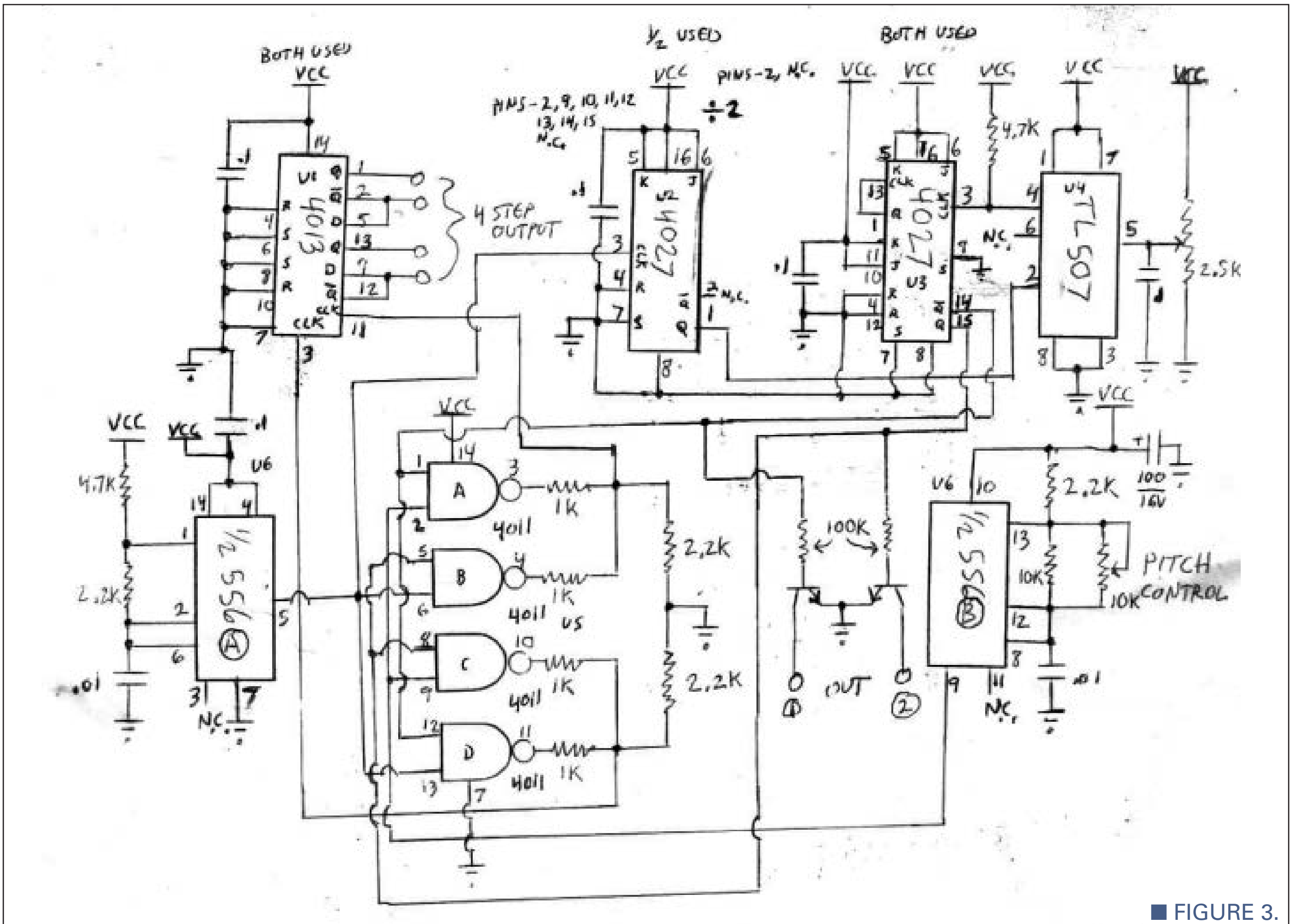
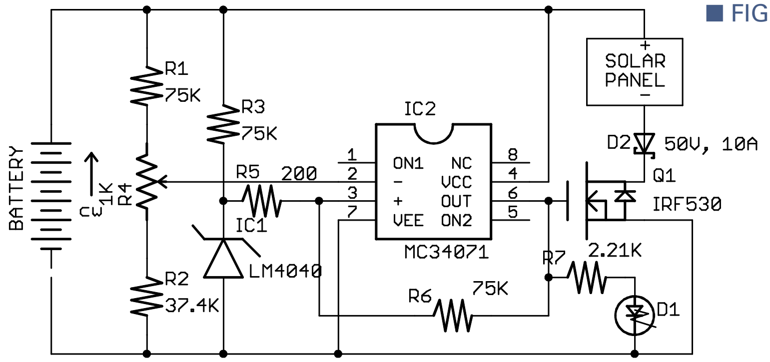


FIGURE 3.

■ FIGURE 4.



PARTS LIST

PART	DESCRIPTION	MOUSER PART NUMBER
R1, R3, R6	75K, 1%, 1/4W	271-75K-RC
R2	37.4K, 1%, 1/4W	271-37.4K-RC
R4	1K TRIMPOT	652-3296Y-1-102LF
R5	200 OHMS, 1%, 1/4W	271-200-RC
R7	2.21K, 1%, 1/4W	271-2.21K-RC
IC1	4 VOLT REFERENCE	595-LM4040D41ILPE3
IC2	OP AMP	863-MC33071APG
Q1	N-MOS, 100V, 10A	844-IRFI530GPBF
D1	LED, RED, T1-3/4	604-WP132XID
D2	SCHOTTKY, 45V, 10A	844-MBR1045PBF

in detail, it may be possible to write a program to accomplish the desired result. From your questions, I sense that you do not know how this circuit works and I cannot help you with that.

SOLAR CONTROLLER

Q I have only received a couple issues of *Nuts & Volts* and enjoy your Q & A section. Therefore, I thought you might be able to help me with a simple circuit I need to fabricate.

Here is my situation: I have two solar panels on the roof of my van camper to keep the batteries charged. A problem developed in the ignition switch that put 4 ohms to ground on the + side of the batteries.

Since I wasn't using the van, I didn't notice the batteries going down. Eventually, what apparently happened was the batteries became so low they drew more current than the controller could handle.

The solar panels are putting out 19V but, the controller was putting 0V into the batteries. The controller is a SOLAR COMMANDER SERIES IV model FM16C made by Kyocera Solar, Inc., Kyoto, Japan which they no longer manufacture or repair.

This controller is quite complicated with five LEDs, a screen that shows voltage, and a pushbutton to show amps. I don't believe I need such a sophisticated device.

Back when I was working in electronics — almost 50 years ago — we used tubes, not these tiny little components the size of a grain of rice that I have no idea what they are.

What say you? Am I a hopeless case or could you develop a controller that would suffice for my application? I wish to keep two 12V vehicle batteries charged. I can still read a schematic, more or less.

— Denis Kellogg

A I checked the Harbor Freight website; it has a 15 watt solar panel. Two of them would be more than

MAILBAG

Dear Russell: Re: Leak Noise Correlator, July '11, page 22:

With regards to Howard Epstein's question regarding a "Leak Noise Correlator," you might want to check your definition of velocity (V). Using V = D/T, the quantity T1 + T2 becomes D1/V + D2/V, and that becomes the constant K = (D1 + D2)/V or D/V, the known quantity.

$\Delta T = T1 - T2 = D1/V - D2/V$
$= D1/V - D2/V + D2/V - D2/V$;
cleverly add zero then regroup the terms,
$= D1/V + D2/V - 2D2/V$
$= K - 2D2/V$

In a similar fashion as above, by adding zero in the form of (D1/V - D1/V), we get:
$= 2D1/V - K$

Simple algebra gives the two relations:

$D1 = (K - \Delta T)/2$ and $D2 = (K + \Delta T)/2$

— Ken Meier

Response: Thanks for the feedback, Ken. If I had plugged some numbers in, I would have discovered my error in the beginning! I wonder how many were aware that I started off with the wrong premise? You were the only one to let me know of the error and I appreciate the opportunity to let the readers know that the math was wrong.

Dear Russell: Re: Transistor Replacement Needed, August '11, page 22:

I love your column but found a major error in the theory of operation for "Transistor Replacement Needed."

The International Rectifier B2M was a popular circa 1966 hobbyist photovoltaic (solar) cell and not a photoresistor. The germanium transistor is merely used as a "common emitter," albeit one requiring a lower base voltage than a silicon transistor to turn it on.

R1 and C1 are simply a snubber to protect the transistor from back EMF transients when the coil is de-energized.

Workarounds to allow a silicon transistor to be used include using a second B2M in series to provide a higher drive voltage, or returning the grounded end of the original cell instead to the tap of a voltage divider between B+ and ground so that the cell voltage adds to the tap voltage. The drawback would be a constant low current drain on the battery due to the divider.

Better yet would be to replace the B2M as well, by using a common phototransistor along with a suitable current limiting transistor between base and B+, with a second resistor between base and ground to ensure that the transistor remains off when the light level is below the desired turn-on threshold.

Relays with ultra-sensitive 4,000Ω coils (~20 mW) are also quite expensive and difficult to find. There's no reason other than battery life why a far more economical normal sensitivity relay couldn't be used.

— Don Eden

Response: Thanks for the feedback, Don. I was on the wrong track on that one.

adequate to maintain the batteries.

There are two ways to regulate the voltage: one is a shunt which bypasses the battery when it is fully charged. The problem is that the regulator will have to dissipate 30 watts at times when the battery is fully charged. The other way is a series transistor to turn off the current when the battery is fully charged. I like this better because the power dissipation is less.

In **Figure 4**, I use an op-amp to compare the battery voltage with a fixed reference. When the divided battery voltage rises to equal the fixed reference, the series transistor (Q1) will be shut off. The positive feedback provides hysteresis so that the charge — once shut off — will not start until the voltage drops about 0.2 volts. The LED (D1) lights to show that the system is charging. The diode in series with Q1 prevents the negative lead of the solar panel from going to ground through the internal diode of Q1.

To calibrate the charger, connect a fully charged battery (13.8 VDC) and adjust R4 until the LED just goes out.

BTW, I have used a smaller solar panel (four 3V cells) and connected it directly to the battery (two 12V truck batteries). The batteries stayed up for three years until I sold the truck.

LITHIUM-ION BATTERY CHARGER

Q I'm working on a project that I need a schematic for and hope you can help me.

First, I need a circuit to charge a 4.2 VDC 900 mAh rechargeable Li-Ion prismatic cell (All Electronics Corp.; cat# LBATT-60; $2.50 ea. They are listed as Iomega p/n31021100).

I'm building rechargeable lighting devices that will drop into a recharge station and will likely spend most of their lives on it, so overcharging is a big issue. Each unit will contain one of the Li-Ion packs, and the charger should be able to charge up to 12 at one time individually as some may not be present at times while in use. (I have heard charging Li-Ion cells requires different circuits than do NiMH or NiCAD) The charging station will permanently be in a vehicle and powered off 12 VDC to 14.4 VDC (vehicle batteries). A slow charge rate is acceptable if necessary.

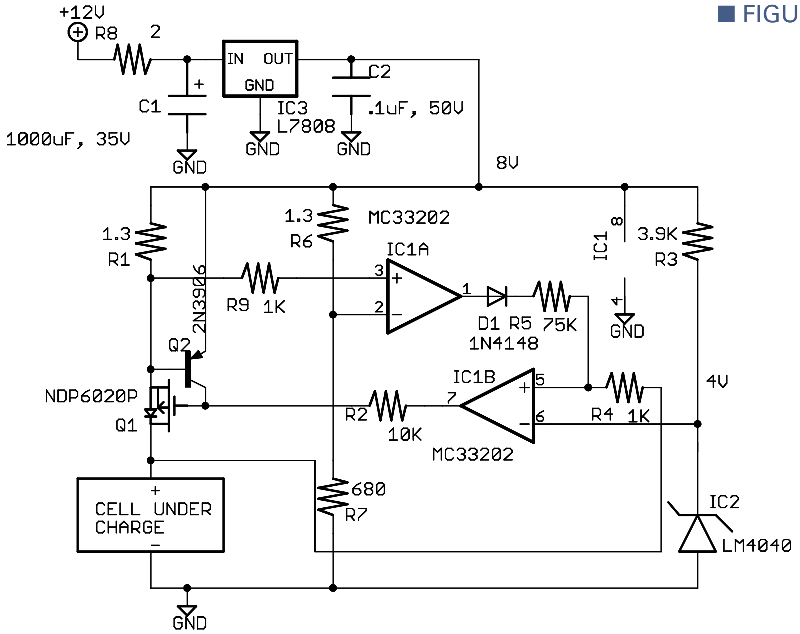
— Geoff Mayberry

A The lithium-ion cell is charged from a current source with a voltage limit. Service life is reduced by charging to higher voltages; 4.2 volts is the max. Since your application has the cell in the charger most of the time, charging to a lower voltage for longer service life will probably be desirable. A 4.0 volt limit will give 82% capacity, and charge time will be several hours.

A 900 mAh cell can deliver 90 mA for 10 hours. The charge rate could be as high as 900 mA but that is stressful; some recommend half that or 450 mA. The charge time in that case could be four or five hours.

The recommended charger (Battery University, courtesy of Cadex) will charge at a constant current to the voltage limit, then maintain that voltage until the current

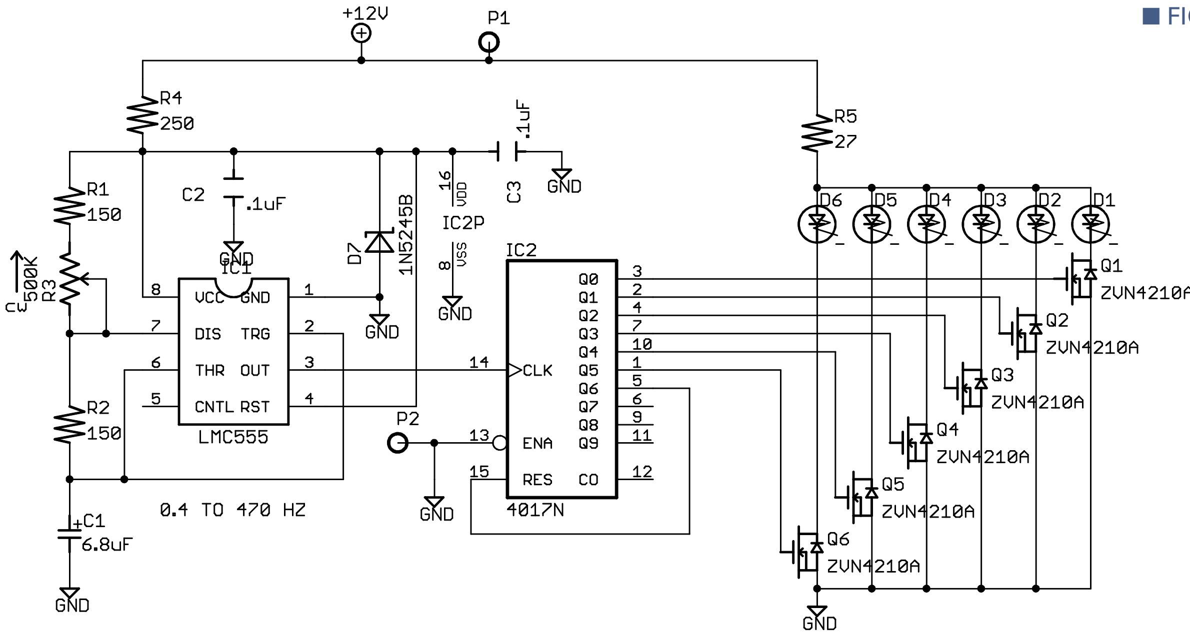
■ FIGURE 5.



LITHIUM-ION CHARGER PARTS LIST

■ FIGURE 6.

PART	DESCRIPTION	MOUSER PART #
R1, R6	1.3 OHMS, 5%, 1/4W	594-5073NW1R300J
R2	10K, 5%, 1/4W	271-10K-RC
R3	3.9K, 5%, 1/4W	271-3.9K-RC
R4, R9	1K, 5%, 1/4W	271-1K-RC
R5	75K, 5%, 1/4W	271-75K-RC
R7	680 OHMS, 5%, 1/4W	271-680-RC
R8	2 OHMS, 5%, 1/4W	594-5073NW2R000J
Q1	P-MOS, 20V, 24A, LOGIC LEVEL	512-NDP6020P
Q2	PNP, 40V,100 mA	512-3906TA
D1	DIODE, 40V, 100 mA	78-1N4148
IC1	DUAL, RAIL/RAIL OP-AMP	863-MC33202PG
IC2	4V REFERENCE, TO-92	595-LM4040C41ILP
IC3	8V REGULATOR, 40V IN, 1A	511-L7808ACV
C1	1,000 µF, 35V, 20%	647-UHE1V102MHD
C2	0.1 µF, 10%, 50V CERAMIC	810-FK18X7R1H104K



■ FIGURE 7.

LED SEQUENCER PARTS LIST

■ FIGURE 8.

PART	DESCRIPTION	MOUSER PART #
R1, R2	150 OHMS, 5%, 1/4W	271-150-RC
R3	500K TRIMPOT	652-3266W-1-504LF
R4	250 OHMS, 5%, 1/4W	271-249-RC
R5	27 OHMS, 5%, 5 WATT	594-AC05W27R00J
D1, D2, D3,D4, D5, D6	COOL WHITE LED, 3 WATT	ASMT-AW31-NUV00-ND (Digi-Key no stock)
	LUMILEDS LXHS-PW01	93K5864 (Newark four in stock)
D7	15V ZENER, .5 W, 5%	78-1N5245B
IC1	CMOS TIMER, 555	511-TS555ID
IC2	1 OF 10 DIVIDER/DECODER	595-CD4017BE
Q1, Q2, Q3, Q4, Q5, Q6	N-MOS, 100V, 500 Ma	522-ZVN4210A, ZVN4210A-ND (Digi-Key)
C1	6.8 µF, 16V, 5% TANTALUM	74-199D16V6.8
C2, C3	0.1 µF, 50V, 10% CERAMIC	810-FKX7R1H104K

falls to 3%. It then will shut off completely. The circuit of **Figure 5** does that and when the cell voltage falls due to self-discharge, the circuit turns on to charge it up again. I simulated the circuit in SwitcherCad; the voltage is maintained between 3.96 and 4.0 volts.

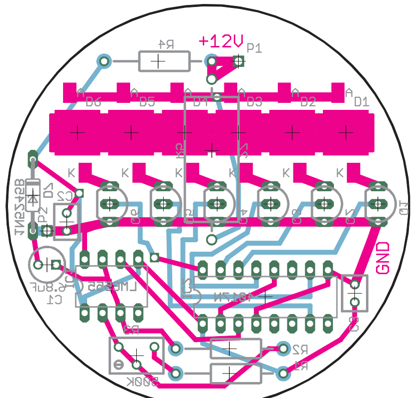
In **Figure 5**, the PMOS transistor, Q1, is turned on by IC1B as long as the cell voltage is less than the reference voltage of IC2 (4.096 VDC nominal). The current is regulated by Q2 and R1. The current is Vbe/R1 = 462 mA; I couldn't find a 1.4 ohm resistor to get 450 mA. The output of IC1A is low until the drop across R1 falls to 15 mV which is equal to the drop across R6. When the output of IC1A goes high, the output of IC1B goes high, shutting off Q1. Q1 stays off until the cell voltage drops enough to pull the positive input of IC1A below the reference voltage. IC3 is an automotive voltage regulator to protect against load dump transients which can reach 60 volts. IC3 is rated 40 volts max but R8 and C1 will attenuate the higher transients.

You will need a separate circuit for each unit to be charged.

I tried simulating with MC33202 — a rail-to-rail op-amp — but the simulation did not work. The op-amp output would not go rail-to-rail. The simulation worked fine with an LM393 comparator, but I know it will not work in practice because the input of IC1A is higher than the common mode range. So much for simulation; you also have to apply common sense!

HIGH POWER LED FLASHER

Q I want to obtain a schematic to make six Luxeon Lumiled (LXHL-PW01) high power cool-white LED emitters flash in sequence, preferably with an adjustable pot for speed control. (The emitters are All Electronics Cat#LED-145.) The only catch is that space is extremely limited in the housing (about a 2-1/4" dia. x approx 5/8" height available). If necessary, I could modify my design to accommodate the circuit. I'm also not_yet equipped for SMT



■ FIGURE 9.

components, so "old tech" is my only present option (iron soldering only).

Note: The pot for speed control can be a mini PCB mount because once it's set, it won't be accessible without opening the unit. The sequence should repeat until switched off manually.

— Geoff Mayberry

A All Electronics does not recognize that part number, but Newark has four units in stock and similar devices are made by other manufacturers. However, I did not find any in stock. The LED is surface-mount but easily hand-solderable. The operating condition is 3.2V, 350 mA (1.12 watts).

The circuit in **Figure 7** consists of a 555 oscillator driving a 4017 counter/1 of 10 decoder. Feedback to the reset pin limits the output of the 4017 to one of six. Since only one LED is on at any one time, only one current limiting resistor is needed. The ZVN4210A is rated 100 volts so it can be connected to 12 volt power and survive the load dump transient, but the CMOS ICs have to be protected by R4 and D7. **Figure 8** is the Parts List.

I made a layout (**Figure 9**) to see if the parts will fit in a 2-1/4" circle. It does fit — just barely — and I have the Gerber files. The heatsinks for the three watt LEDs are all connected because it gives greater heat dissipation and the cool white LEDs are isolated; some others are not isolated and should be used with caution. **NV**

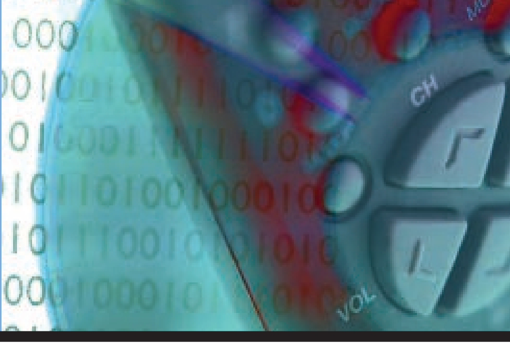
EARN MORE MONEY
Get your dream job!
Be an FCC Licensed Wireless Technician!
Make up to $100,000 a year and more with NO college degree

Learn Wireless Communications and get your "FCC Commercial License" with our proven Home-Study Course!
- No need to quit your job or go to school.
- This course is easy, fast and low cost.
- No previous experience needed!
- Learn at home in your spare time!

Move to the front of the employment line in Radio-TV, Communications, Avionics, Radar, Maritime and more… even start your own business!

Call now for FREE info
800-932-4268 ext. 209
Or, online:
www.LicenseTraining.com

COMMAND PRODUCTIONS
Warren Weagant's FCC License Training
P.O. Box 3000, Dept. 209 • Sausalito, CA 94966
Please rush FREE info immediately!
NAME:
ADDRESS:
CITY/STATE/ZIP:
email: info@LicenseTraining.com



NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

NEW 4-1/2 DIGIT BENCH DIGITAL MULTIMETER

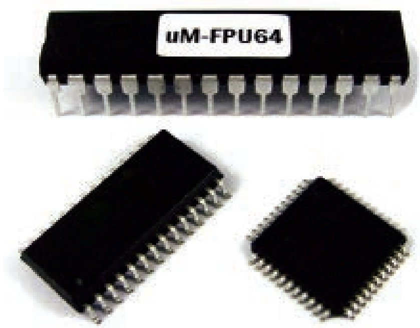
Global Specialties has introduced a new digital multimeter. The PRO-1000 is a portable, bench type digital multimeter with a 4-1/2 digit LED display that can measure diodes, frequency, current, voltage, and resistance, as well as test continuity for a list price of $345.

Important features of the new PRO-1000 include:

- True RMS digital multimeter.
- Basic DC voltage accuracy of 0.05%.
- Basic AC voltage accuracy of 0.75%.
- Overload protection on all ranges.
- AC/DC voltage measurement up to 1,000V DC and 750V AC.
- AC/DC current measurement up to 10A.
- Resistance measurement up to 20 MΩ.
- Frequency measurement up to 200 kHz.
- Audible continuity test.
- Diode test voltage, 2V.
- 110-120V AC @ 50 Hz/210-220V AC @ 50 Hz input voltage.
- Weighs only 4.4 lbs (approx 2.0 kg).
- Comes complete with user's manual, one set of test leads, power cord, and spare fuse.

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

64-BIT FLOATING POINT COPROCESSOR



Micromega Corporation announces the release of the uM-FPU64 floating point coprocessor chip. The uM-FPU64 extends Micromega's family of coprocessors to provide support for IEEE 754 compatible 64-bit floating point and integer calculations, expanded digital I/O and analog input capabilities, and support for local peripheral devices. The uM-FPU64 can be interfaced to a wide range of popular microcontrollers to provide extensive floating point capabilities, and optionally control a subsystem of local peripherals. It can also be configured as a stand-alone microcontroller for embedded applications.

The precision required for GPS navigational calculations and the transformation of data from MEMS-based sensors can easily exceed the capabilities of 32-bit floating point numbers. The uM-FPU64 coprocessor — with support for both 64-bit and 32-bit floating point numbers — provides the added precision needed for these demanding applications, and can offload the floating point calculations from the microcontroller.

The uM-FPU64 is compatible with the instruction set of Micromega's popular uM-FPU V3.1 32-bit floating point coprocessor. Advanced instructions are provided for fast data transfer, matrix operations, FFT calculations, serial input/output, NMEA sentence parsing, string handling, digital input/output, analog input, and control of local devices.

Local device support includes: RAM, 1-Wire, I^2C, SPI, UART, counter, servo controller, and LCD devices. A built-in real time clock and foreground/background processing is also provided. The uM-FPU64 can act as a complete subsystem controller for sensor networks, robotic subsystems, IMUs, and other applications.

The uM-FPU64 IDE (Integrated Development Environment) makes it easy to create, debug, and test code. Code can be written in the IDE's high level language or in assembler, then compiled to generate code targeted for one of the many microcontrollers and compilers supported, or it can be stored internally in Flash memory. The IDE provides support for editing code, compiling, tracing code execution, setting breakpoints, examining registers, and programming user-defined functions in Flash memory.

The uM-FPU64 chip is RoHS compliant and has an operating voltage of 3.3V, with 5V tolerant SPI and I^2C interfaces. SPI interface speeds up to 15 MHz and I^2C interface speeds up to 400 kHz are supported. The chip is available in PDIP-28, SOIC-28, or TQFP-44 packages. The single unit price is $24.95 with volume discounts available.

For more information, contact:
Micromega Corporation
1664 St. Lawrence Ave.
Kingston, ON K7L 4V1
Tel: **613-547-5193**
Web:
www.micromegacorp.com

Continued on page 77

SHOWCASE

Recycling & Remarketing High Technology
WEIRDSTUFF® WAREHOUSE
Software,Computers,Electronics,Equipment,Doohickies
WE BUY/SELL EXCESS & OBSOLETE INVENTORIES
FREE COMPUTER AND ELECTRONIC RECYCLING
GIANT 10,000 SQ. FT. AS-IS SECTION
384 W. Caribbean Dr.
Sunnyvale, CA 94089
Mon-Sat: 9:30-6:00 Sun: 11:00-5:00
(408)743-5650 Store x324
WWW.WEIRDSTUFF.COM

AMATEUR TV
start from
$50/unit
Quality Wireless A/V
Transmitter/Receiver
2.4GHz or other HAM frequencies
www.4ATV.com (800) 719-9605

NKC ELECTRONICS
Zeroplus LAP-C 16032
Logic Analyzer
16-channel - 100MHz - USB 2.0
SPI - i2c - UART - 7-segment
2 free additional protocols
$120
Arduino UNO
$29.95
Rigol DS1052E DSO
50MHz - up to 1GSa/s
1 Meg mem - TFT LCD - USB
Advanced triggering: Edge,
Pulse, Video, Slope, Alt
Open Source Hardware
Arduino UNO - MEGA 2560
Arduino Duemilanove $24.95
Freeduino - Seeeduino
DSO Nano
Arduino Shields - Ethernet
RGB LCD - XBee
Special
$399
http://www.NKCelectronics.com

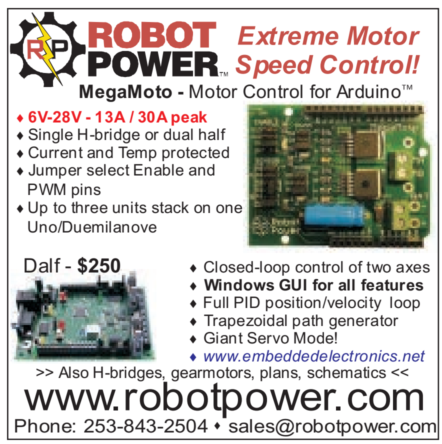
QKITS.COM
Power Supply:
12/24VDC
Load Voltage
30A PWM DC Motor
Speed Control
Control the speed of
your electric motors or
the brightness of your
DC light bulbs.
$24.95
Quantity discounts
available.
1-888-GO-4-KITS

www.Primecell.com
Battery rebuilding service
Dead Batteries ? Don't toss them.
Send them to us - our rebuilds are
better than original specifications.
Tools
Hilti Skil
Milwaukee
Panasonic
B&D DeWalt
Makita All
2-36 Volts
Electronics
Bar Code
Scanners
Surveying
Printers
Laptops
Photography
Radios
APELCO
UNIDEN
G.E. ICOM
KENWOOD
MOTOROLA
MIDLAND
MAXON
YAESU
ALINCO
Visit www.primecell.com for important details
24 Hr Secure recorder tel-fax (814) 623 7000
Quotes email: info@primecell.com
Cunard Assoc. Inc. 9343 US RT 220 Bedford PA 15522

BlinkM
Arduino
I2C RGB "Smart LED"
USB - BT - XBEE
Prototyping Supplies
Serial LCD
Save 5% with coupon code NV
FunGizmos.com

RF Specialists
ZigBee Solutions
ProBee Series
High Performance and Robust Data Transfer Capability
ZigBee Solutions
Low Cost
Low Power
Long Range
LEMOS INTERNATIONAL
www.lemosint.com
866.345.3667
sales@lemosint.com

CHIPINO
The Arduino Style Module for the Microchip PIC User
$19.95 kit
$29.95 assembled
WWW.CHIPAXE.COM



ROBOT POWER
Extreme Motor Speed Control!
MegaMoto - Motor Control for Arduino™
♦ 6V-28V - 13A / 30A peak
♦ Single H-bridge or dual half
♦ Current and Temp protected
♦ Jumper select Enable and PWM pins
♦ Up to three units stack on one Uno/Duemilanove
Dalf - $250
♦ Closed-loop control of two axes
♦ Windows GUI for all features
♦ Full PID position/velocity loop
♦ Trapezoidal path generator
♦ Giant Servo Mode!
♦ www.embeddedelectronics.net
>> Also H-bridges, gearmotors, plans, schematics <<
www.robotpower.com
Phone: 253-843-2504 ♦ sales@robotpower.com

Nuts & Volts 7 CD-ROMs & Hat Special!
Complete with supporting code and media files.
NUTS AND VOLTS 2010 Volume 31, No. 1-12
NUTS AND VOLTS 2009 Volume 30, No. 1-12
NUTS AND VOLTS 2008 Volume 29, No. 1-12
NUTS AND VOLTS 2007 Volume 28, No. 1-12
NUTS AND VOLTS 2006 Volume 27, No. 1-12
Nuts & Volts 2005
Nuts & Volts 2004
NUTS AND VOLTS Magazine
Free Shipping!
Only $149.95
www.nutsvolts.com

By Michael Day
Power Management Application Supervisor, Texas Instruments

REPLACE INCANDESCENT LIGHTING WITH LEDs — AN EASY HOME CONVERSION

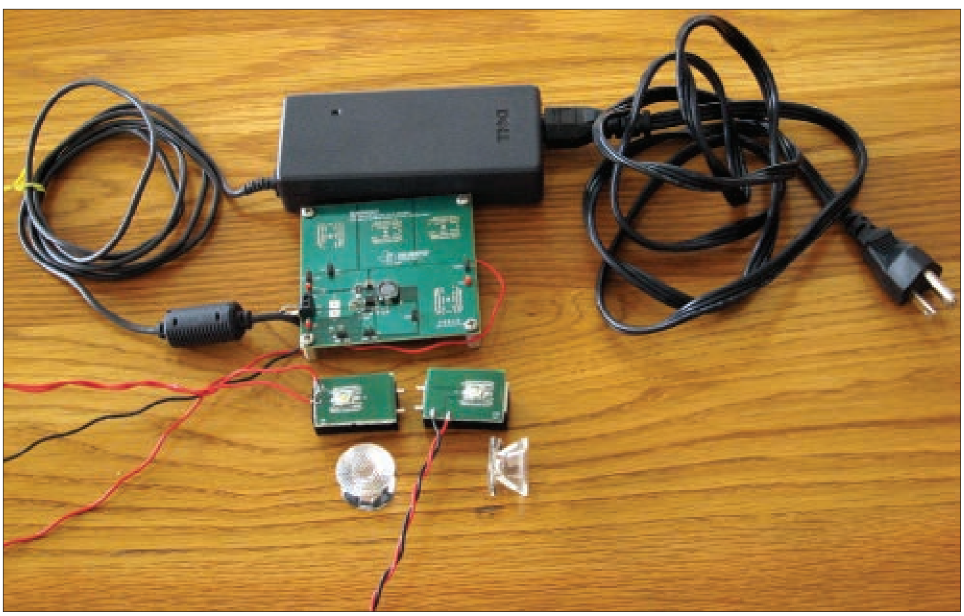
This article shows how to replace standard incandescent lighting with LED based lighting. The design operates from standard 120V household power and uses a standard laptop AC adaptor to generate a useable DC voltage. This article covers how to convert a standard constant voltage power supply into a constant current power supply that powers two 1A LEDs, and also touches on some key design considerations. It shows the final assembled system, as well as the yearly power savings achieved when replacing incandescent bulbs.

ABSTRACT

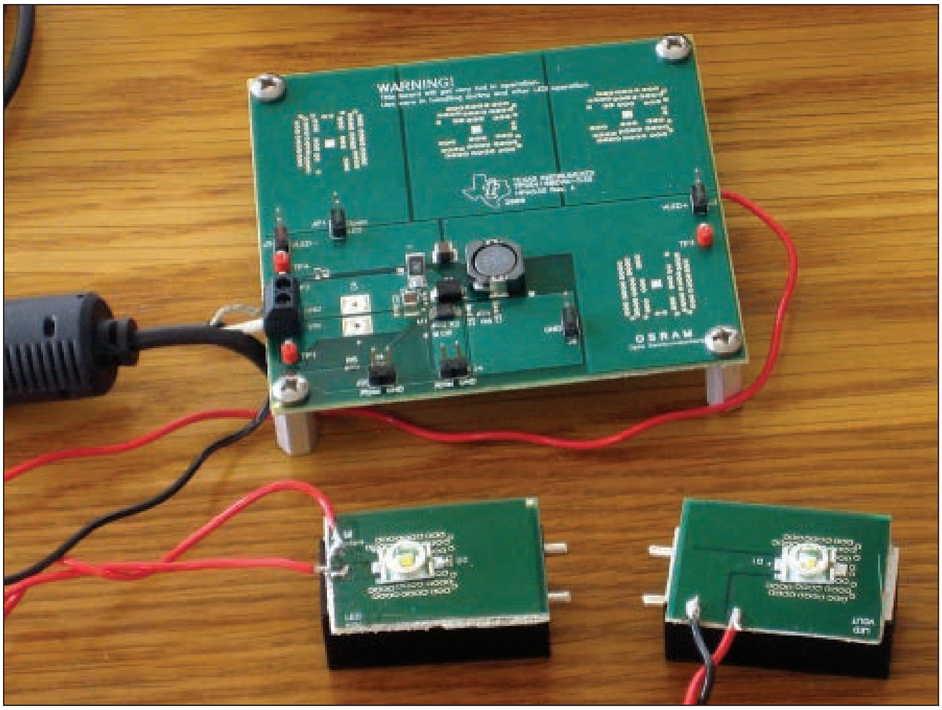
Accent lighting like that in curio cabinets typically uses specialty incandescent light bulbs. These bulbs are expensive, consume a considerable amount of power, and generate significant amounts of heat — and ultimately are being phased out by the government. These traditional incandescent bulbs can easily be replaced with a system made from a spare laptop AC adaptor and high brightness LEDs. This design saves energy, enhances ambiance, and eliminates frequent replacement of expensive incandescent specialty bulbs.

MEET THE COMPONENTS

Figure 1 shows the system components. An unused laptop AC adaptor is an ideal choice for the AC/DC converter. They are inexpensive and readably available, probably lying around in a box waiting to be thrown away. They provide the power conversion from the standard 120 VAC household power to a safe DC voltage level that is easily connected to an



■ **FIGURE 1.** System components.

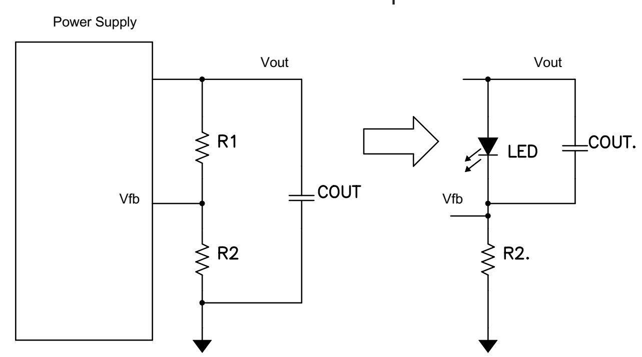


■ **FIGURE 2.** Laptop adaptor's DC voltage wiring, stripped and connected to the TPS54160 PWB.

integrated DC/DC power supply. A DELL Latitude ™ AC adaptor generates 18V at 3.5A. You can access the DC voltage by cutting off the connector that plugs into the laptop. Peel back the outer insulation to reveal the power and return wires as shown in **Figure 2**.

The AC adaptor directly powers a standard DC/DC power supply that has been converted to provide a constant current output. Almost any standard DC/DC converter can be used. The converter's input voltage rating must be higher than the laptop adaptor output voltage. It also must have an appropriate output current rating. A power supply controller typically is a cheaper solution, while a fully integrated converter simplifies the design process. The chosen power supply must provide the user with access to the feedback resistors to allow for modification from constant output voltage to constant output current.

■ **FIGURE 3.** The power supply's top feedback resistor replaced with the LED load.



SHEDDING LIGHT ON THE BUILD

Figure 3 shows how to convert a standard power supply into a constant output current supply. By replacing the top feedback resistor with the LED load and then changing the bottom feedback resistor to set the LED current, the power supply now regulates the voltage across R2 to its internal reference voltage. Because relatively no current flows into the feedback (FB) pin, the fixed voltage across R2 sets the LED current. The output capacitor, Cout, return connection is moved from ground to the FB pin to minimize the ripple current in the LEDs while still stabilizing the power supply's feedback loop.

Equation 1 calculates the correct value of R2. Vref can be found in the power supply's datasheet. This project takes advantage of the TPS54160 LED driver EVM. This is a standard DC/DC power supply that already has been converted into a constant current source.

$$R2 = \frac{V_{ref}}{I_{LED}}$$

■ **EQUATION 1.**

The circuit in **Figure 3** automatically adjusts its output voltage to keep a constant current flowing through the LEDs. It compensates for changes in the input power supply voltage and for changes in the LED forward voltage drop. You can add additional LEDs in series, as long as the sum of the LED forward voltage drops, plus, Vref is less than the voltage supplied by the AC adaptor. Select an LED color temperature that compliments the area being illuminated.

This design uses a cool white Cree® 1-A XLamp® LED to bring out the blue

PARTS LIST

ITEM	SOURCE
LEDs	CREE XRE
Lenses	L2 Optics
Heatsinks	Wakefield Solutions
TPS54160EVM	Texas Instruments
PWBs	Misc.
Laptop adaptor	Junk drawer

REFERENCES

Download a datasheet or other technical documents: **www.ti.com/product/tps54160**.

For more information about LEDs, visit: **www.ti.com/led-ca**.

See videos, ask questions, and share knowledge on the TI E2E™ Community: **www.ti.com/e2e-ca**.

■ FIGURE 4. The finished project. Cree® 1-A XLamp® LEDs bring out the blue from the curio cabinet contents.

highlights in the dishes in the china curio cabinet (**Figure 4**). With darker china patterns, a warm white LED may be more appropriate. The LED provides up to 100 lumens. While this is significantly less lumens than a standard incandescent bulb, the LED focuses this light to where it is needed which significantly reduces the required lumen output.

The necessary LED current for a specific application is difficult to calculate. The best approach is to empirically adjust the LED current until you get the desired lighting effect. Select the lowest current that provides acceptable results. Lower currents minimize power dissipation and reduce the LED temperature which increases the LED's lifetime.

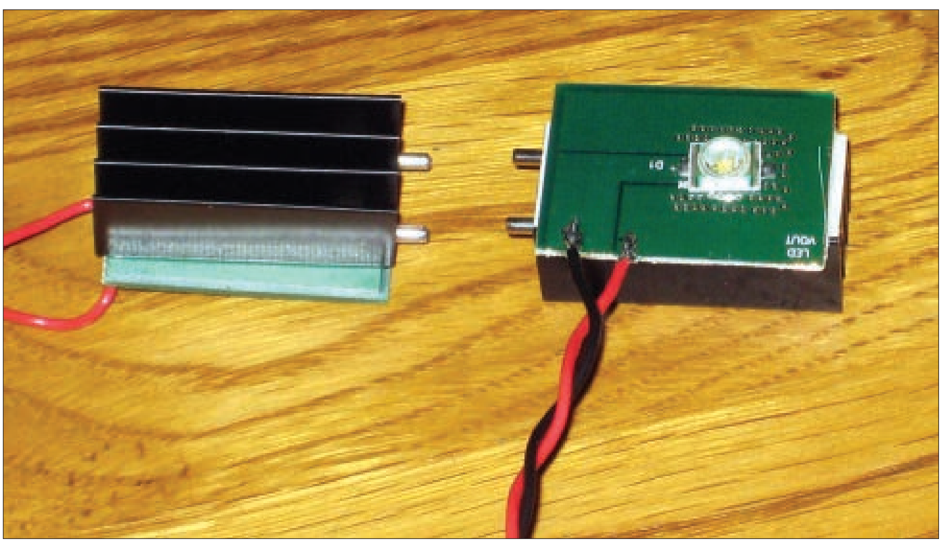
$$P_{R2} = \frac{I_{LED}^2}{R2}$$

■ EQUATION 2.

Size R2 to handle the required power dissipation. Because the full LED current flows through R2, this resistor is required to dissipate up to 800 mW. **Equation 2** calculates R2's required power dissipation.

We settled on an 820 mohm resistor in this design which results in 975 mA of LED current; it dissipates 780 mW of power. You must design the remaining power supply components to operate with the actual input and output voltage range. An application note for the TPS54160 provides all necessary design equations; all design equations are integrated into an easy to use Excel

■ FIGURE 6. LED and heatsink assemblies mounted to the incandescent light fixture.



■ FIGURE 5. LEDs and PWB with thermal vias mounted to the aluminum heatsink.

Michael Day, Power Management Application Supervisor for Texas Instruments' Power organization, has more than 16 years design experience in the field of power conversion. Currently, Michael manages the DC/DC Power Applications group at TI. He received his BSEE and MSEE in Pulsed Power from Texas Tech University, Lubbock, TX. Michael is a member of IEEE and has published over 65 articles on power, portable power, and lighting topics. You can reach Michael at ti_michaelday@list.ti.com.

spreadsheet (LEDDRIVER60VSWIFT-CALC) available for download at **www.ti.com/tool/leddriver60vswift-calc**. The spreadsheet compliments an application note available at **http://focus.ti.com/general/docs/litabsmultiplefilelist.tsp?literatureNumber=slva374**

IMPLEMENTATION

Thermal management is important to achieve the 50,000+ hr lifetime advertised by LED manufacturers. In order to keep the LEDs cool and to extend their life time, mount them on a PWB with many thermal vias as shown in **Figure 5**. Attach a standard aluminum heatsink to the back of the PWB. If possible, mount the LED and heatsink assembly where natural convection can effectively cool the LEDs. Depending on the application and the chosen LED viewing angle, you may decide to add a plastic lens to the LED to focus the light.

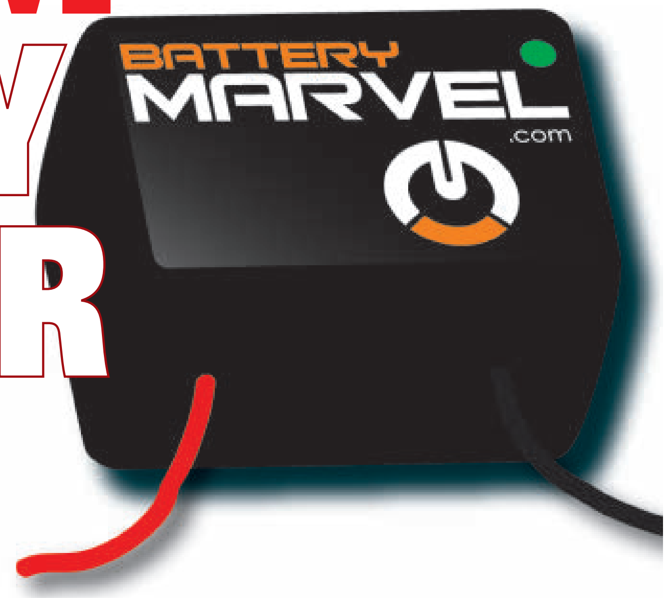
Final assembly requires soldering only a few wires to connect the AC adaptor, LED driver, and LEDs together. Use a minimum of 22 AWG wire and ensure you don't exceed their current carrying capability. The project does not require adding or modifying any existing household wiring because the AC/DC adaptor plugs into the same plug as the old incandescent lights. Mechanically mount the AC adaptor and LED driver, and secure all loose wiring. **Figure 6** shows how the LED and heatsink assemblies are glued into the original light fixtures to provide enough recess so the LEDs and lenses do not show. The LEDs' light intensity is matched to the room's ambient lighting to give the perfect accent to the curio cabinet. The slightly blue hue of cool white LEDs perfectly compliments the china pattern.

LEDs ARE A BRIGHT CHOICE

The final design replaces two 40W incandescent bulbs (85.3 W) but only consumes 10.5W which reduces the curio cabinet's internal temperature from 30.0 deg C to 22.2 deg C. Yearly electricity savings — based on operating the lights 12 hours per day at $0.15/kw-hr — is $45.66. The LED-based design also eliminates frequent changing of expensive specialty incandescent bulbs, which historically costs me $10 per year. The result is a $55 reduction in operating costs per year. The break-even time for this project is 15 months. My project has been operating seven days a week for 21 months and I've yet to replace a bulb. **NV**

By Dave Decker

"BATTERY MARVEL" 12V AUTOMOTIVE BATTERY MONITOR



This easy-to-build device alerts you well before your car, truck, boat, or motorcycle battery fails!

In this article, we're going to introduce you to the Battery Marvel — a small but powerful device designed to constantly monitor the health of common 12V lead-acid batteries found in cars, trucks, boats, motorcycles, and more. This simple project is based around a PIC microcontroller and sophisticated embedded software designed to continuously analyze your battery. The Battery Marvel gives visual and audible alerts before a battery's health becomes critical, and therefore helps prevent being caught off guard by a dead battery. It also monitors your vehicle's charging system and can identify a bad alternator, a loose fan belt, bad electrical connections, a faulty voltage regulator, plus a host of other common problems.

The Battery Marvel installs quickly and easily by connecting just two wires (power and ground). It is compatible with all 12V lead-acid batteries, including those also found in RVs, ATVs, personal watercraft, scooters, snowmobiles, and tractors. The Battery Marvel is great for vehicles in storage, as well as those you drive daily.

A single LED glows green, yellow, or red, indicating the health of your battery and electrical system at a glance. If your battery is in good condition and well charged, the Battery Marvel simply blinks green and stays quiet. If battery strength becomes marginal (yellow) or critical (red), the LED changes color and a loud audible alert is issued. The alert plays for a few minutes, and then automatically changes to an occasional reminder "chirp."

You probably already know that temperature has an impact on the performance, capacity, and service life of all batteries. The Battery Marvel continuously monitors the ambient temperature and incorporates this information into its ongoing analysis.

To support the analysis of battery condition, certain data are maintained in non-volatile Flash memory:

- A set of tables listing eight critical battery parameters vs. temperature (-40°F to 150°F).
- Historical data collected from your vehicle such as the number of engine cranks, number of engine starts, number of times the battery was disconnected, number and type of alerts issued, voltages observed, etc.
- An "abnormal" event log containing the last 64 "out of spec" events with time and temperature.
- A "normal" event log containing the last 64 "in spec" events with time and temperature.

During the first few seconds at power-up the Battery Marvel transmits the historical data and event logs optically by very rapidly blinking the red LED. In a follow-up project, we'll show you how to build an optical data reader that can capture these details and enable it to be viewed on a PC.

CAUTION: *The Battery Marvel is not compatible with high voltage (>12 volt) hybrid or electric vehicles. This device is designed to monitor common 12 volt lead-acid automotive batteries. Do not connect the Battery Marvel to high voltage (>12 volt) systems since this could be dangerous and may result in damage!*

LEAD-ACID BATTERY CONSTRUCTION

Lead-acid batteries can be broadly divided into two categories: the starting/lighting/ignition (SLI) type found in cars, trucks, and motorcycles; and the deep cycle type found in boats, golf carts, and forklifts. SLI batteries are designed to deliver maximum peak current, but they are not tolerant of being deeply discharged. In contrast, deep cycle batteries can tolerate deep discharge without damage, but they generally have a lower maximum "peak" current output than SLI batteries of similar size.

Regardless of type, every 12V lead-acid battery is constructed from six individual cells connected in series. Each cell produces about 2.108 volts at room temperature. This means that a 12V lead-acid battery actually produces about 6 x 2.108V = 12.65V at room temperature when it is fully charged. However, the cell voltage drops rapidly with temperature. At 0°F, the fully charged voltage is only 2.086V per cell and the output is around 6 x 2.086V = 12.52V. As we'll see later, a built-in temperature sensor allows the Battery Marvel to incorporate temperature into the appropriate internal calculations.

STATE OF CHARGE (SOC)

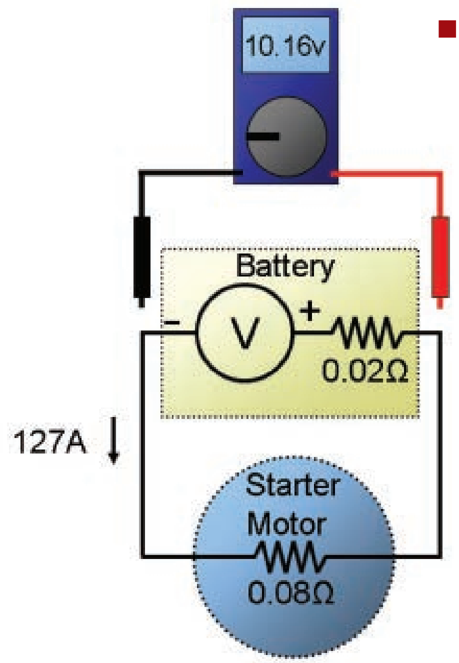
A very common measure of battery condition is "state of charge" or SOC. SOC is expressed as a percentage from 0% (fully discharged) to 100% (fully charged). The Battery Marvel continuously estimates SOC by measuring the no-load output voltage of the battery, the ambient temperature, and using a set of lookup tables in Flash memory. The Battery Marvel issues an alert if the estimated SOC drops below a minimum threshold.

Notice that a low SOC doesn't necessarily mean that a battery is bad. It might simply be low on charge because the headlights were left on or because the vehicle's charging system is not working, for example.

CAPACITY

An ideal battery has no internal resistance and is able to supply infinite current. That's a nice goal, of course, but it isn't achievable in the real world. All real batteries have some internal resistance and therefore an upper limit on the peak current they can supply.

To illustrate, let's assume that we have a 12V lead-acid battery with an internal resistance of 0.02 ohms. The peak current output of this battery is 12.65V/0.02 ohms = 633 amps. This is the current that would flow if a zero ohm load (a short circuit) was placed across the terminals. If the internal resistance of this battery increased by merely 0.01 ohms, the peak current output would drop to 12.65V/0.03 ohms = 422 amps. Thus, even a small change in a battery's internal resistance makes a big difference in the peak current output.



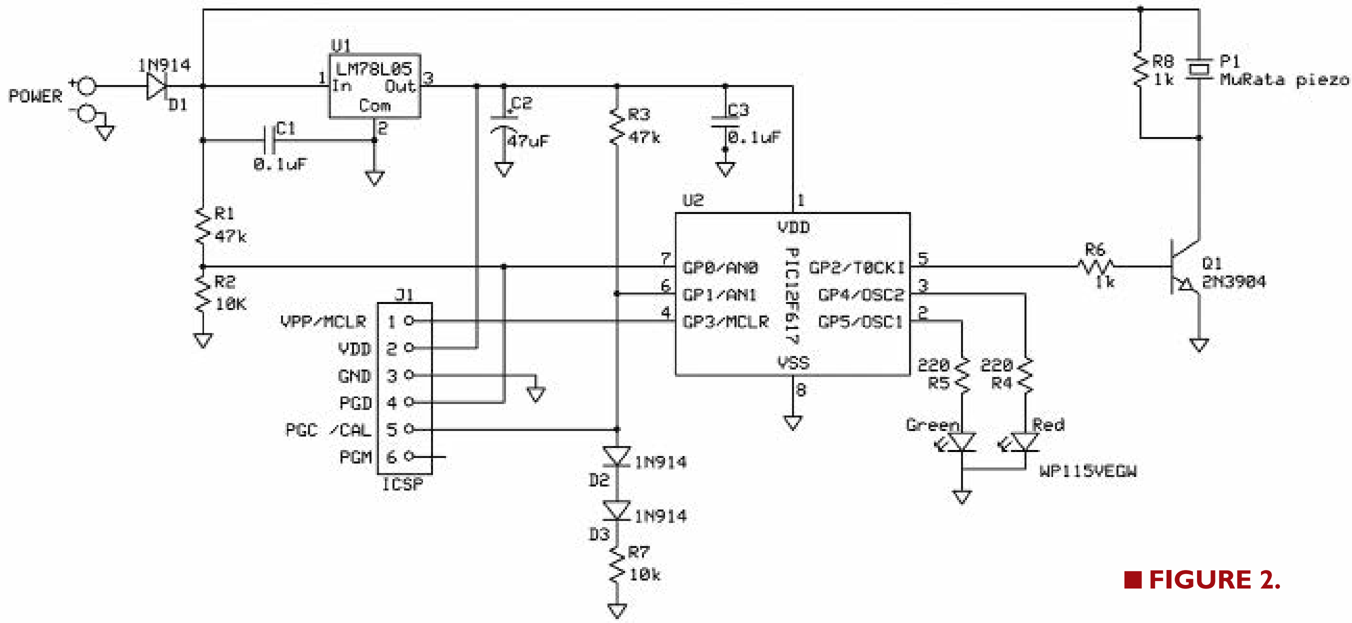
■ FIGURE 1.

CRANKING MATH

To continue with our discussion, let's assume that a particular automotive starter motor has a DC resistance of 0.08 ohms. We'd expect this starter motor to draw 12.65V / 0.08 ohms = 158 amps of peak current when it was connected to an "ideal" battery. Incidentally, it is interesting to point out here that the instantaneous current actually fluctuates rapidly, depending on the mechanical load on the starter motor at any instant — whether a winding is energized (and which one), whether a magnetic field is just starting to form, already established, or collapsing, and many other factors. The peak current and the average current through the motor are quite different, as well.

If we connected our starter motor described above to a battery with 0.02 ohms internal resistance, we'd have a 0.02 ohms + 0.08 ohms = 0.1 ohms total load which would draw 12.65V/0.1 ohms = 127 amps (peak). The minimum voltage measured across the starter motor (and also the battery posts, assuming the connecting cables have no resistance) would be 127 amps x 0.08 ohms = 10.16V. We can see that even with a fully charged, healthy battery capable of delivering 633 amps, the voltage across the battery terminals would drop to around 10.16V when the starter motor was engaged. This is illustrated in **Figure 1**.

As lead-acid batteries age, their internal resistance gradually increases. This is mainly due to a chemical build-up of hard lead sulfate crystals on the internal metal plates called "sulfation." The rate of sulfation increases as the battery's SOC drops, and it also increases with temperature. Poorly charged, hot batteries experience a



■ FIGURE 2.

much higher rate of sulfation than do fully charged cold batteries. Unfortunately, the effects of sulfation are cumulative and largely irreversible. The ever-increasing internal resistance gradually reduces the peak output of the battery, until it can no longer start the vehicle. This is how many lead-acid batteries die.

STATE OF HEALTH (SOH)

Let's assume that a certain battery has suffered some sulfation and its internal resistance has increased from 0.02 to 0.04 ohms. When the starter motor is engaged, the battery sees an effective load of 0.04 ohms + 0.08 ohms = 0.12 ohms. The current flow will be 12.65V / 0.12 ohms = 105 amps (peak). The voltage across the starter (and battery posts, assuming the cables have no resistance) drops as low as 105 amps x 0.08 ohms = 8.4V.

If a battery has good SOC and SOH, the voltage should remain above 9V when the vehicle is started at 70°F. If it doesn't, it could indicate that the battery may require some maintenance (such as adding water to one or more cells which may be low on electrolytes), or that the battery may need to be replaced.

Each time your vehicle is started, the Battery Marvel computes an SOH score (0 to 100%) based on the temperature, the SOC, and the voltage drop measured while your starter motor is engaged. A score of 100% means the battery is very healthy, i.e., there's very little drop in voltage and minimal internal resistance. A lower score is evidence of increased internal resistance and a reduced ability to deliver current. The Battery Marvel watches for deteriorating SOH and issues an alert if it becomes critical.

Complete kits are available from the *Nuts & Volts* Webstore at **http://store.nutsvolts.com**. Assembled and calibrated units are available at **www.batterymarvel.com**.

CHARGING SYSTEM

Once the engine starts, the alternator works to replenish the energy used by cranking. Modern alternators are designed to produce a varying AC voltage (linked to engine RPM) which is rectified to create an unregulated DC voltage. The unregulated DC voltage then goes to a linear voltage regulator which provides approximately 14.4V DC for powering the electrical and charging systems.

The regulated charging voltage can vary from about 13.5 to 14.8V DC, depending on the make and model of the vehicle, whether headlights or other accessories are on, SOC, and temperature. Some vehicles have a fixed-output voltage regulator while others are manually adjustable. Many newer vehicles feature a variable voltage regulator with built-in temperature compensation. This allows a higher charging voltage when the battery is cold, and a lower charging voltage when it is hot. The Battery Marvel continuously monitors your vehicle's charging system and issues an alert if any problems are detected.

SURFACE CHARGE

When the vehicle is switched off, you might expect the voltage across the battery terminals would immediately drop back to 12.65V once the engine stopped, but this is not the case. Instead, a residual "surface charge" slowly dissipates over a period of several minutes to several hours. Surface charge is due to a non-uniform concentration of ions in the electrolyte near the surface of the plates.

During charging, ions build up near the plates where the electrochemical reactions are taking place. When charging stops, the ions begin to slowly migrate away from the plates, seeking to establish a uniform concentration within the electrolyte. As the ions slowly diffuse throughout the electrolyte, the voltage gradually drops. The Battery Marvel monitors this process, and alerts you if the battery does not properly dissipate surface charge.

DESIGN AND THEORY OF OPERATION

The schematic in **Figure 2** shows the Battery Marvel is based around an eight-bit PIC12F617 (U2). The eight-pin PIC includes 2,048 14-bit words (3.5K bytes) of Flash memory, 128 bytes of RAM, and a 10-bit A/D converter. U2 is pre-programmed with software written entirely in assembly language.

Diode D1 provides reverse polarity protection in case the Battery Marvel's power and ground wires are accidentally connected "backwards." U1 — an LM78L05 linear voltage regulator — provides a stable, regulated +5V supply for U2, the temperature sensor, and the LED. This regulated supply also serves as a stable voltage reference for the U2's 10-bit A/D converter.

R1 and R2 form a simple voltage divider which scales the battery voltage down (minus the ~ 0.7V drop across D1) into a 0-5V range, suitable for the A/D converter. A typical fully charged battery voltage is 12.65V for a healthy battery which results in a scaled analog input of (12.65 – 0.7) x (10K / (10K+47K)) = 2.096V at U2's AN0 pin. J1 is a standard Microchip in-circuit serial programming (ICSP) connector, used for programming U2 "in place" on the PCB. It is not used for this project, since U2 is pre-programmed.

D2 and D3 form a very low cost ambient temperature sensor. The forward voltage drop across a silicon diode changes by roughly -2.2 mV per degree C. Here, two silicon diodes are connected in series to multiply this effect. Since our PIC has a 10-bit A/D converter with an analog input range of 0-5V, we calculate a best-case resolution of 5V/1024 = 4.8 mV. Our sensor won't win any awards for high accuracy, but it does report temperature within a few degrees and that's good enough for this application.

General-purpose NPN transistor Q1 drives P1, a piezoelectric transducer. In my initial prototype design, Q1 and R6 were not included and the piezo was instead driven directly from U2. We decided that P1 wasn't loud enough, so we added Q1 and R6 to ensure that the Battery Marvel could be heard over a vehicle's engine. The revised design generates a sound pressure level (SPL) of about 100 dB at one meter, which is extremely loud.

SOFTWARE OPERATION

The Battery Marvel's embedded software measures the battery voltage many times per second. It normalizes each voltage measurement, adjusts for ambient temperature, and takes different actions depending on the current operating state of the vehicle. See **Table 1**.

If any problems are discovered, the Battery Marvel issues an audible alert and updates the LED color as appropriate.

State	Action
Charging	Monitor vehicle charging system, charging voltage, and surface charge dissipation
Idle	Monitor SOC
Cranking	Monitor SOH

Table 1.

The software also performs many other functions such as diagnostics, calibration, optical data transmission, maintenance of historical and log data in Flash memory, and tracking the operating state of the vehicle.

CONSTRUCTION

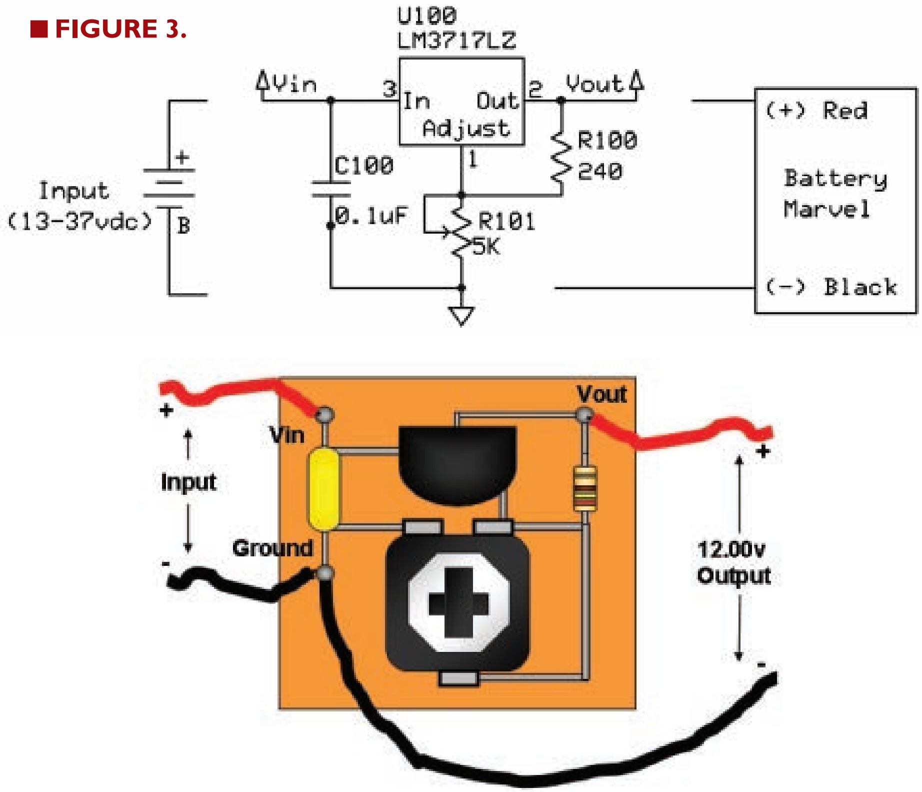
1. Begin by inserting/soldering the 1/8W resistors, R1-R8. It is important to make sure these parts lie fully flat against the PCB, as the piezo needs to mount over the top of them. The resistors are delicate — be careful not to overheat them when soldering.
2. Insert and solder diodes D1-D3. Observe the markings carefully, lining up the band on each diode with the mark on the PCB. The band on D1 goes toward the right, while the bands on D2 and D3 go toward the left. Make sure D2 and D3 lie fully flat against the PCB, since the piezo will be mounted over the top of them, as well.
3. Next, insert and solder bypass capacitors C1 and C3. These may be inserted in either direction.
4. Insert and solder U2 (the PIC12F617). The notch on the case should be toward the left.
5. Insert electrolytic capacitor C2. The negative lead goes toward the bottom of the PCB.
6. Now, insert and solder Q1, the 2N3904 NPN transistor. The flat side should be toward the left when the board is viewed from above. Q1 and U1 look almost identical, so check carefully!
7. Next, insert and solder U1, the LM78L05 voltage regulator, with the flat side toward the left.
8. Insert and solder the piezo transducer, P1. The PCB is designed so that it can be inserted in any orientation.
9. Insert LED1 with the flat side of the case toward the left. The top surface of the LED should be the same height as the piezo. If the LED is mounted too close to the PCB, the light output will be significantly reduced after it is installed in the case.
10. DO NOT power up the board yet, as there is a specific calibration procedure described in the next section.

CALIBRATION

The first time the Battery Marvel is powered up with 10V DC or more, it will attempt to calibrate itself. If you want to test it before calibrating, you can use a 9V transistor battery. It won't attempt to calibrate itself when powered by only 9V DC.

The accuracy of the calibration reference is critical to the proper operation of the Battery Marvel. If you don't

FIGURE 3.



be heard. This completes the calibration. The calibration data is stored in non-volatile Flash memory. You only need to calibrate once. The Battery Marvel is now ready to use.

To erase the calibration data/recalibrate, boot your kit with pins 3 and 4 of J1 (the center pins) temporarily connected. This erases the calibration data. Remove the jumper on pins 3 and 4 and calibrate as before by attaching your 12.00V DC source.

MECHANICAL

Once everything checks out, trim the stainless steel mesh and place it in the small recessed area in the case. Peel the backing from the self-adhesive Battery Marvel label and attach it to the front, fitting it carefully into the recessed area in the case.

Insert the wires through the holes in the case and solder them into place. Solder the red wire to the "+" connection on the PCB. Make sure the LED and the clear window in the label line up, then press the back of the case into place. We recommend that you wait before gluing the back — just in case. Tape the back in place temporary. Attach the Velcro to the back of the case.

have a 12.00V DC reference available (or a variable voltage source which can be adjusted to precisely 12.00V DC output), you may want to build one using the four extra components included with your kit. Build the circuit in **Figure 3** using the components as shown. Perfboard, breadboard, or wirewrap construction is fine.

Attach any 14-37V DC supply to the input and adjust R101 until Vout is exactly 12.00V DC. Two 9V batteries wired in series makes a good 18V input if you don't have a power supply.

Before calibrating, ensure the ambient temperature is as close to 70°F as possible. The Battery Marvel assumes during calibration that the ambient temperature is 70°F and will calibrate its temperature sensor accordingly.

Connect your completed Battery Marvel to the 12.00V DC reference source of your choice. It should make a "tick-tock" sound for 30 seconds, and the LED should alternately blink red/green. A brief alert will then

INSTALLATION

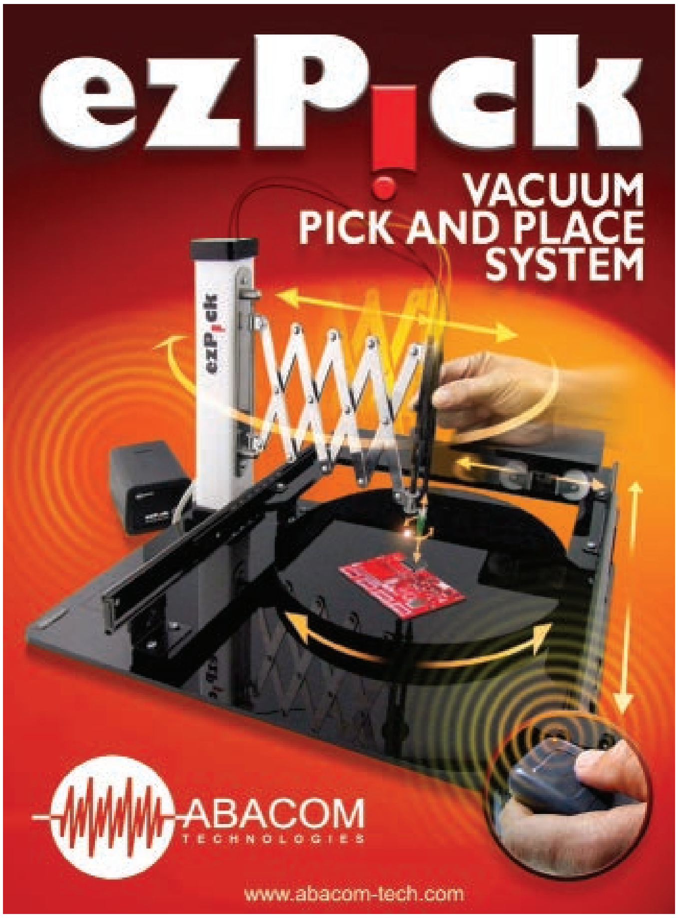
A good mounting location is right on the battery itself, though you can also mount the Battery Marvel in any other convenient location, including inside your vehicle. If you decide to mount it farther from the battery, use 14 gauge or larger wire so the voltage drop is minimized.

WRAP-UP

I hope you have as much fun building and using this kit as I had creating it! Your Battery Marvel should provide you with many years of trouble-free service. **NV**

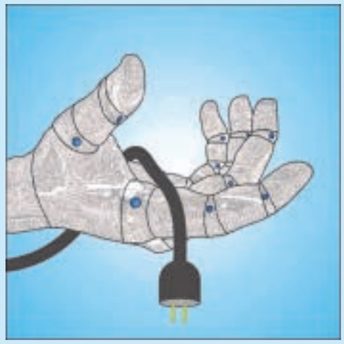
PARTS LIST

ITEM	QTY	DESCRIPTION	SUPPLIER	P/N
R1, R3	2	47K ohm resistor, 1/8W (yellow, violet, orange)	Mouser	299-47K-RC
R2, R7	2	10K ohm resistor, 1/8W (brown, black, orange)	Mouser	299-10K-RC
R4, R5	2	220 ohm resistor, 1/8W (red, red, brown)	Mouser	299-220-RC
R6, R8	2	1K ohm resistor, 1/8W (brown, black, red)	Mouser	299-1K-RC
C1, C3	2	0.1 µF bypass capacitor (10V or greater)	All Electronics	RM-104
C2	1	47 µF electrolytic capacitor (10V or greater)	Mouser	140-REA470M1ABK0511P
D1-D3	3	1N914 diode	Mouser	78-1N914
Q1	1	2N3904 NPN transistor	Mouser	610-2N3904
LED1	1	Bi-color (red/green) common cathode, T1 3 mm	Mouser	604-WP115VEGW
U1	1	LM78L05 5V voltage regulator	Mouser	512-LM7805ACZ
U2	1	Microchip PIC12F617 (programmed)	**batterymarvel.com**	PIC12F617



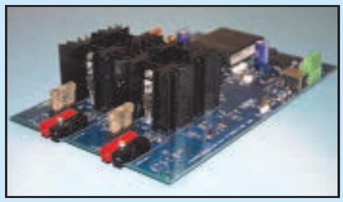
PowerBotix

Robotic Power System



www.powerbotix.com

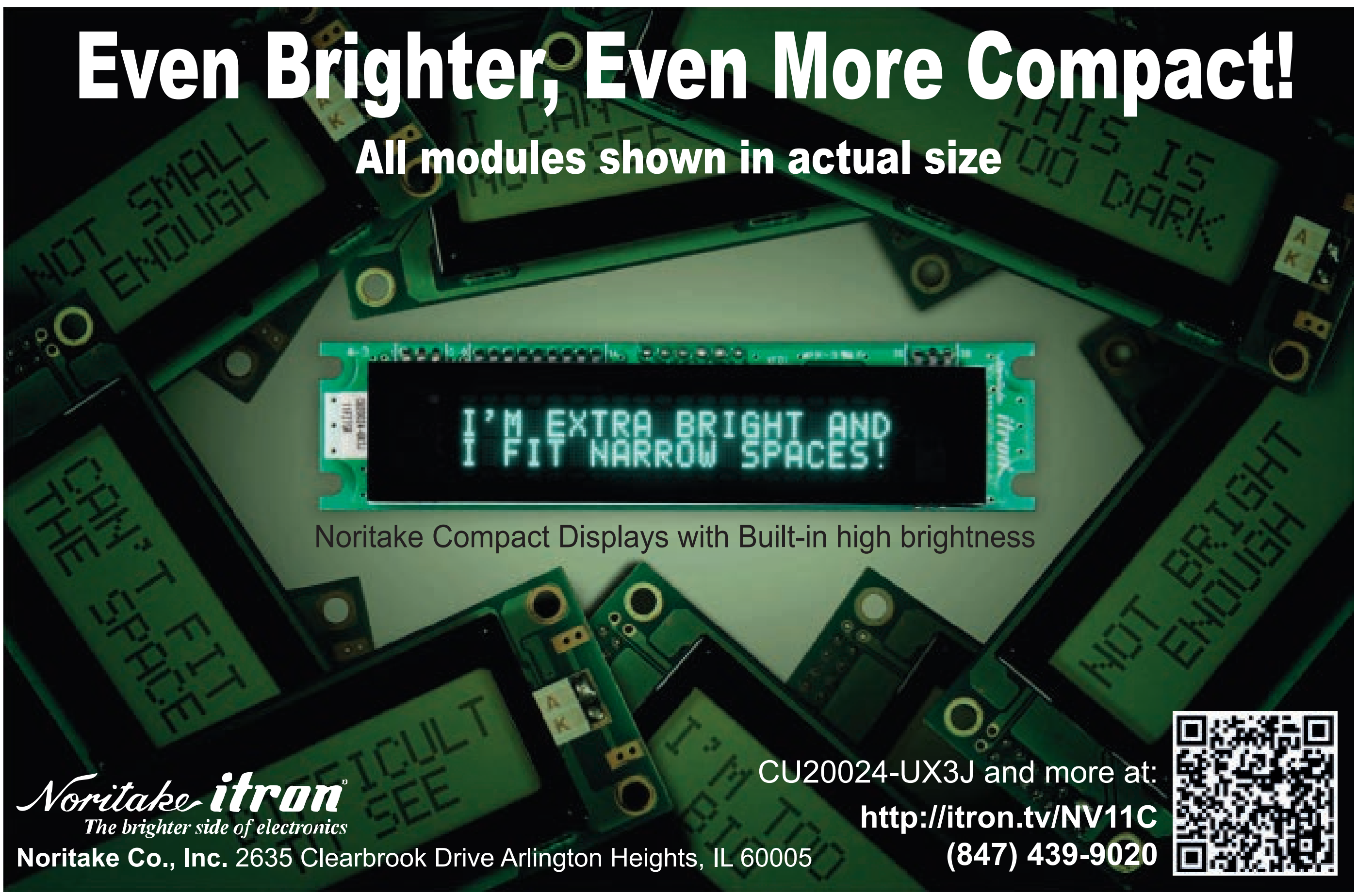
Let PowerBotix take the drudgery out of engineering your power systems.



PowerBotix is a brand of powerful robotics components designed to simplify robotic power supply systems for commercial and hobbyist applications alike. PowerBotix is off-the-shelf and a-la-carte which allows you to quickly configure a system that is right for your application.

PowerBotix makes use of an extraordinary design that incorporates two banks of batteries. This design allows the switching between battery banks without losing power to any of your systems. In effect, you have a hot-swappable battery system.

See more at www.powerbotix.com



Review

By Bryan Bergeron

www.nutsvolts.com/index.php?/magazine/article/november2011_Bergeron

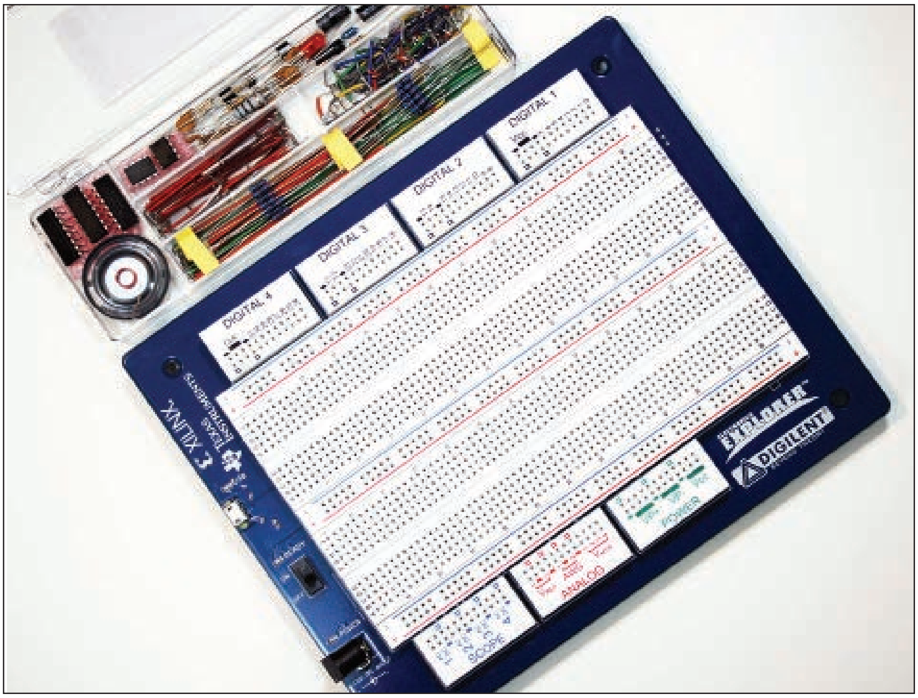
The Digilent Electronics Explorer

The Digilent Electronics Explorer Board — which I'll refer to as the EE Board — is marketed as an all-in-one analog circuit design station. With the addition of a laptop or desktop computer, I found this to be true. To determine if this solderless breadboard and virtual instrument suite is for you, read on.

If you're into low cost electronics experiments, you're familiar with breadboarding. Solderless breadboards enable anyone to insert wires and leaded components, test a circuit, and make rapid changes as necessary — all without damaging the components. Breadboards come in a variety of sizes, from a few square cm to page-size boards that can hold dozens of components. Some have built-in power supplies. Others can be powered readily with plug-in supplies, such as the Breadboard Power Supply 5V/3V from SparkFun ($10).

What sets the Digilent's EE Board apart from the pack is the programmable power supply and data I/O hardware combined with a formidable array of virtual instruments and controls. **Figure 1** shows the breadboard and component kit. For about $600 ($400 for teachers and $300 for students), you not only get a 6.5″ x 4″ solderless breadboard, but an impressive set of virtual instruments that are as powerful as they are easy to use. There's a virtual oscilloscope/spectrum analyzer, waveform generator, power supply, voltmeter, logic analyzer, digital pattern generator, and static input/output interface.

In case you're wondering, to qualify for academic pricing, you must be a student or employee at a qualifying academic institution, and use the board for academic purposes such as class work or research. See the website for more information.



Specifications

Highlights of the test and measurement specifications for each virtual instrument/test device are listed below. Refer to the user manual (downloadable from **www.digilentinc.com**) for more details.

- Oscilloscope/Spectrum Analyzer — Four-channel, 40 MSps (million samples/sec), AC/DC coupling, ± 20V input range. There's an FFT function and support for data capture and export.
- Waveform Generator — Two-channel, 4 MHz bandwidth, 10V output, with frequency sweep and AM/FM modulation.

FIGURE 1. The breadboard and component kit.

• Voltmeter — Four-channel, 200V max input, 1.2 mohm input impedance.
• Programmable Power Supply — Two supplies with ± 9V @ 1.5A and fixed 5V and 3.3V at 2A.
• Logic Analyzer — 32 channels.
• Digital Pattern Generator — 32 channels.
• Input/Output Panel — A panel of 32 virtual buttons, sliders, and other input/output devices.

Note that these specifications make certain assumptions on use. For example, the power supply is powered by a 12V @ 2A brick — for a total of 24W input. Clearly, if you maxed out the fixed and programmable power supplies, you'd have to provide 43W of power. That's not going to happen with a 24W brick. Similarly, the logic analyzer uses the same 32 channels as the digital pattern generator and input/output panel.

Hardware

The EE Board is deceptively simple when viewed from above, as in **Figure 1**. There's the main solderless breadboard flanked by seven miniature boards that connect to the power supply and virtual instruments. See **Figure 2** for a close-up of one of the miniature boards. There's also a USB connection, a power switch, and a jack for the 12V @ 2A input from the power supply brick. A USB cable is supplied with the kit.

The underside of the board is where the action is, as shown in **Figure 3**. The big chip is a TI Xilinx Spartan FPGA, shown in detail in **Figure 4**. Check out **www.xilinx.com** if you want to learn about this FPGA processor. To take the photo, I removed the protective plastic shield from the bottom of the board. The shield is a good idea, given that it's likely a wandering screwdriver or pair of pliers will eventually find their way under the board.

The board is supported by four 1-1/4" metal standoffs. I found these loosened with use, primarily because the screws used to hold them in place are too short. However, the screws are easily replaced. In addition, I found the legs enable the board to slide effortlessly on my Formica tabletop. Mount the board on a plastic or wood cutting board for a more stable work platform.

The kit ships with a modest assortment of parts, including about a dozen resistors and capacitors, a handful of ICs, transistors, diodes, LEDs, speaker, and about 140 jumper wires. That should be more than enough to get you started. When you're ready for more, you can purchase an advanced parts kit for $39. There are numerous alternative suppliers of jumper wires, and leaded components are commodity items.

Software

I tested the system with Windows 7, running on both a 3 GHz PC with 4 GB of RAM and Parallels on a Macintosh Tower. Both installations performed flawlessly.

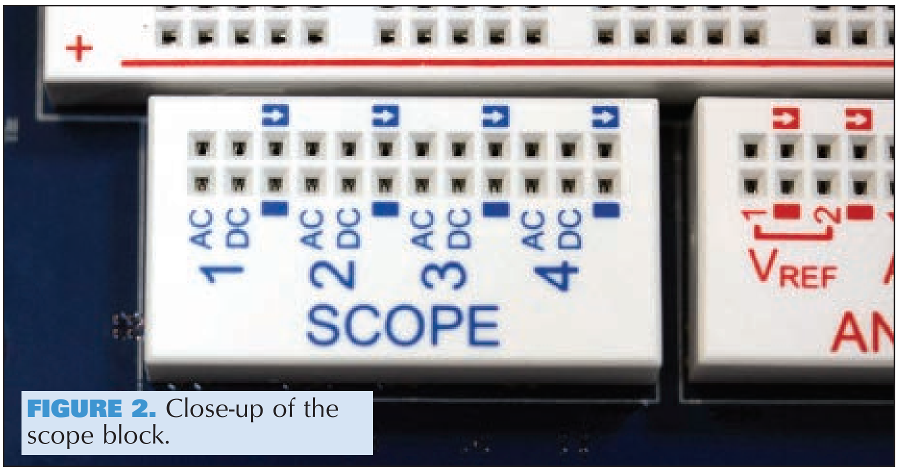


FIGURE 2. Close-up of the scope block.

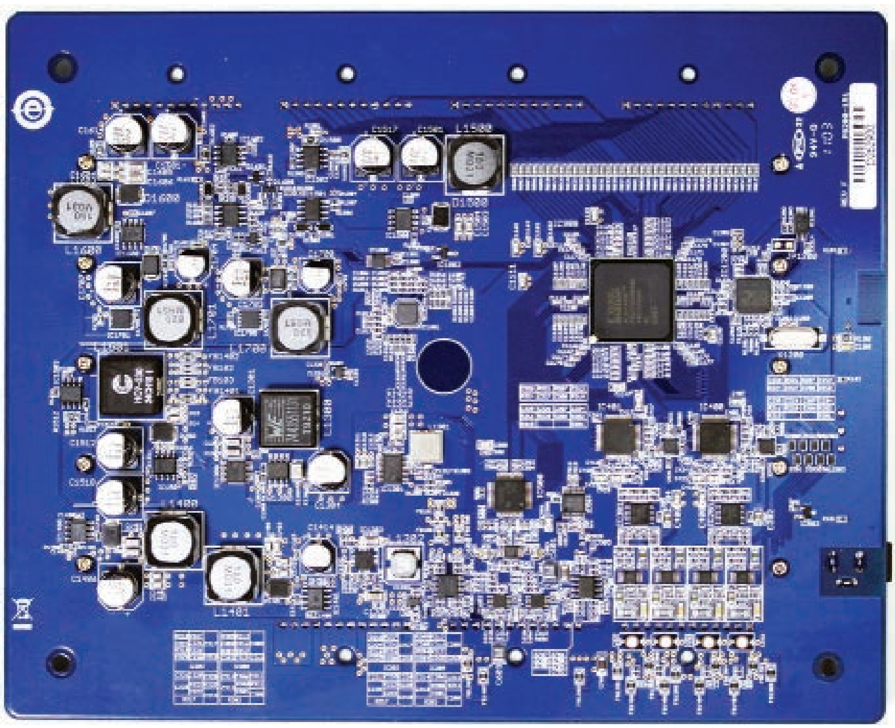


FIGURE 3. Underside of the Electronics Explorer board.

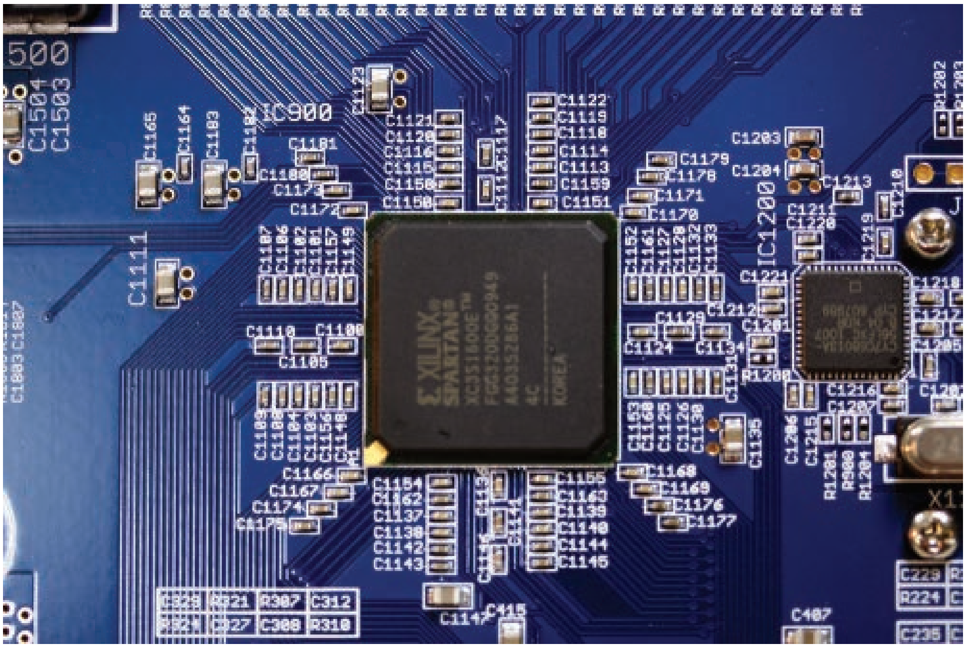


FIGURE 4. TI Xilinx Spartan FPGA processor.

Over several hours of testing, I didn't experience a single crash.

Figure 5 shows the general flavor of the user interface. It's clean, colorful, and easy to navigate. At the lower right of the screen is the main menu, where you can select the oscilloscope or other virtual instrument. Behind the menu is the input/output panel which I configured from top to bottom with a seven-segment display, a couple sliders, and binary output indicators.

In the upper left of the figure is the programmable power supply and voltmeter. The voltmeter is virtually hidden in the upper right corner of the panel, leaving most of the screen real estate to the power supply. Note the sliders for both voltage and current output.

At the lower left of the figure is the waveform generator. I have it set for a 3.3 Vpp, 2 kHz sine wave, with no offset. You can see the sliders that allow you to easily change amplitude, frequency, offset, and other properties.

In the upper left of the figure is the oscilloscope — easily the most impressive of the virtual instruments. I used a piezo transducer to create the impulse shown in the figure. You can see that the voltage swing is from -12V to 20V — the upper limit of the display. Sliders enable you to easily adjust time, offset, and voltage range. Everything is color coded for clarity.

Figure 6 shows the spectral analysis of the waveform from the piezo transducer. As you can see, the software enables you to specify the window of activity in the oscilloscope that should be analyzed spectrally. Not shown in the figures are the logic analyzer and pattern generator applications.

Evaluation

There are several ways to evaluate this hardware/software system. For example, I could focus on the power supply and examine the ripple, noise rejection, accuracy of tracking, and other technical parameters. Instead, I'd like to focus on the suitability of the kit for the intended purpose. In short, I found the combination of the EE Board hardware and Waveforms software a powerful learning platform for anyone experimenting with analog circuits.

Using my recently calibrated Fluke 45 DMM, a Tektronix 2022D dual-trace digital oscilloscope, and a B&K signal generator, I found the virtual analog and digital input and output devices sufficiently accurate for the intended task. Sure, the volt meters varied by a few tenths of a volt here and there, and there appeared to be a slight falloff in response of the oscilloscope above about 3 MHz, but nothing significant.

To be fair, I didn't take the

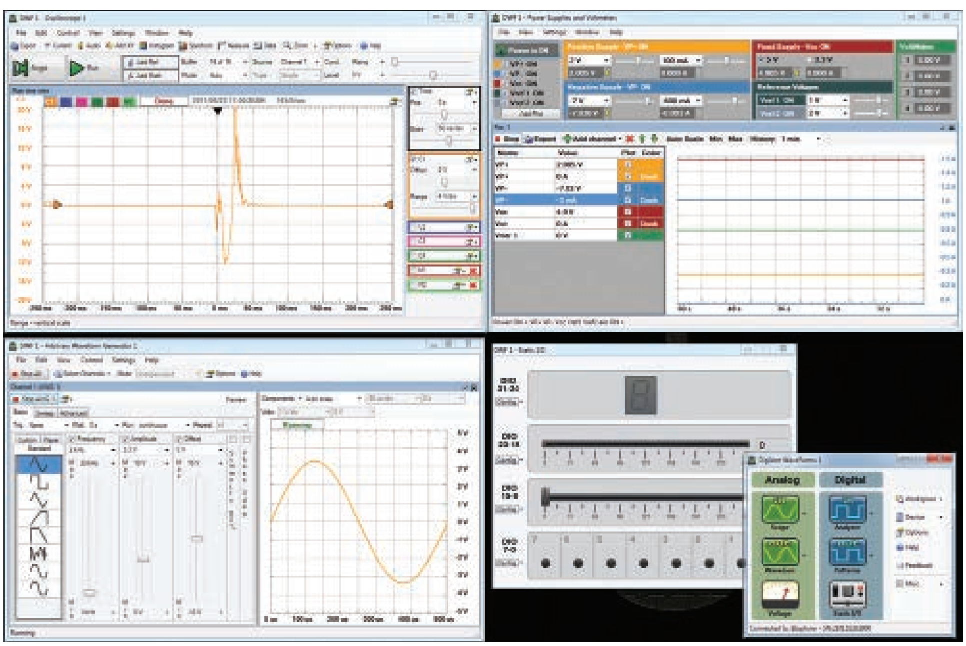


FIGURE 5. Clockwise from top left: Virtual oscilloscope, power supply/voltmeter, waveform generator, and digital I/O configuration panel.

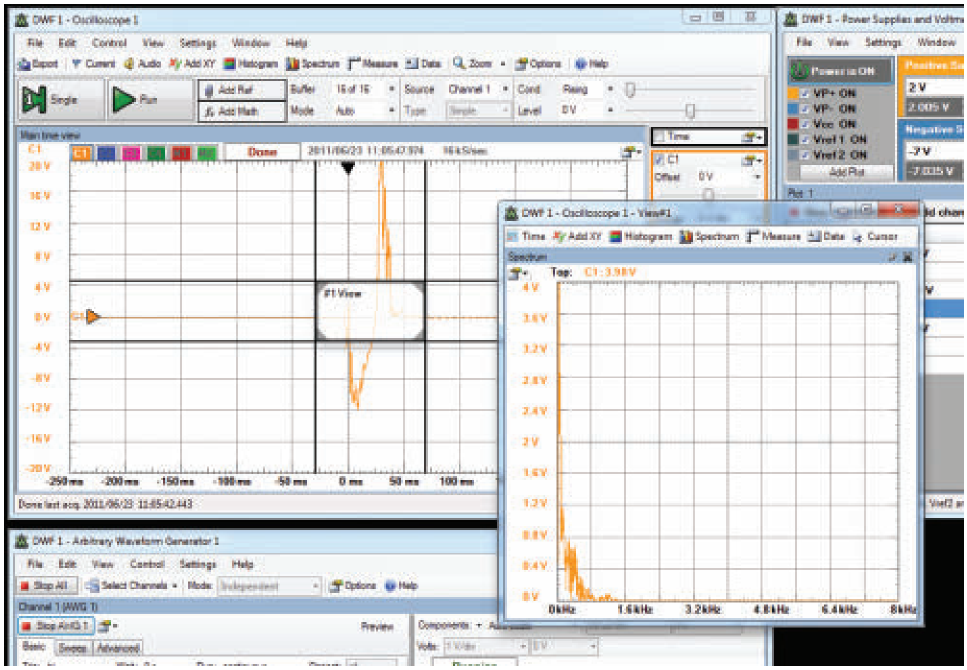


FIGURE 6. Spectral analysis window of the virtual oscilloscope.

time to calibrate the system — a procedure that's explained in the manual.

For the price, the software alone is an impressive value. I own several suites of virtual instruments, and this WaveForms suite is by far the easiest to use. Go to the website and download the software. You'll find installation painless. You can use the software in demo mode without the board.

Documentation is available in a help file as well as pop-up, context-sensitive balloons. The online documentation will get you started on circuit design, and any good reference book should help get you to the next level.

Final Note

The strength of the EE Board — an all-in-one, self-contained learning center for electronics — is also its greatest limitation. I'd be willing to pay, say, $20 more, for a few output posts for the power supply, and a pair of BNC connectors for standard scope and data probes. Given the utility of the Waveforms virtual instruments, I'd like to have them available for my workbench to use with circuits not constructed on the board. It would be a simple matter to create a series of binding post shields for the input/output blocks.

Another limitation is the lack of traditional probes in general. I'd like the ability to move a test probe around a circuit to take spot measurements. Moving a jumper wire to get a new reading can be painfully slow. That said, for someone new to electronics and measurement, a stable, verifiable connection to a meter or signal generator might be a good thing.

Finally, this kit isn't a curriculum on circuit design — it's a platform upon which you can follow just about any curriculum you or your instructor can imagine. Once you've made it through the four or five example circuits, you're on your own. If you're using this as part of your class, then curriculum isn't an issue. If, however, you're going it alone or with a small, self-directed group, then you'll need to get your hands on a good introductory book of electronics, such as the *Getting Started in Electronics* by Forrest Mims III. **NV**

PBP3
PICBASIC PRO™ Compiler

Experimenter - $49.95
Silver Edition - $119.95
Gold Edition - $269.95

The industry-standard BASIC compiler for Microchip PIC® microcontrollers.

Multi-Seat Licensing
for Educational Institutions

Upgrade from
PICBASIC™ Compiler (PBC)

Download a FREE trial version now.
www.PBP3.com

microEngineering Labs, Inc. ***www.melabs.com*** ***888-316-1753***

PICBASIC and PICBASIC PRO are trademarks of Microchip Technology Inc. in the USA and other countries. PIC is a registered trademark of Microchip Technology Inc. in the USA and other countries.

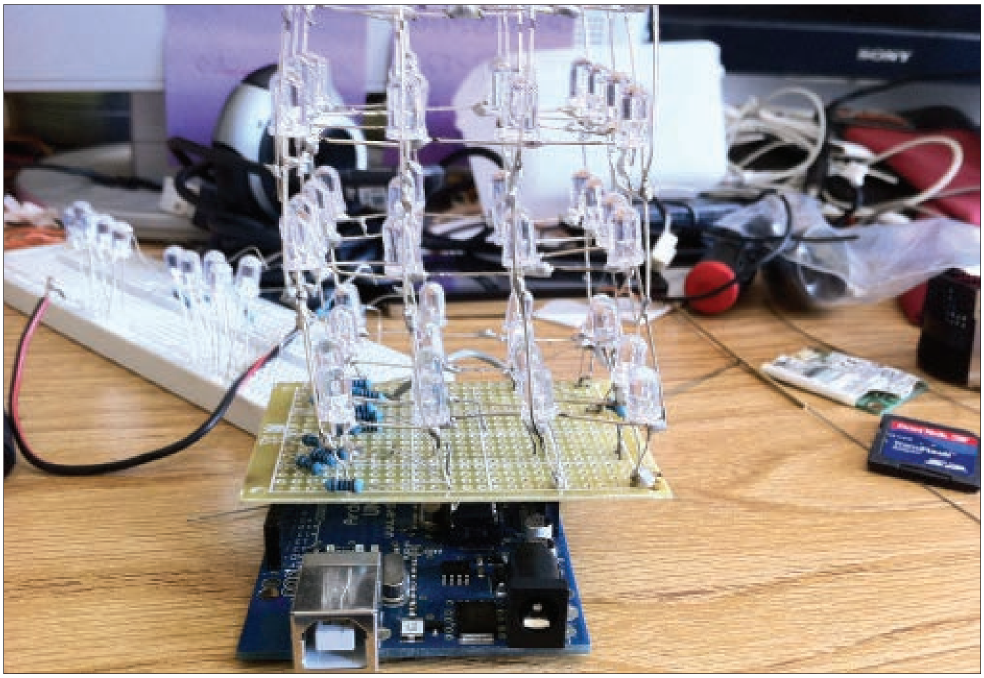
LED Madness Contest Winner Details

Nuts & Volts recently hosted a contest on Facebook in which participants uploaded videos of their best LED projects and the public voted for who they liked the best. Prizes were awarded for the top three winners. These included the grand prize which was a 3D LED Matrix Cube kit (valued at $59.95); second prize which was a magazine CD-ROM (valued at $24.95); and third prize which was a *Nuts & Volts* hat (valued at $14.59). You'll find descriptions of our top winners here. Be sure to check out the *Nuts & Volts* Facebook page for upcoming contests! You might just find yourself in print too!

1st Place: My Little Cube Creation *Michael Uylaki*

I came up with this idea because my son had an LED sword and had broken the plastic, and he was very upset about it. So, I decided to cut some Plexiglass into squares, and then I super-glued three of the squares together. I left one side open so I could put the LEDs in. With the last Plexiglass piece, I drilled a small hole out of it so there would be access to press the button to turn it on and off. I took the LED sword apart, and super-glued the battery compartment down on the Plexiglass that was left over. I then took the light string and stuffed it into the three squares that were previously glued together. I attached the last piece on and then I cut out duct tape to make the design on the square. It's a really easy build and only took about a half hour to build. Unfortunately, my kids broke it within a day of me making it, but you can view the video at **www.youtube.com/watch?v=kmfsm746fR8**.

2nd Place: LED Cube With Arduino *Josue Rojas*



I built this for fun and to improve my ability to solder — it involves a lot of soldering.

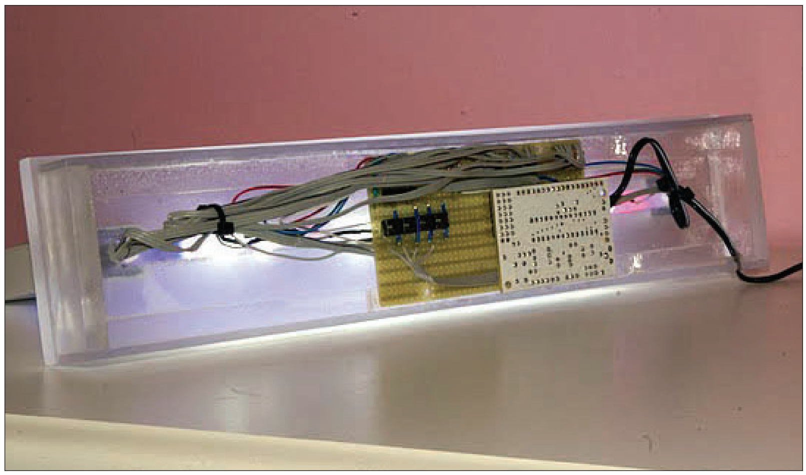
I also built it because it was very mesmerizing. There's a guide you can follow at **www.instructables.com/id/The-4x4x4-LED-cube-Arduino/?ALLSTEPS**. Instead of wood, I used cardboard with the dotted pictured pasted on it, then I just cut out the holes.

Parts List:
64 LEDs (I used white 5 mm LEDs); piece of cardboard; 16 100 ohm resistors; printed circuit board, soldering iron, and solder.

3rd Place: Ruby's Night Light
Troy Hartwig

I am a mechanical engineer and this was my first forray into an electronics project. I am the father of three young girls and don't find a lot of time for building, but I have been looking for a project that they might enjoy with the end project being to encourage them to get into building. I have been inspired by numerous articles in *Nuts & Volts* and *Make Magazine* to construct something with an Arduino. I was particularly inspired by Gene Scogin's article in *Make* Vol. 13 for an analog clock.

While I was working on a modified version, my youngest daughter started having trouble waking up early in the mornings, and since she couldn't read a clock (too young to tell time plus poor vision) she would call for her parents to find out if it was time to get up. After waking up enough to summon us, she would often have a hard time getting back to sleep. After responding to a number of these 2:00 am calls, I decided it was time for an engineering intervention. I had the idea that a color changing nightlight could help her know immediately what time it was — even through blurry eyes — so that she could confidently go back to sleep knowing she wasn't missing the fun of a new day.



I started with Scogin's code and added some code that converted HSV color values to RGB values. Since the Arduino's PWM output channels can provide enough current to power five LEDs, I used a simple transistor circuit to drive them. (I sill used the Arduino's onboard voltage regulator for power.) The transistors and LED current-limiting resistors were mounted on a perfboard with a header to connect to the Arduino (specifically, a Bare Bone Board variant).

I had been looking for an excuse to use Ponoko to make something, and this was my opportunity. I wanted to keep the design simple — but personal to my daughter — so I used Inkscape to lay out her name, and had Ponoko laser cut it in clear acrylic. I drilled holes around the perimeter to mount the LEDs, and frosted the plastic by sanding it. I used square acrylic tubing to make a border to cover the LEDs and wiring, and built the base to hold the microcontroller (out of acrylic also). I had hoped the discrete LEDs would blend better, but the border wasn't big enough, so you can still easily discern the individual colors around the edge.

I have started working on a modified version for my second daughter, and it will utilize tri-color LEDs in a single package with more border for better blending. I might try just etching the name instead of cutting it through.

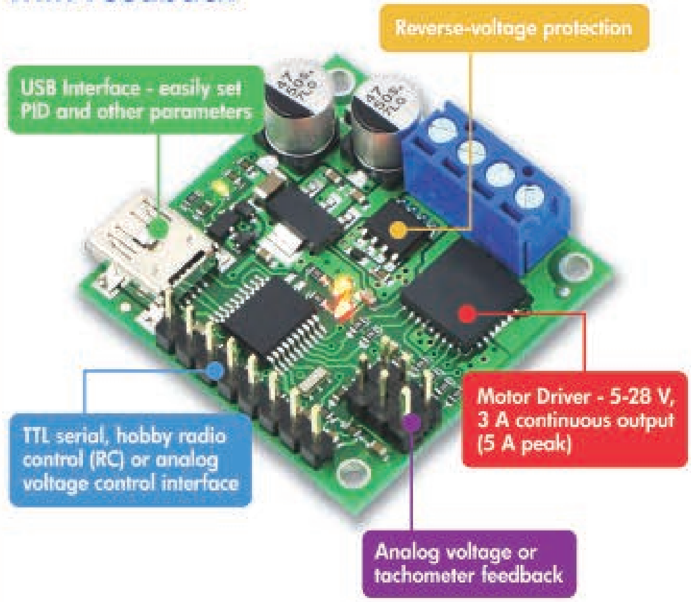

THE ORIGINAL SINCE 1994
PCB-POOL®
Beta LAYOUT
Europe's leading prototype supplier now also in America
Order direct from our US facility!
PCB-POOL RULES!
DAS ORIGINAL SEIT 1994
PCB-POOL®
Beta LAYOUT
order!
PCBs 1-6 layers
free!
Free Stencil
fast!
8 hour service
NEW!
cool!
Aluminium-Core IMS PCBs
Beta LAYOUT
www.pcb-pool.com
email : sales@beta-layout.us
Toll Free USA : 888-977-7443
All registered brands remain the registered trademarks of the respective manufacturer !
p-cad 2006
Altium Designer
EDWin
cadence
GraphiCode
PROTEUS
NATIONAL INSTRUMENTS
RS-274-X
Easy-PC
Sprint Layout
PULSONIX
www.pcb-pool.com
Beta LAYOUT

DIY Projects:

Wild Thumper-Based Robot

Motor Controllers:

Item #1392: Jrk 21v3 USB Motor Controller with Feedback



Sensors:

Orientation, Reflectance and More

Custom Laser Cutting:

Design Your Own Chassis

Finding the right parts for your robot can be difficult, but you also don't want to spend all your time reinventing the wheel (or motor controller). That's where we come in: Pololu has the unique products - from actuators to wireless modules - that can help you take your robot from idea to reality.

Pololu
Engage Your Brain

Find these products and more at **www.pololu.com** by Joe Pardue

Digital I/O — Part 2

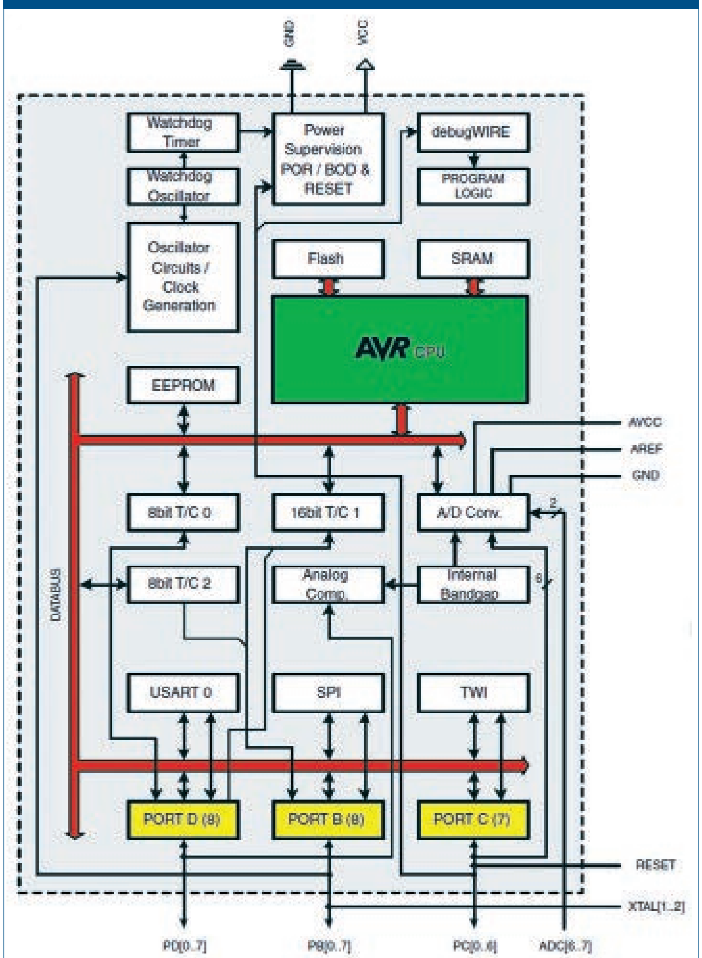
Follow along with this series! Joe's book & kits are available at www.nutsvolts.com

Recap

Last month in Part 1, we started looking at digital I/O (Input/Output). We got our toes wet with a library to provide Arduino-like elementary functions, and then jumped into the deep end looking at the I/O pin's electrical characteristics. You might have found that my switching from relatively simple software to some fairly complex AVR hardware architecture caused a bit of technical whiplash, but I haven't yet figured out a way to discuss both the AVR hardware architecture and the hardware independent C software without floundering around a bit. You really need to know both to use either, but the connection is kind of fuzzy. This month, we are going to jump off the high board into both hardware and software by confronting the AVR digital I/O peripheral registers and learning how to manipulate them in software.

Let's approach this by first looking at the hardware, then move on to some additions to our elementary digitalio functions that we'll apply to reading an eight-bit DIP switch and writing to eight LEDs using the Butterfly and the Arduino board (used with AVRStudio 4 and the avrtoolbox\libavr\elementary library instead of the Arduino IDE and library). Finally, we'll apply all that to yet another chaser lights program.

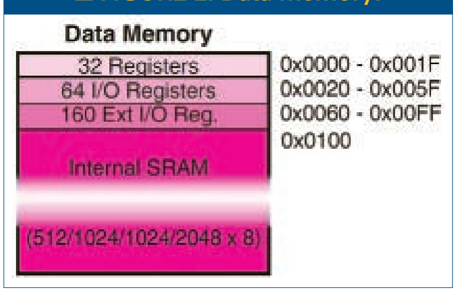
■ FIGURE 1. AVR hardware block diagram.



Digital I/O is Memory Mapped

We had an extended discussion of AVR memory architecture and C programming in Smiley's Workshops 23 through 27 (June through October 2010). We learned that the AVR has two main memory spaces — data and program — in different physical locations. One of the things we didn't go into then is that the AVR hardware peripherals are mapped into the data memory. This means that peripherals like timers/counters, ADC, PWM, etc., are viewed by the AVR core as being memory locations to set up the functionality and read the results. Likewise for digital input and output, the AVR core sees input and output ports and pins as just bytes and bits in data memory locations to be written to or read from. We can get a better view of this in **Figure 1** which shows the AVR core in green, the main data bus in red, and the digital I/O ports in yellow.

■ FIGURE 2. Data memory.



0x0E (0x2E)	Reserved	–	–	–	–	–	–	–	–
0x0D (0x2D)	Reserved	–	–	–	–	–	–	–	–
0x0C (0x2C)	Reserved	–	–	–	–	–	–	–	–
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0
0x08 (0x28)	PORTC	–	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0
0x07 (0x27)	DDRC	–	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0
0x06 (0x26)	PINC	–	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
0x02 (0x22)	Reserved	–	–	–	–	–	–	–	–
0x01 (0x21)	Reserved	–	–	–	–	–	–	–	–
0x0 (0x20)	Reserved	–	–	–	–	–	–	–	–

■ FIGURE 3. PORT, PIN, and DDR memory map.

The data memory space is shown in **Figure 2** and consists of the 32 lowest bytes used for general-purpose processor working registers, then the next 64 bytes used as I/O registers, followed by 160 bytes of extended I/O registers, and then finally beginning at address 0x0100 (decimal 256), the SRAM. The digital I/O is mapped into the 64-byte registers section as shown in **Figure 3**.

Digital I/O is Based on Registers

These digital I/O registers are eight-bit bytes. Any bit within that byte (which to the outside world is an I/O pin) can be individually addressed without affecting any other bit/pin in the byte/port. This is an important concept since it allows us to have one port pin set as an input and another set as an output, with the ability to change either without affecting the other.

So, how does this work? **Figure 4** provides some visual clues. Each port has three registers associated with it. A data direction register, DDRx, will — as the name suggests — set the direction of the port to input or output. There's a PORTx register you use to write data to that is then output on the port pins. A very poorly named register, PINx, lets you input data from the port pins. Why do I say it is poorly named? Because it is a full eight-bit byte-sized representation of the port input and isn't restricted to a single pin as the name may imply. They might have named these with out and in — POUTx and PINx — to be less confusing, but folks would laugh at POUT and still confuse PIN with pin. Maybe PORTOUTx and PORTINx would have been clearer (but who wants to type that much).

This is one of those weird things that you just have to get used to and memorize — that you write to the eight bits as PORTx and you read the eight bits as PINx. If you want to actually look at any one pin of a port, then depending on whether you are reading or writing (based on the DDRx setting for the pin), you have to use the bitwise operators to do that single pin reading and writing. Since this invariably bites novices, let me repeat: **You write eight-bit output to PORTx and you read eight-bit input from PINx.**

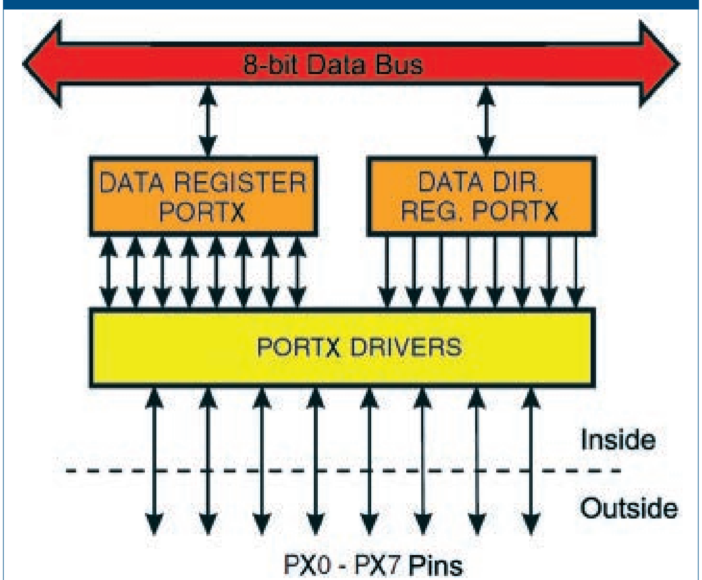
Now, memorize this: **Writing a 1 to a DDRx bit sets the port pin for that bit to output. Writing a 0 to a DDRx bit sets the port pin for that bit to input. So, 1 = output; 0 = input.**

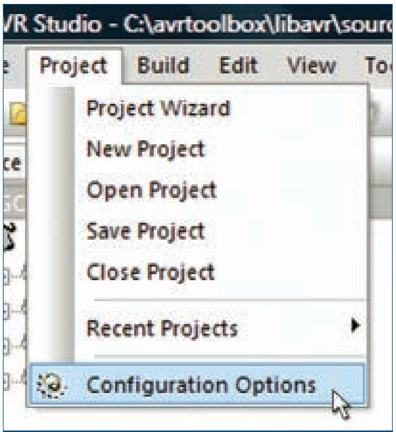
Avrlibc Input Output Header Files

Among the many goodies supplied by avrlibc is a header file that allows you to use convenient #define constants for the registers and bits associated with the ports and pins. The Arduino-like simplification that we learned last month in Workshop 39 provides a layer of code that is great for doing 'simple.' If you want to get a little deeper with real C, then having the io.h constants helps keep things sort of simple without having to get right down to the actual register names.

When you compile a file in AVRStudio, you first select the AVR device in the projects options as shown in **Figures 5** and **6** where we select the atmega328p. This selection is used by AVRStudio to generate a makefile that is used by the version of gcc supplied by WinAVR to

■ FIGURE 4. Port I/O module.





■ FIGURE 5. Project options.

compile and link the text into your executable .hex file.

The line inserted in the makefile is: MCU = atmega328p. This is used under the hood to find the correct header file information to compile and link for that device. If you use a variety of AVRs, you will eventually run into the problem of register or pin naming inconsistencies such that, for example, one device calls pin 0 on port A PA0 while on another device it is called PORTA0.

What they say in io.h is:

```
Included are definitions of the IO register set
and their respective bit values as specified in
the Atmel documentation. Note that
inconsistencies in naming conventions, so even
identical functions sometimes get different
names on different devices
```

What they mean is that nobody was paying attention when the various datasheet writers needed a violent shaking. If you try to move some code that works on one AVR device to another AVR but you get errors or warnings that indicate you are using the wrong register names, this is probably where it comes from and is just another AVR datasheet thing to get used to.

For the ATmega328p, we see that the io.h leads the compiler to iom328p.h. For Port B, you see:

```
#define PINB _SFR_IO8(0x03)
#define PINB0 0
#define PINB1 1
#define PINB2 2
#define PINB3 3
#define PINB4 4
#define PINB5 5
#define PINB6 6
#define PINB7 7

#define DDRB _SFR_IO8(0x04)
#define DDB0 0
#define DDB1 1
#define DDB2 2
#define DDB3 3
#define DDB4 4
#define DDB5 5
#define DDB6 6
#define DDB7 7

#define PORTB _SFR_IO8(0x05)
#define PORTB0 0
#define PORTB1 1
#define PORTB2 2
#define PORTB3 3
#define PORTB4 4
#define PORTB5 5
#define PORTB6 6
#define PORTB7 7
```

The first line of these three sets of #defines name the actual register that you will be using for the pin input, data direction, and port output, respectively. In the datasheet, the Registry Summary (as shown in **Figure 3**) shows these register and pin names in low memory.

A Little Weirdness

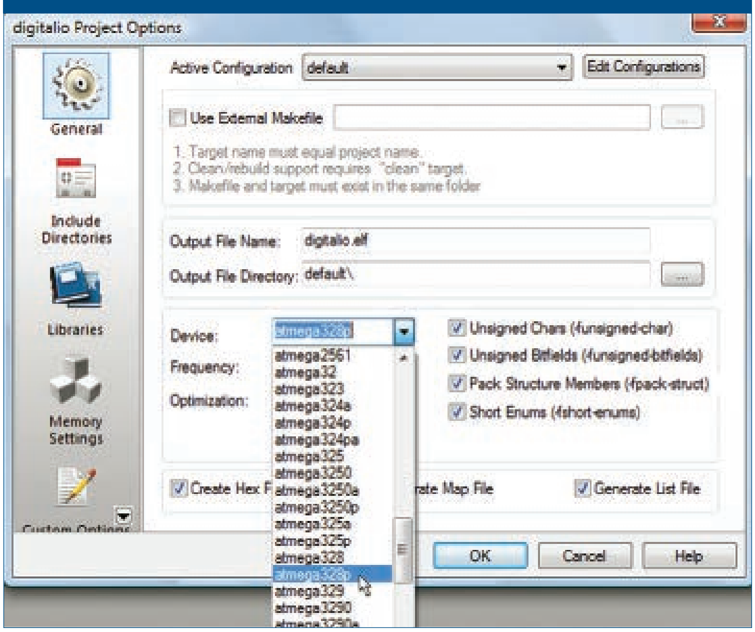
Activate Pull-up and Toggle a Pin

There are two operations that you do with the digital I/O registers that don't make much intuitive sense. First, in order to activate a pull-up resistor on an input pin you write a 1 to that pin. Second, in order to toggle an output pin on the PORTx register you write a 1 to the PINx — the input register. My first response to this was 'wait a cotton pickin minute ... write to an input, what's with that?' However, this bit of weirdness is a clever yet confusing way to avoid having to have another register.

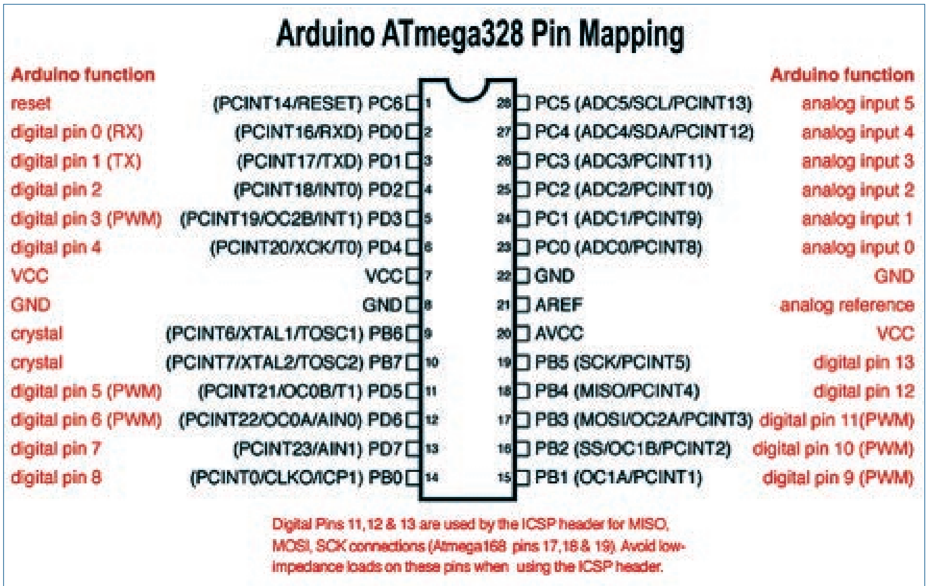
Since writing to an input doesn't make sense, we can then use that nonsense operation to accomplish two different things: either set a pull-up or toggle a bit. If DDRx for the pin is 1 (input), it sets the pull-up; if 0 (output), it toggles the pin state. I've always used the XOR (^) bitwise operator to toggle a bit, but this takes several cycles while writing to the input PINx bit does it as a single atomic operation — an important consideration if you want to toggle a pin at the maximum rate.

Even Atmel must have realized that this is unnecessarily complex because in their Xmega series, they have separate and appropriately named registers for these operations. Since this is so non-intuitive, it becomes a really good item to show off your AVR

■ FIGURE 6. Select device.



chops. If you want to take a more humane and neuron-saving approach, then use macros with sensible names. We will take the latter approach and write the macros port_pin_activate_pullup(), port_pin_deactivate_pullup(), and port_pin_toggle() that we will discuss below.



■ FIGURE 7. Arduino ATmega328 pin mapping.

Switching Between Input and Output

It is possible to get problematic intermediate states when changing between certain states:

- From tri-state to output HIGH.
- From input with pull-up to output LOW.

We will take care of this in the digitalio pin_mode() macro which will always deactivate the pull-up and set the output to 0 before setting the data direction to output.

Setting a Pin to Tri-state

This is only odd because it indicates that there is a third state for a binary system which — by definition — only has two states. Tri-state is considered a third state for a pin; the first two being HIGH (Vcc) or LOW (GND). Tri-state means that the pin is disconnected from the voltage and can be considered no longer in the circuit to which it is attached. When the AVR system is reset, the digital I/O pins are in the tri-state condition.

Warning Arduino Pin 13 is Funky

While we are cataloging funkiness, let's not forget to mention that digital I/O is a bit off on the Arduino pin 13 which is attached to an LED and resistor. This doesn't have much effect if you want to use it as an output pin, but it does if you use it for input. If you activate the internal pull-up, then the high voltage will be about 1.7V rather than the expected 5V. The Arduino reference states "If you must use pin 13 as a digital input, use an external pull-down resistor."

Expanding the avrtoolbox Digitalio Library

Now that we have a good idea about the underlying AVR digital I/O architecture, let's expand our avrtoolbox libavr digitalio toolset to include some more useful functions and macros. We'll demonstrate this with a chaser light application that reads the digital input from an eight-bit DIP switch and writes the digital output to eight LEDs configured as shown in the figures from last month's workshop, except that now we will be using ports rather than the Arduino style pins.

Expanded Digitalio Functional Requirements Specification

The digitalio toolset will provide functions or macros to do the following:

- Set a port pin mode to input or output.
- Read a port pin.
- Set a port pin.
- Clear a port pin.
- Activate a port pin pull-up resistor.
- Deactivate a port pin pull-up resistor.
- Toggle a port pin.

Expanded Digitalio Application Programmer's Interface

port_pin_mode()

Description: Set a port pin mode to input or output.
Syntax: port_pin_mode(uint8_t PORTx, uint8_t pin, uint8_t mode)
Parameters:
uint8_t PORTx: The port as identified in io.h.
uint8_t pin: The pin number 0 to 7.
Uint8_t mode: Either INPUT or OUTPUT.
Returns: Nothing.
Example:
// Set PORTB pin 4 to output
port_pin_mode(PORTB, 7, OUTPUT);

port_pin_read()

Description: Reads the state of a pin in a port.
Syntax: port_pin_read(uint8_t PORTx, uint8_t pin)
Parameters:
uint8_t PORTx: The port as identified in io.h.
uint8_t pin: The pin number 0 to 7.
Returns: HIGH, LOW.
Example:
// Get the pin state

myPinState = port_pin_read(myPort, myPin);

port_pin_set()

Description: Sets a pin in a port to 1.

Syntax: port_pin_set(uint8_t PORTx, uint8_t pin)

Parameters:

uint8_t PORTx: The port as identified in io.h.

uint8_t pin: The pin number 0 to 7.

Returns: Nothing.

Example:

```
// if myPin is clear, set  myOtherPin
if (port_pin_read(myPort, myPin) )
port_pin_set(myPort, myOtherPin);
```

port_pin_clear()

Description: Clears a pin in a port to 0.

Syntax: port_pin_clear(uint8_t PORTx, uint8_t pin)

Parameters:

uint8_t PORTx: The port as identified in io.h.

uint8_t pin: The pin number 0 to 7.

Returns: Nothing.

Example:

```
// if myPin is set, clear  myOtherPin
if (port_pin_read(myPort, myPin) )
port_pin_set(myPort, myOtherPin);
```

port_pin_activate_pullup()

Description: Activates the pull-up resistor for a pin in a port.

Syntax: port_pin_activate_pullup(uint8_t ddrx, uint8 _t pin)

Parameters:

uint8_t ddrx: The port as identified in io.h.

uint8_t pin: The pin number 0 to 7.

Returns: Nothing.

Example:

```
// Activate the pullup on PORTB pin 5
port_pin_activate_pullup(DDRB, 5)
```

port_pin_deactivate_pullup()

Description: Deactivates the pull-up resistor for a pin in a port.

Syntax: port_pin_deactivate_pullup(uint8_t ddrx, uint8_t pin)

Parameters:

uint8_t ddrx: The port as identified in io.h.

uint8_t pin: The pin number 0 to 7.

Returns: Nothing.

Example:

```
// Deactivate the pullup on PORTB pin 5
port_pin_deactivate_pullup(DDRB, 5)
```

port_pin_toggle()

Description: Toggles (if 0, sets to 1; if 1, sets to 0) the state of a pin in a port.

Syntax: port_pin_toggle(uint8_t PORTx, uint8_t pin)

Parameters:

uint8_t PORTx: The port as identified in io.h.

uint8_t pin: The pin number 0 to 7.

Returns: Nothing.

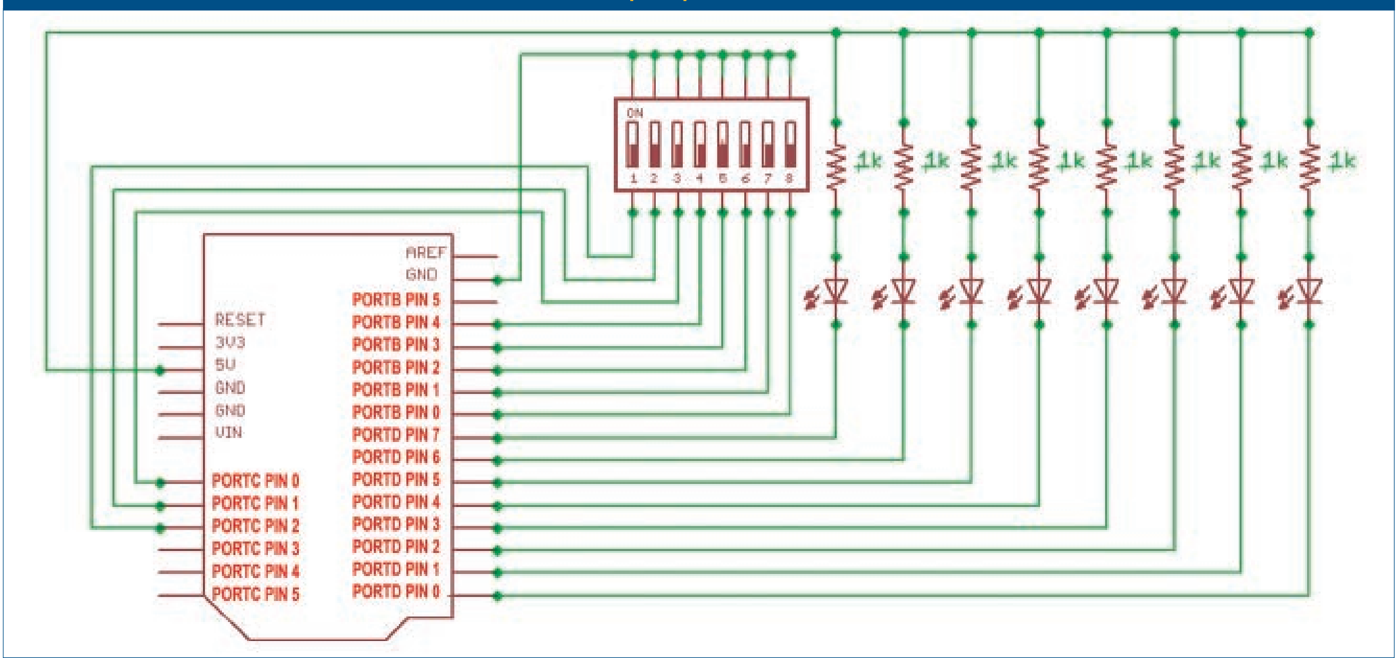
Example:

```
// Force pin 5 to change state regardless of state
port_pin_toggle(PORTB, 5)
```

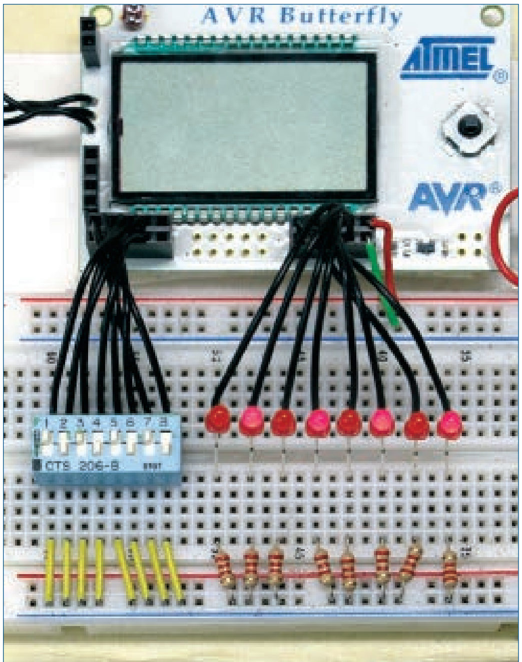
Applying Digitalio — Simple Chaser Lights

Last month, we showed how to set up the hardware for the AVR Butterfly and the Arduino to use the Arduino

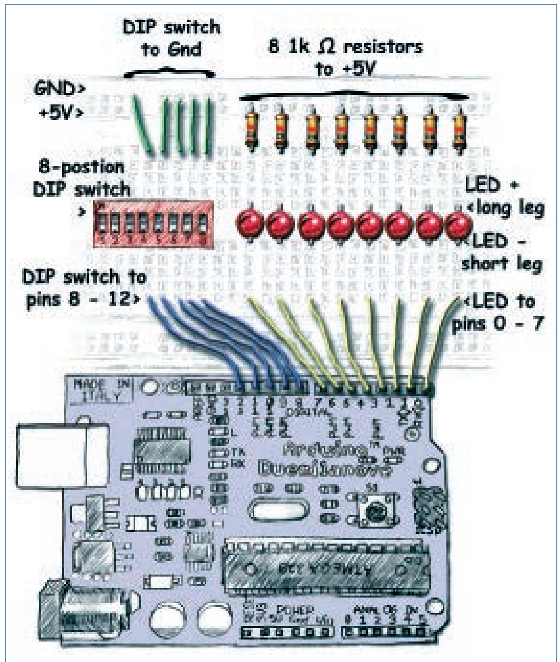
■ FIGURE 8. Arduino port/pins for DIP switch and LEDs.



style numbered pins to do input from an eight-bit DIP switch, and output that state to eight LEDs. The illustrations for the Butterfly had both the pin numbers and the port/pin numbers, but since the Arduino figures did not have the ports shown, we'll use **Figure 7** which shows the port pin numbers with Px for the port followed by the pin number. For example, PD5 is PORTD pin 5. In **Figure 8**, we see how the Arduino pins relate to the ATmega328 port/pins.



■ FIGURE 9. Chaser lights using the AVR Butterfly.



■ FIGURE 10. Chaser lights using the Arduino board.

As usual, I've been having so much fun I wasn't paying attention to the time. It looks late and long, so let's put the code in avrtoolbox at **http://code.google.com/p/avrtoolbox/avr_applications/simple_chaser_lights**. Note that the hardware to do the chaser light project (as shown in **Figures 9** and **10**) with either the Arduino or the Butterfly is available from the article link. Refer to last month's Workshop for more details on how these are wired.

Final Thoughts

Questions? As usual, if you want to be helpful when you find a problem or have a question you'll need to put on your biohazard suit and start a thread on **www.avrfreaks.net** with the word 'avrtoolbox' in the title (I probably will see it). Read my blog entry first, that will tell you why you need the biohazard suit at **http://smileymicros.com/blog/2011/01/24/using-an-internet-forum**.

Next month, we will finish up AVR Digital I/O where — if all goes well — I'll apply it to a breadboardable LCD and keypad project.

If you just can't wait and want to get a leg up on all this serial stuff and real C programming for the AVR, you can purchase my C Programming book and Butterfly projects kit at **www.nutsvolts.com**. **NV**

■ BY L. PAUL VERHAGE

AN ANTENNA FOR NEAR SPACE

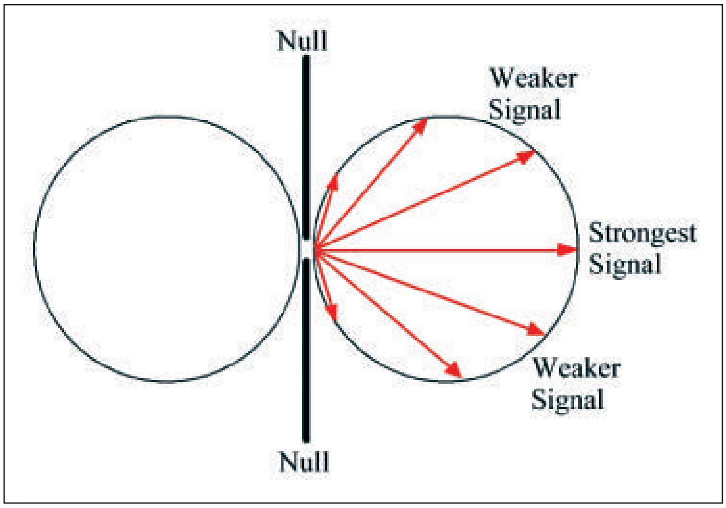
The radio tracker in my near spacecraft connects to a simple-to-build center-fed dipole antenna. I like this antenna because it's lightweight and has an excellent radiation pattern. However, while designing the UltraLight flight computer, I decided I should attempt to make improvements to my traditional antenna design. The result is a beefier antenna and antenna boom that are quicker and easier to build. So, this month let's look at this new antenna design.

The dipole is perhaps the simplest radio antenna. It consists of two metal conductors, called elements, placed end to end that convert the alternating electrical current created by the radio into a radio wave. This transformation from electrical current to electromagnetic wave occurs because of the electric charge that the electron carries. As the physicist leading up to James Clerk Maxwell explained, a changing electric field creates a changing magnetic field, and a changing magnetic field creates a changing electric field. The whole process can be self-supporting and travels at the speed of light in the form of electromagnetic radiation. This is a two-way process, so not only does alternating current inside an antenna produce an electromagnetic radio wave, but the electromagnetic field of a radio wave can jiggle electrons inside an antenna to create a tiny alternating electric current. The first stage amplifier of the radio receiver then boosts the signal to useable levels. The result is that one radio can communicate with another by creating an alternating current inside its antenna. Ah, the magic of physics.

The two elements of a dipole antenna are metal conductors — usually wire — cut to a length that depends on the desired frequency of the radio transmission. The elements are aligned end to end (in line with each other) and separated by a gap. The dipole antennas I use for near spacecraft are center fed; that is, the current to drive them is applied to both elements at the gap between them or, in other words, the center of the antenna. Because the antenna is center fed, both elements look like a mirror image of each other and the antenna is balanced (that makes designing the antenna simpler).

The wire connecting the dipole antenna to the radio is called transmission line and typically has a coaxial design (there are other designs, like ladder line). Coaxial cable or coax consists

■ **FIGURE 1.** One of my near spacecraft modules modeling its fashionable antenna and antenna boom.



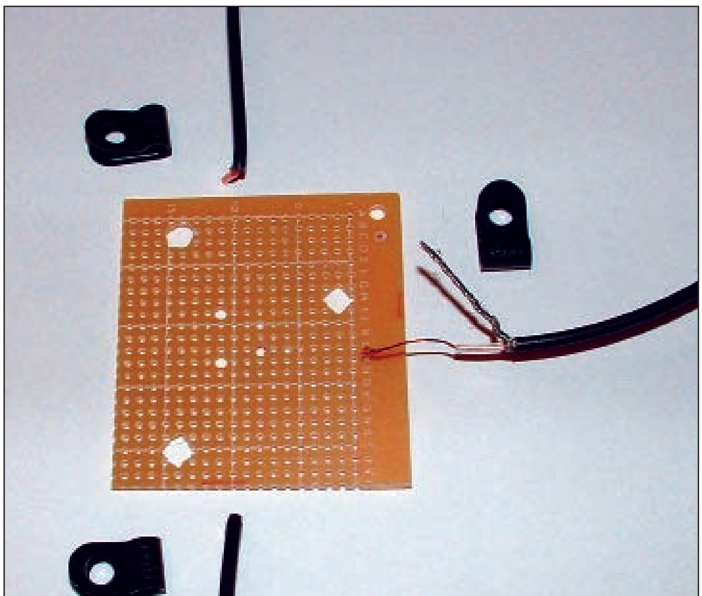
■ **FIGURE 2.** The radiating pattern of a typical dipole antenna. The signal is strongest in the direction of the horizon and weakest vertically.

of a center conductor (usually stranded wire) surrounded by a metal shield (usually a woven copper braid). In most cases, between the two conductors is a plastic dielectric insulator; surrounding the entire coax is a plastic jacket for protection from abrasion. Coax makes a good transmission line because the electric currents on the center conductor and the shield have opposite polarities. This limits current to only flowing on the surfaces between the center conductor and shield, and cancels any electromagnetic fields outside the coax. The cancellation of the fields means coax doesn't transmit a radio wave.

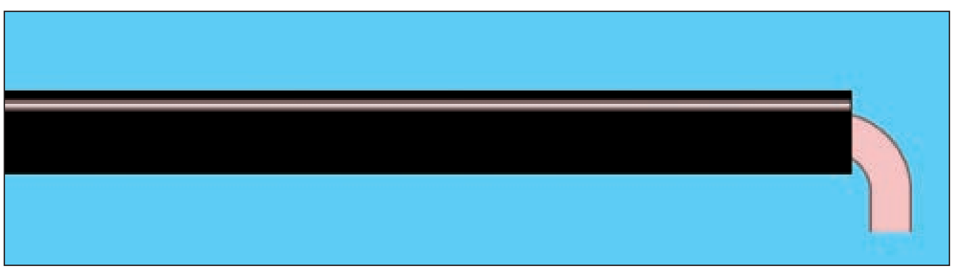
Because the longest electron oscillations occur when they take place perpendicular to an observer, the strength of the radio waves emitted by a dipole antenna is strongest parallel to the dipole elements and weakest at the tips of the elements. The pattern of radio wave strength is called the antenna's radiating pattern. In three-dimensional space, the radiating pattern of a dipole antenna looks like a donut or torus. The top and bottom where — theoretically — there is no signal are called nulls. The thickness of the torus depends on the length of the antenna's elements (compared to the radio frequency). By changing the length of the elements, the dipole antenna can transmit more power towards the horizon at the loss of power transmitted vertically. That is how the effective power of the radio is changed (by redirecting more of the antenna's watts of power towards the horizon and less to the sky or ground). The radiating pattern of a dipole also indicates how sensitive the antenna is to receiving radio transmissions. Two dipole antennas communicate more strongly when they are aligned vertically with each other and most weakly when they are aligned vertically to each other.

I recommend mounting the antenna vertically to the near spacecraft. If the antenna is horizontal instead, chase vehicles would also need to mount their antennas horizontally for the best reception from the near spacecraft. However, the near spacecraft spins constantly. As a result, chase vehicles would receive a signal that varies constantly as the near spacecraft spins. It's better to have all the antennas mounted vertically instead, so that near spacecraft spin and chase vehicle orientation doesn't modulate the transmissions from the near spacecraft.

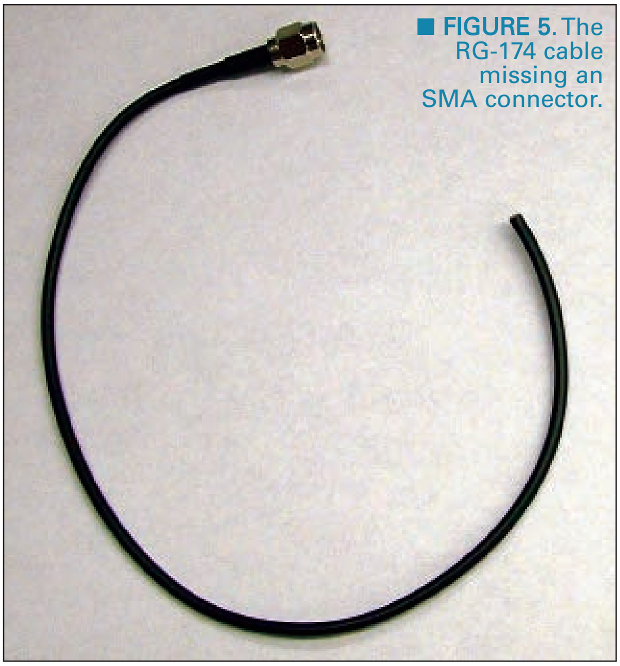
Readers should realize this leads to another problem. The nulls of the vertical antennas align when the chase vehicle drives under the near spacecraft. In that situation, a radio receiver in the chase vehicle is incapable of receiving transmissions from the near spacecraft (this is less of a problem if the radio receiver has lots of gain). However, since chase crews are seldom directly beneath the near spacecraft, they frequently avoid being within the null. However, in those cases were they are, chase crews can rely on the Internet-gates (I-Gates), or amateur radio stations that put radio transmissions on the Internet. I-Gates stations located away from the near spacecraft will still receive strong signals and will send position reports to servers like



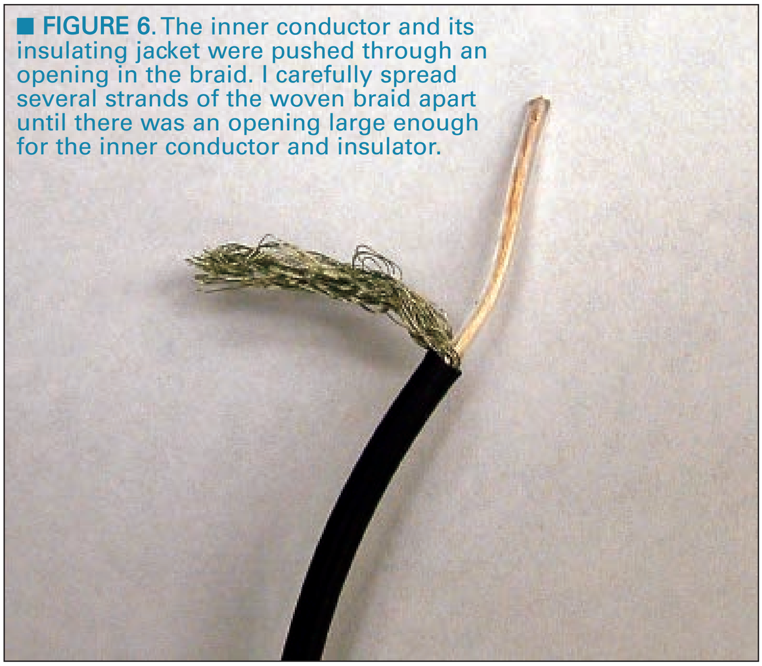
■ **FIGURE 3.** After cutting the perf board into a square, the parts of the antenna look like this.



■ **FIGURE 4.** The end of one of the antenna elements. Leave the rest of the insulation on the wire.



■ **FIGURE 5.** The RG-174 cable missing an SMA connector.



■ **FIGURE 6.** The inner conductor and its insulating jacket were pushed through an opening in the braid. I carefully spread several strands of the woven braid apart until there was an opening large enough for the inner conductor and insulator.

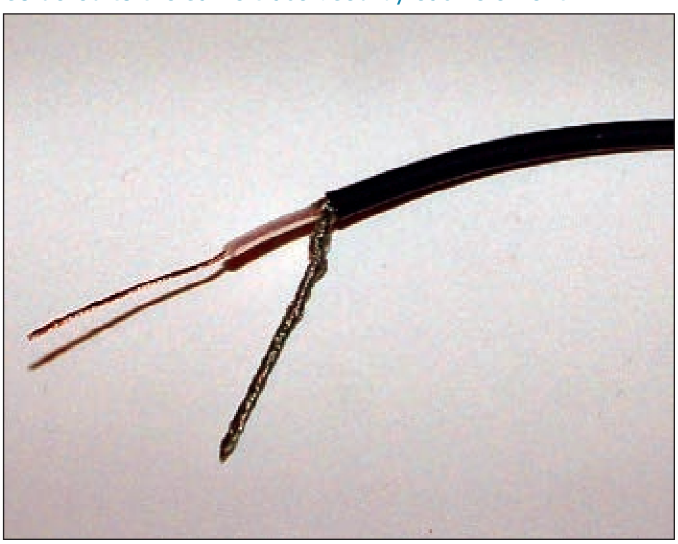
APRS.fi and **FindU.com**. So, a smart phone or notebook PC equipped with a wireless Internet card can provide tracking reports to a chase vehicle while it remains inside the null.

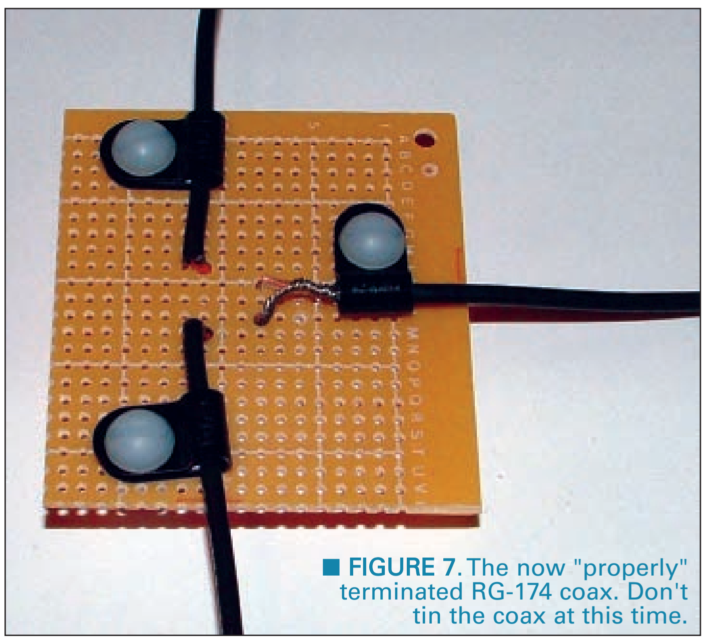
The length of the dipole's elements influences the antenna's AC resistance (impedance) and radiating pattern. The dipoles I recommend are 5/8 wave, or cut to a length that is 5/8 of the wavelength of the radio's frequency. The impedance of a 5/8 wave dipole is around 73 ohms if there are no structures nearby to disturb the antenna. It's not enough to simply cut a wire to 5/8ths the length of a radio wave. For several reasons — including that the speed of light is slower in a metal conductor like a copper wire than in a vacuum — we must use a different equation to calculate the best length for the dipole antenna elements. That equation is:

Length (in feet) of dipole = 468/Frequency (in MHz)

Be sure to divide the calculated length by two to get the length of each element in the dipole. For a frequency of 144.390 MHz, you should calculate that each element is 19.5 inches long. The dipole will have an impedance of about 73 ohms and is center fed by a RG-174 coax transmission line with an impedance of 50 ohms. Although there is a mismatch between the impedances of the coax and dipole antenna, the length of the coax is so short and the power level of the radio is so small that the mismatch is of little concern (only about 4% of the power is lost due to reflection). Okay, so now we know the

■ **FIGURE 8.** The completed antenna will look like this. There is no electrical short between the dipole elements of the antenna, and both conductors in the coax are soldered to the same trace used by each element.





■ **FIGURE 7.** The now "properly" terminated RG-174 coax. Don't tin the coax at this time.

■ FIGURE 9. An example of a quad. This module is shorter than most of my other modules, so its quad isn't square. The opening created by the quad lets me mount experiments to the outside of the module and still wire them to the flight computer.

length of the elements. How are we going to turn them into an antenna?

CONSTRUCTING THE NEARSYS NEAR SPACE ANTENNA

When I started in this near space business, I soldered the elements of the dipole to the center conductor and shield of a coax. I then sealed everything in hot glue. I found this design worked well initially, but over time and several landings, the glue would loosen its grip on the wire elements. When the elements are too loose, they risk being broken off the coax. Therefore, I came up with a design I'll share with you now. Listed below are the parts you'll need for this antenna:

- Perf board (I usually grab the 2″ by 3″ perf board at my local RadioShack.)
- Two feet SMA coax cable (I use Jameco part number 153382.)
- 40 inches of 12 gauge solid wire (household wiring from a home improvement store)
- Three 1/8″ plastic wire clamps (available at Ace Hardware)
- Three 10-24 nylon bolts 3/8″ long (also at Ace)
- Three 10-24 nylon nuts (again at Ace)

Cut the 12 gauge wire in half to make the dipole elements. Then, strip about 1/8 inch of insulation from one end of each wire and bend it at a 90 degree angle.

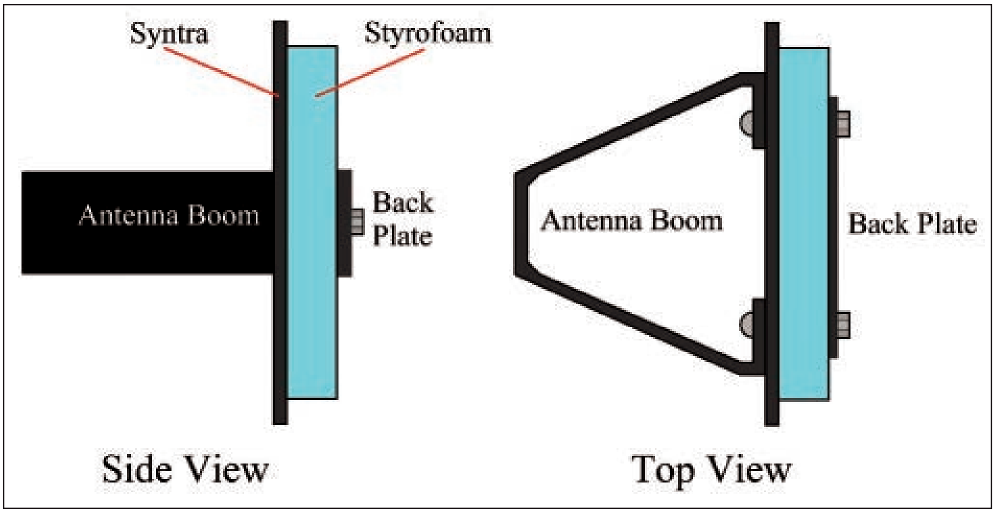
Next, take the RG-174 coax cable and cut one of the SMA connectors off. That will expose the braid and conductor inside.

Now, strip the outer jacket off the RG-174 to expose the braided jacket. Then, spread the woven braid slightly and push the inner conductor and the insulation through the opening in the braid.

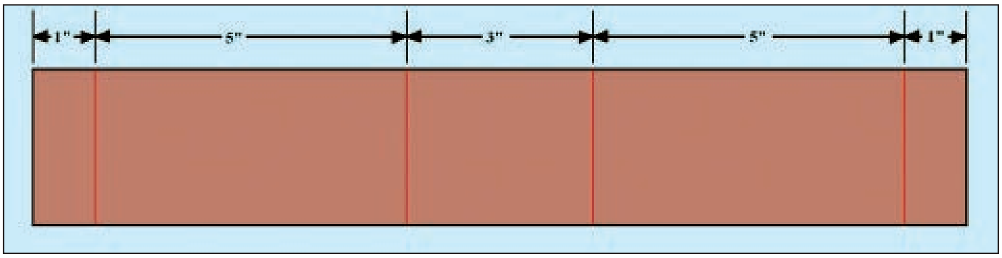
Now, strip the inner conductor to expose the wire inside, twist the stranded wires, and also twist the woven braid. You now have two "wires" that you can solder to dipole elements.

Rather than soldering the coax conductors directly to the dipole elements, we'll solder the coax and the elements to copper traces on the perf board. Those soldered connections are not nearly strong enough to keep the antenna together. Therefore, the design uses nylon wire clamps for strain relief for both elements and the coax transmission line. You'll need to enlarge the openings (pads) in the perf board to fit the elements and coax braid (the center conductor will fit the pads as they are currently drilled). Make sure you don't solder both dipole elements to the same copper trace. However, the coax center conductor and braided jacket are soldered to the same copper trace as each of the elements.

Treat the perf board gingerly for now. Slide one of each clamp over the coax and both dipole elements. Then, locate three places on the perf board where the nylon clamps can be bolted to the perf with the nylon bolts (without cutting important traces). Drill three large holes through the perf board for the nylon clamps and



■ FIGURE 10. A side and top view of the antenna boom mounted to a quad. The antenna and its perf board are bolted to the inside of the boom where it receives some protection at landing.



■ FIGURE 11. Measure and mark the Syntra boom at these dimensions. The Syntra is bent at these lines.

bolt them into place. If you find the coax and elements are still a little wobbly, then wrap each with a strip of electrician's tape and reclamp. Finish the antenna by measuring the length of the elements and cutting them 19-1/2 inches long.

A dipole antenna built this way is more durable than the older designs I used to use. So now, it was time to see if I could build a durable boom to hold the antenna a small distance away from the near spacecraft. I used to laminate styrofoam with thin plywood to create a composite structure that was lightweight and resistant to bending. The process was a little messy and quite time-consuming since it used epoxy followed with lots of sanding. Eventually, using plywood began to bother me because I felt high tech equipment should be made from metal and plastics, and wood should be used to make nice furniture. Therefore, I decided to use plastic in a new boom design. Here's a list of parts you'll need to make an antenna boom:

- 1/8″ thick Syntra plastic strip (at least 3″ by 26″)
- 1/8″ thick Syntra plastic sheet (6″ by 6″)
- 3/4″ thick blue or pink styrofoam sheet (6″ by 6″)
- Four 4-32 bolts (3/4″ long), nuts, and washers
- Four 6-32 bolts (1-1/2″ long), nuts, and washers
- Gorilla glue

Note: I recommend using nylocks for the nuts. They're much more resistant to loosing up and falling off.

■ FIGURE 12. Keep the hot air gun moving to evenly heat the Syntra, both on top and on the bottom. It's safer it you do this heating where there is adequate ventilation.

All my near space experiments and antennas are mounted to the sides of my near space modules. Since the modules are four sided, I refer to the sides as quads. Each quad is a square opening in the side of the module where I can bolt panels (quad panels) holding the experiments for the mission — like camera boxes and booms.

As I said, in the past I used a lot of thin plywood in my near space projects, but now I'm replacing the plywood with plastic. Since the material used to make the airframes is 3/4 inch thick styrofoam, I start with a square of the stuff cut to fit the opening of the quad (in my case, that's 5-1/4 in square). A larger square of Syntra plastic (6″ by 6″ for my modules) is then glued, centered to the styrofoam with the Gorilla glue. Gorilla glue requires 24 hours to set, so do this step before going to bed and let the glue set up over night. Gorilla glue will hold the styrofoam to the Syntra, but not strongly enough for the Syntra to be bent. Therefore, after adding the antenna boom we'll clamp another strip of Syntra to the quad panel to strengthen the bond. Speaking of the antenna boom, it's a triangularly shaped plastic strip as you can see in **Figure 10**.

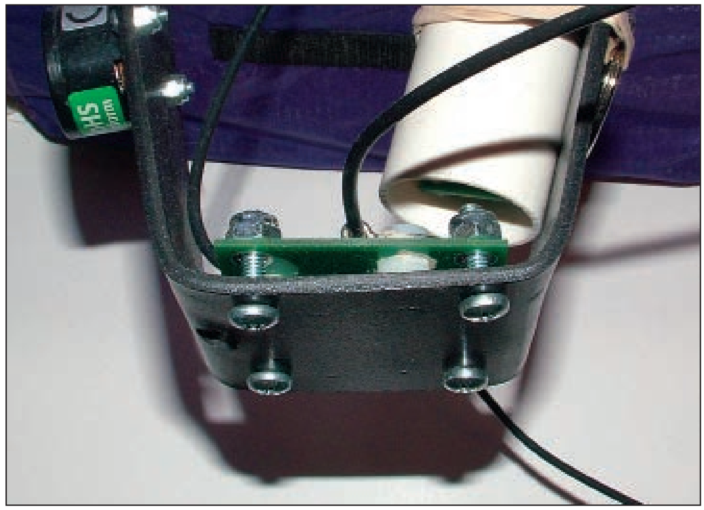
There is some flexibility in the following design, so feel free to adapt the directions to your particular needs. I cut a strip of 1/8 inch thick Syntra sheet to 2-1/2 inches wide and 15 inches long. Syntra is foamed PVC plastic and easy to cut and bend. After cutting the strip, I marked it in the dimensions shown in **Figure 11**.

The way to shape Syntra is to warm it until it gets soft and then bend it over a flat surface. I prefer to use a hot air gun to do the heating and to use a wooden board to bend the plastic. You'll need to warm one bend at a time, as Syntra won't stay warm enough for you to make more bends. Wave the hot air gun across one line and be sure to warm both the top and bottom faces of the Syntra. You'll know the plastic is hot enough when it wants to bend under the influence of gravity. If it gets too hot, the plastic will start to curl and shrink.

Once the hot air gun has warmed the Syntra sufficiently, shut off the gun and lay the Syntra against a flat surface like a counter top. Then, bend the Syntra with a board to the desired angle. Hold the Syntra in place for a few seconds until it has had enough time to cool. The Syntra will hold its new shape at that point. Follow up by heating and bending the Syntra at each line. Afterwards, you might want to reheat one or two bends and tweak the boom into the perfect shape.

The one inch ears are where the Syntra boom bolts to the quad panel. I don't recommend drilling the holes into the Syntra before heating it since the bending process can warp the holes. Now, drill two holes into each ear of the boom that are large enough for the 6-32 bolts. Then, lay the boom on the Syntra face of the quad panel and mark the location of the holes. Remove the boom and drill

■ **FIGURE 13.** Syntra can get hot and you probably don't want to leave your finger prints in the warm plastic. Therefore, use a flat board to bend the warm Syntra. Don't use a sheet of metal as it cools the Syntra too quickly.



■ **FIGURE 14.** An example from one of my antennas. I used 10-24 bolts in this example; definite overkill in this case.

holes through the quad panel at those marks. The holes must pass though the Syntra and the styrofoam. Finally, cut a strap of Syntra that is 2-1/2 inches wide and five inches long. Lay the boom on the strap and mark the location of the holes in the boom onto the strap. Then, drill holes in the strap for 6-32 bolts. This strap forms the back plate of the antenna boom and quad panel.

Place the boom on the quad panel and place the strap on the other side against the styrofoam. Use the 6-32 bolts, washers, and nylocks to bolt the sandwich together as shown in the top and side view of the antenna boom as shown back in **Figure 10**.

Next, we need to mount the antenna plate to the boom. Find and mark the location of four places in the perf board where you can drill holes without damaging the soldered elements or transmission line. Drill these holes for 4-32 bolts and then place the antenna plate against the end of the boom. Mark the location of the four holes in the end of the boom and drill these holes.

I recommend attaching the antenna plate to the inside of the boom rather than to the outside. Therefore, place the antenna perf board inside the boom and use 4-32 bolts to attach it to the inside of the boom. You'll need to sandwich some washers between the antenna perf board and the antenna boom.

Lastly, drill a hole through the quad panel so the antenna transmission line can pass into the near space module. Don't drill the hole any larger than necessary to pass the SMA connector. Doing so will limit the amount of cold air infiltration into the interior of the module. You can attach other items to the boom, like the speaker of an audio locator or other lightweight experiments.

That's the antenna and antenna boom for your UltraLight flight computer. Until next time,

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

ELECTRONIX EXPRESS

Visit Our Website At http://www.elexp.com

RSR 3MHZ SWEEP FUNCTION GENERATORS
6 Waveform Functions, Int/Ext Counter, lin/log sweep
MODEL FG-30 (No Digital Display) $135.00
MODEL FG-32 (5 Digit Display) $195.00

INSTEK OSCILLOSCOPE
MODEL GOS-620
Dual Channel – 20MHZ
(INCLUDES PROBES)
$305.00

DC POWER SUPPLIES
MODEL HY3003 – DIGITAL DISPLAY
Variable output, 0-30 VDC, 0-3 Amp $95.00
MODEL HY3003-3 – TRIPLE OUTPUT
Two 0-30 VDC, 0-3 Amp variable outputs plus 5V 3A fixed. Digital Display. $184.00

Weller® SOLDERING STATION
#1 BEST SELLING STATION $39.99
MODEL WLC 100
0603WLC100

ROTARY TOOL KIT $35.95
Variable speed tool (37,000 RPM) with accessory kit in a hard plastic carry case.
#29DR101

BENCH DMM WITH RS232 INTERFACE
MODEL DM9803R
True RMS, digital and bar graph display, AC/DC Cap, Res, frequency functions. Includes software, AC or DC operation.
$139.95

DIGITAL MULTIMETER
32 Ranges – 3 1/2 Digit
MODEL MY-64 $33.95
AC/DC Volt/Current, Res. Cap., Frequency. Rubber Holster Included

ALLIGATOR LEADS
SET OF 10 $3.50

RSR HIGH PERFORMANCE 3-WIRE IRON
#060509 $6.50

SOUND SENSOR CAR
REQUIRES SOLDERING
Reverses direction whenever it detects noise, or touches an obstacle.
$9.95
#3221881

RSR DIGITAL MULTIMETER SUPER ECONOMY
MODEL 820B
$6.50 10+
1-9 ..... $7.50
#01DM820B

MORE Low-Priced Items In Our FREE 350+ Page Catalog

SWITCHES	1-9	10+
8 POS DIP (V17DIP8SS)	.90	.85
Toggle Mini SPDT (17TOGSD-M)	1.40	1.20
Toggle Mini DPDT (17TOGDD-M)	$1.55	1.35

POTENTIOMETERS	1-9	10-99	100+
Cermet (STS Series)	85¢	75¢	65¢
Multiturn (MTT Series)	85¢	75¢	55¢
Panel Mount (PMA Series)	$1.15	80¢	70¢

Standard Values Available

TERMS: Min. $20 + shipping. School Purchase Orders, VISA/ MC, Money Order, Prepaid. NO PERSONAL CHECKS, NO COD. NJ Residents: Add 7% Sales Tax.

In NJ: 732-381-8020
FAX: 732-381-1006
900 Hart St • Rahway, NJ 07065
800-972-2225
http://www.elexp.com
email: electron@elexp.com

Custom Front Panels & Enclosures
FREE Software
Front Panel Designer
Sample price $57.32 + S&H
Designed by you using our FREE software, Front Panel Designer
■ Cost effective prototypes and production runs
■ Powder-coated finish and panel thickness up to 10mm now available
■ Choose from aluminum, acrylic or customer provided material
■ 1, 3 and 5-day lead times available
FRONT PANEL EXPRESS
FrontPanelExpress.com
(206) 768-0602

V-MODULE
Make Design Easier
Class D Audio Amplifiers
High Quality, High Effeciency
DC/DC Converters
High Effeciency, No Heat Sink
FM Audio Transmitters
HiFi Sound Quality
Evaluation Boards
Low Cost, Ready-to-Use
Features:
All integrated design
Ultra compact
Almost no external parts
Soldered by SMT or by hand
Low cost
High Reliability
Many ready–to–use EVB
Applications:
Consumer
Auto accessories
Instruments
Industry
Toys
Communication Equipments
And many more
Dealer Wanted!
URL: http://www.v-module.com
Email: sales@v-module.com
Tel: +8610 82562708
Fax: +8610 82562707

* Quality Quick Turn Sheet Metal Products & Precision Machined Parts
* No Minimum Quantity Restrictions
* Quote in 24 Hours or Less!
* Several Metallic & Non-Metallic Materials in Stock
Visit www.iitmetalfab.com today for your free, no obligation quote!
Integrated Ideas & Technologies, Inc.
ITAR Compliant
ISO 9001:2008
AS 9100 Certified
Precision Laser Cut Stencils
Sheet Metal Fabrication
Precision Parts Manufacturing
Defense
Aerospace
Medical
Aviation
Communications
Maritime
Electronics
Serving All Industries
Metal Fabrication: www.iitmetalfab.com
SMT Stencils: www.integratedideas.com

Number One Kits for Electronic Enthusiasts

KIT OF THE MONTH

SD/MMC Card Web Server Kit In a Box

KC-5489 $65.00 plus postage & packing

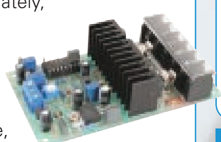
Host your own website on a common SD/MMC card with this compact Web server In a Box (WIB). Connecting to the Internet via your modem/router, it features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 serial port, four digital outputs and four analoge inputs. Kit includes PCB, case and electronic components.

- Requires a SD memory card, some SMD soldering and a 6 - 9VDC adaptor
- PCB Dimensions: 123 x 74mm

12/24VDC 20A Motor Speed Controller Kit

KC-5502 $29.00 plus postage & packing

Control the speed of 12 or 24VDC motors from zero to full power, up to 20A. Features optional soft start, adjustable pulse frequency to reduce motor noise, and low battery protection. The speed is set using the onboard trimpot, or by using an external potentiometer (available separately, use RP-3510 $2.00).

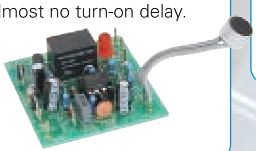


- Kit supplied with PCB and all onboard electronic components
- Suitable enclosure UB3 case, HB-6013 $2.50 sold separately
- PCB: 106 x 60mm

"Minivox" Voice Operated Relay Kit

KC-5172 $11.50 plus postage & packing

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

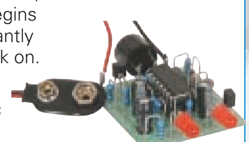


- Kit is supplied with PCB electret mic, and all specified components.
- PCB: 47 x 44mm

Clifford The Cricket Kit

KC-5178 $12.50 plus postage & packing

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



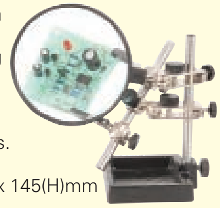
- PCB, piezo buzzer, LDR plus all electronic components supplied
- PCB: 40 x 35mm

Work Bench Accessories

PCB Holder with Magnifying Glass

TH-1983 $8.25 plus postage & packing

Any time you need that extra bit of help with your PCB assembly, this pair of helping hands will get you out of trouble. With a 90mm magnifying glass, it also provides an extra pair of eyes.

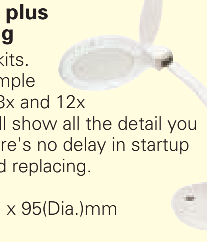


- Dimensions 78(L) x 98(W) x 145(H)mm

Desktop LED Magnifying Lamp

QM-3544 $31.25 plus postage & packing

Ideal for assembling kits. Sixty LEDs provide ample illumination, and the 3x and 12x magnifying lenses will show all the detail you need. Being LED, there's no delay in startup and they'll never need replacing.



- Dimensions: 320(H) x 95(Dia.)mm

Jacob's Ladder High Voltage Display Kit MK2

KC-5445 $31.00 plus postage & packing

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

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

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

Warning: The Jacob's Ladder Kit uses potentially dangerous voltage.

Ultrasonic Antifouling Kit for Boats

KC-5498 $179.50 plus postage & packing

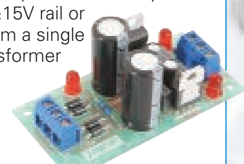
Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/ wind generator
- PCB: 78 x 104mm

Universal Power Supply Regulator Kit

KC-5501 $11.00 plus postage & packing

This is an upgraded version of the original universal power supply kit published in August 1988. One small board and a handful of parts will allow you to create either a regulated ±15V rail or +15VDC single voltage from a single winding or centre tap transformer (not included).



- Includes all PCB and components for board, transformer not included
- PCB: 72 x 30mm

Don't just sit there BUILD SOMETHING!

An excellent way for new comers to dip their toes into the wonders of electronics!

Short Circuits - Volume 1

This volume will teach you everything you need to get started in electronics and is suitable for ages 8+. We give you the option of buying the book on its own, or together with the accompanying kit that contains the components for each of the 20-odd projects described in the book. Some of the exciting projects include a Police Siren, Electronic Organ, Sound Effects Unit, Light Chaser and many, many more! The full color 96 page book, is lavishly illustrated with over 100 drawings and diagrams. No prior knowledge of electronics is needed, projects are fun and safe to build.

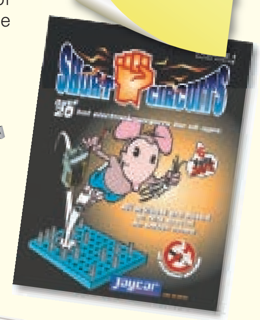
Short Circuits Book
BJ-8502 $7.25

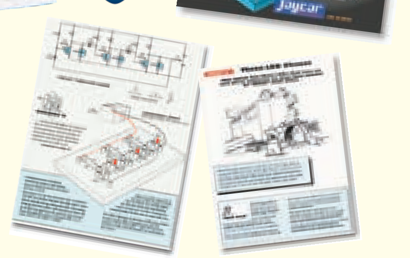
Short Circuits Project Kit
KJ-8504 $24.50

Short Circuits Book and Project Kit
KJ-8502 $29.00

MORE INFO AVAILABLE ONLINE

AGES 8+





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 30/11/2011

HOW TO ORDER

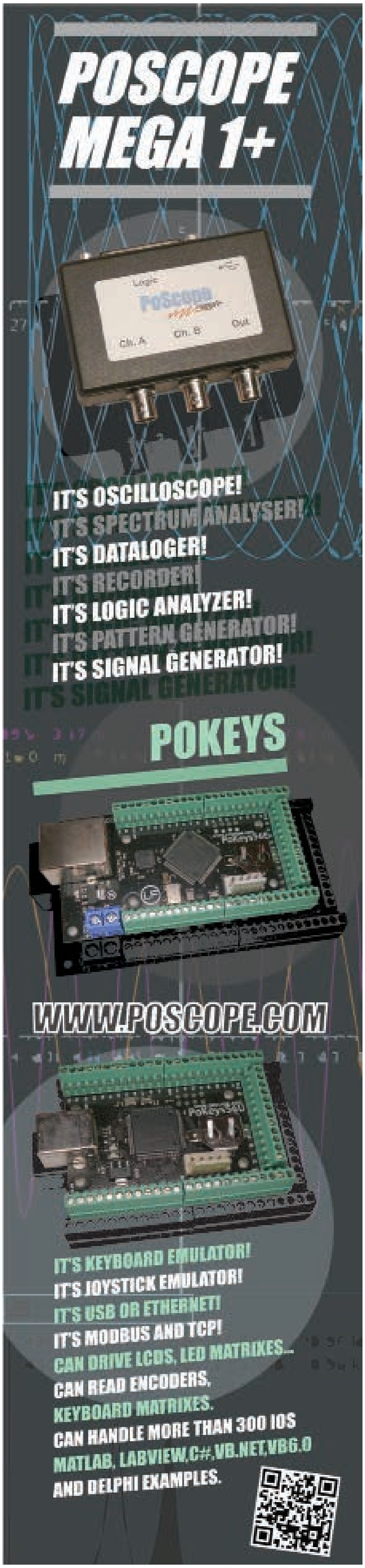
WEB: www.jaycar.com
PHONE: 1-800-784-0263*
FAX: +61 2 8832 3118*
EMAIL: techstore@jaycar.com
POST: P.O. Box 107, Rydalmere NSW 2116 Australia

• 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



Check out Pages 64-66 for more great combos like this one in the Nuts & Volts Webstore!

AP CIRCUITS
PCB Fabrication Since 1984

As low as...
$9.95
each!

Two Boards
Two Layers
Two Masks
One Legend

Unmasked boards ship next day!

www.apcircuits.com

VISA · MasterCard · PayPal · IPC MEMBER · BBB

Saelig.com
unique electronics

This is just a sampling of the thousands of products we offer! Visit www.saelig.com for more amazing unique electronics!

iPhone Scope
5MHz mixed signal scope adapter for iPhone & iPad. **iMSO-104** $297.99

50MHz Scope
50MHz 2-ch 2GS/s scope w/ 2000 wfm/s refresh rate. **DS1052E** $399

Mixed Sig. Scope
100MHz scope, spectrum and logic analyzer. 4MSa storage. **CS328A** $1359

USBscope50
Thumb-drive-size PC based 50MSa/s scope - connects via USB port. $199.95

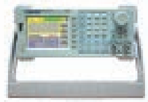
Custom Meter
High contrast 2.4" TFT color LCD w/ built-in touch screen. **SGD 24-M** $90.25

SPI Storm
Dual- & Quad- Serial Protocol Host Adapter controlled from PC through USB. $1199

7-in-1 Scope
2-ch, 10-bit, 2MHz scope, spectrum analyzer & wfm gen. **CGR-101** $199

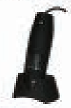
Windows Touchpanel
Touch-input 10.2" LCD 12V powered Windows PC 4GB **CUPC-P80/90/120** $698+

25MHz Scope
2-ch 25MHz color LCD - FFT, autoscale, & trigger delay functions. **PDS5022S** $287



5MHz Function Gen
2-ch, 5MHz DDS function generator 125 MSa/s, 14-bit res. **SDG1005** $349.50

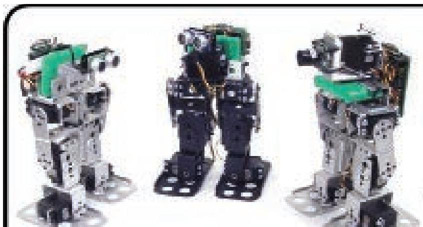
I/O Controllers
Simple-to-use universal I/O controllers for USB interface. No drivers req'd. $10.35+



Digital Microscope
Small handheld USB digital microscope and magnifier. **MV200UM** $59.95

888-772-3544 **www.saelig.com** info@saelig.com

Lynxmotion



Biped BRATs

Johnny 5

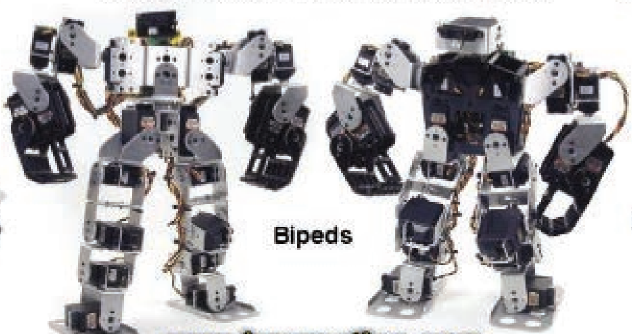
The Lynxmotion Servo Erector Set
Imagine it... Build it... Control it!

With our popular Servo Erector Set you can easily build and control the robot of your dreams. Our interchangeable aluminum brackets make the ultimate precision mechanical assemblies. Our Visual Sequencer for SSC-32 provides powerful PC, Atom, or BS2 based control.

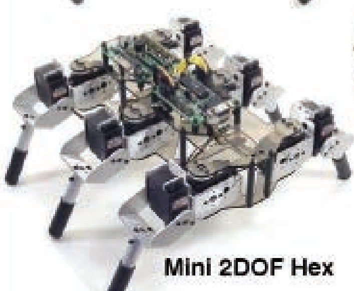
Visit our huge website to see our complete line of aluminum and Lexan based robot kits, electronics, and mechanical components.

Round 3DOF Hex

A4WD1



Bipeds



Mini 2DOF Hex

AL5C Arm

www.lynxmotion.com
Toll Free: 866-512-1024

Images represent a fraction of what can be made!

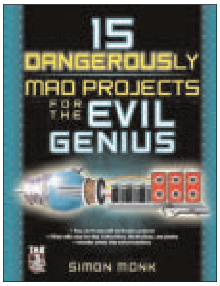
The SES now has 143 unique components!

ELECTRONICS

15 Dangerously Mad Projects for the Evil Genius
by Simon Monk

NEW!

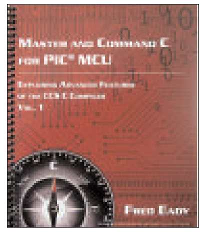
UNLEASH YOUR INNER MAD SCIENTIST!



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

$24.95

Master and Command C for PIC MCUs
by Fred Eady

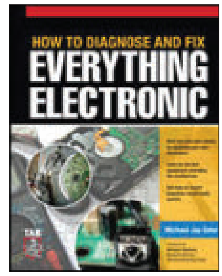


Master and Command C for PIC MCU, Volume 1 aims to help readers get the most out of the Custom Computer Services (CCS) C compiler for PIC microcontrollers. The author describes some basic compiler operations that will help programmers — particularly those new to the craft — create solid code that lends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

$14.95

How to Diagnose and Fix Everything Electronic
by Michael Jay Geier

Master the Art of Electronics Repair!



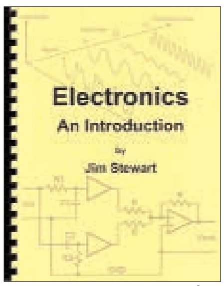
In this hands-on guide, a lifelong electronics repair guru shares his tested techniques and invaluable insights. *How to Diagnose and Fix Everything Electronic* shows you how to repair and extend the life of all kinds of solid-state devices, from modern digital gadgetry to cherished analog products of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

About the Author

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

$24.95

Electronics An Introduction
by Jim Stewart

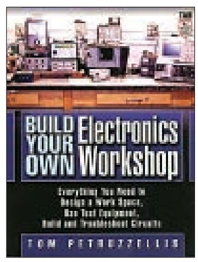


This book is designed as an in-depth introduction to important concepts in electronics. While electronics can be highly mathematical, this text is not about calculations. It is about how electronic equipment is able to extract, process, and present information held in electrical signals. If you are in — 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.

$33.95*

Build Your Own Electronics Workshop
by Thomas Petruzzellis

BUILD YOUR OWN DREAM ELECTRONICS LAB!



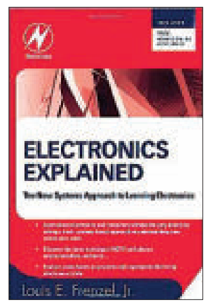
This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action — building, testing, and troubleshooting systems. This great book has it all! And the best part is, it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

Reg Price $29.95

Sale Price $24.95

Electronics Explained
by Louis Frenzel

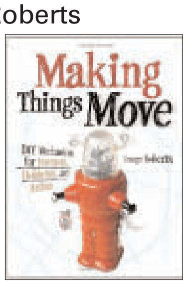
The New Systems Approach to Learning Electronics



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

$29.95

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

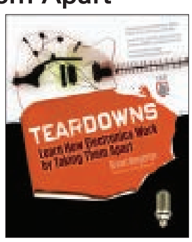


In *Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists*, you'll learn how to successfully build moving mechanisms through non-technical explanations, examples, and do-it-yourself projects — from kinetic art installations to creative toys to energy-harvesting devices. Photographs,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

$29.95

TEARDOWNS
by Bryan Bergeron

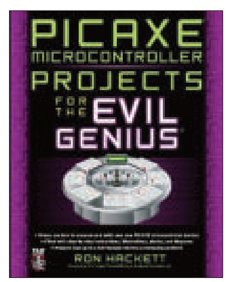
Learn How Electronics Work by Taking Them Apart



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

Reg $24.95 **Sale Price $21.95**

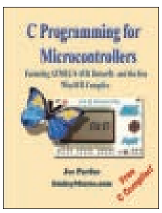
PICAXE Microcontroller Projects for the Evil Genius
by Ron Hackett



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

$24.95

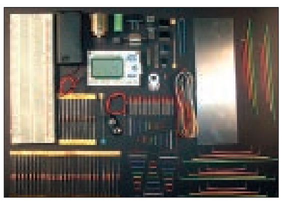
BOOK & KIT COMBOS



Book **$44.95**

From the
Smiley Workshop

C Programming for Microcontrollers
by Joe Pardue

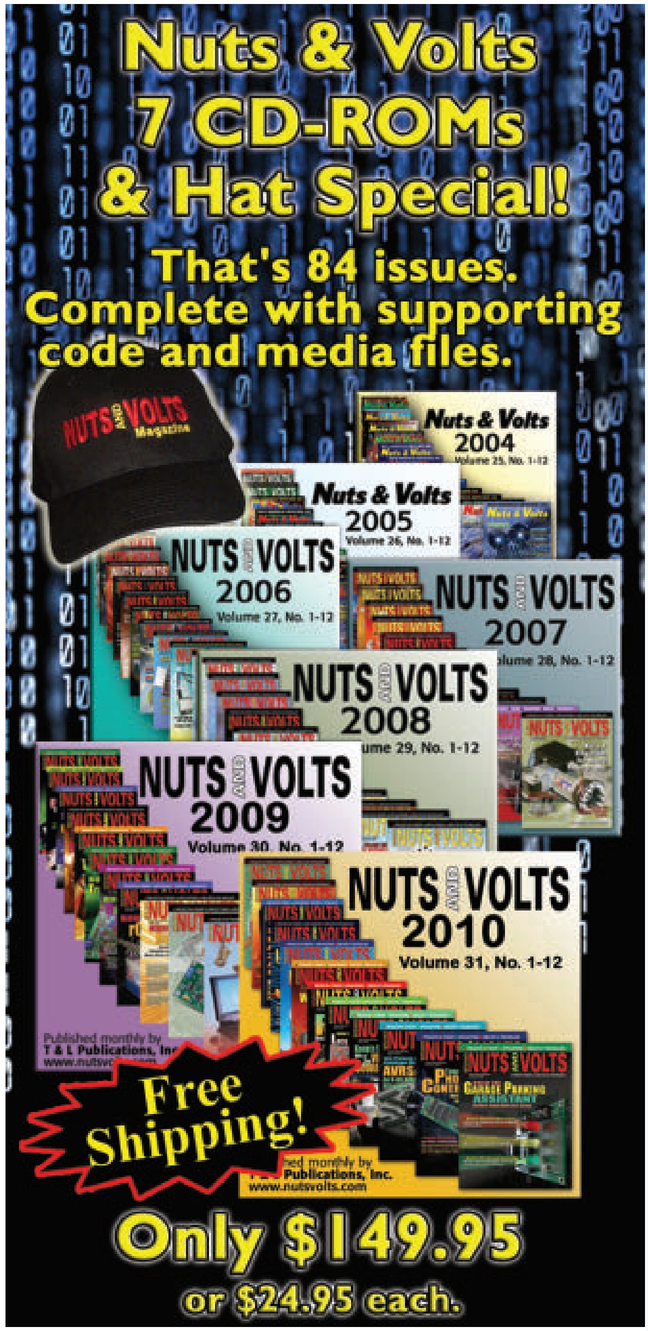


Kit **$66.95**

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

CD-ROM SPECIALS



Other available titles

Bionics for the Evil Genius, Mechatronics for the Evil Genius, 123 PIC Microcontroller Experiments for the Evil Genius, Electronic Circuits for the Evil Genius, Telephone Projects for the Evil Genius, Programming Video Games for the Evil Genius, MORE Electronic Gadgets for the Evil Genius, PC Mods for the Evil Genius, 25 Home Automation Projects for the Evil Genius, Bike Scooter and Chopper Projects for the Evil Genius, 22 Radio and Receiver Projects for the Evil Genius,

50 Model Rocket Projects for the Evil Genius, Sensors for the Evil Genius, Electronic Gadgets for the Evil Genius, 125 Physics Projects for the Evil Genius, Mind Performance Projects for the Evil Genius, 101 Outer Space Projects for the Evil Genius, 46 Science Fair Projects for the Evil Genius, 50 Awesome Auto Projects for the Evil Genius, 101 Spy Gadgets for the Evil Genius, 123 Robotics Experiments for the Evil Genius, and 51 High-Tech Practical Jokes for the Evil Genius.

PROJECTS

Christmas Tree Kit

This microprocessor-controlled Xmas Tree comes with eight preprogrammed light display sequences. All you need is a soldering iron and a couple of batteries, and you'll be ready to show off your electronic tree!

To see a demo video, please visit www.nutsvolts.com

Subscriber's Price **$38.95**
Non-Subscriber's Price **$41.95**

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**

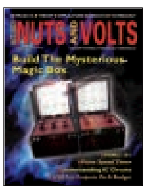
3D Green LED Cube Kit

From the article "Build the 3D LED Matrix Cube" as seen in the August 2011 issue.

This kit shows you how to build a really cool 3D cube with a 4 x 4 x 4 monochromatic LED matrix which has a total of 64 LEDs. The preprogrammed microcontroller that includes 29 patterns that will automatically play with a runtime of approximately 6-1/2 minutes.
Colors available: Green, Red, Yellow & Blue

Subscriber's Price **$57.95**
Non-Subscriber's Price **$59.95**

Magic Box Kit

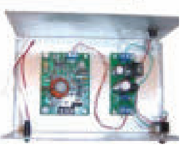


As seen on the April 2007 cover

This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. This clever trick has the observer remove one of six pawns while you are out of the room and upon re-entering you indicate the missing pawn without ever opening the box.
Includes an article reprint.

Subscriber's Price **$39.95**
Non-Subscriber's Price **$45.95**

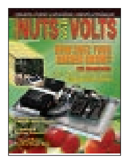
Mini-Bench Supply Complete Kit



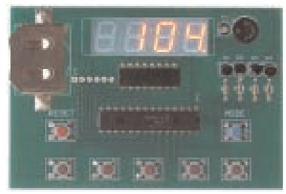
A small power supply with +5V, +12V, and -12V outputs is a handy thing to have around when you're breadboarding circuits with both op-amps and digital ICs.
Kit includes: Enclosure box, accessories, DC-to-DC converter kit, switching regulator kit, and article reprint.
For more information, please see the "feature article section" on the of the *Nuts & Volts* website.

Subscriber's Price **$76.95**
Non-Subscriber's Price **$83.95**

Sorting Counter Kit



As seen in the July 2011 issue.

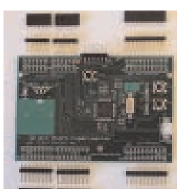


Sorting counters have many uses — keeping score, counting parts, counting people — it is just a handy gadget to have around. This is a very simple project for those who want to learn to solder or are interested in using microprocessors and how they function. No special tools are needed, just a small tip soldering iron. It has no box as it stands alone, therefore there is no drilling.

Subscriber's Price **$33.95**
Non-Subscriber's Price **$39.95**

32-Bit Micro Experimenter Board

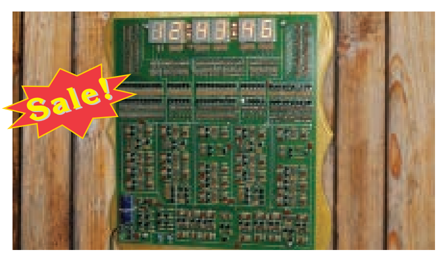
The 32-Bit Micro Experimenter is the fastest way to learn 32-bit microcontrollers.



The kit includes onboard 46 programmable I/O and USB, free software, carefully documented step-by-step experiments for USB, embedded web server, graphics and 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.

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

Transistor Clock Kit



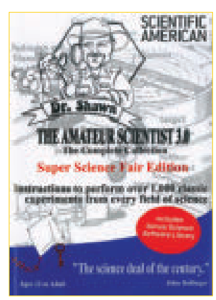
If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

Reg $225.95
Sale Price $199.95

PCBs can be bought separately.

The Amateur Scientist 4.0 The Complete Collection

by Bright Science, LLC

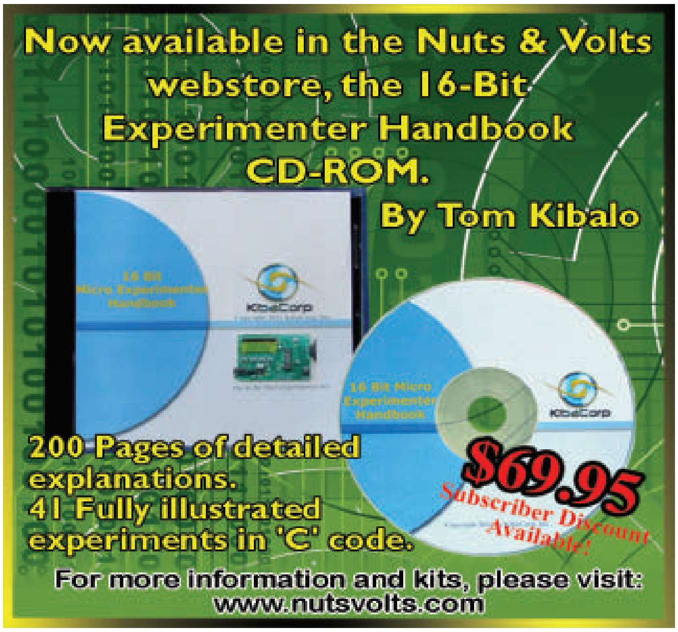


There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of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

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.

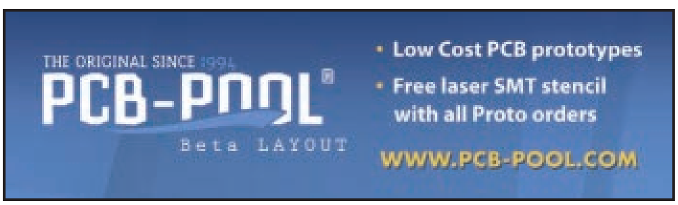
ELECTRONET



Sheet Metal Fabrication

Complete Fabrication Center
Integrated Ideas & Technologies, Inc.
Precision Laser, Waterjet, Plasma, Machining, Forming, and Welding Capabilities
www.iitmetalfab.com

USB Add USB to your next project-- It's easier than you might think! DLP Design
USB-FIFO • USB-UART • USB/Microcontroller Boards
RFID Readers • Design/Manufacturing Services Available
Absolutely NO driver software development required!
www.dlpdesign.com



ALL ELECTRONICS CORPORATION
Electronic Parts & Supplies Since 1967

For the ElectroNet online, go to **www.nutsvolts.com** click ***Electro-Net***

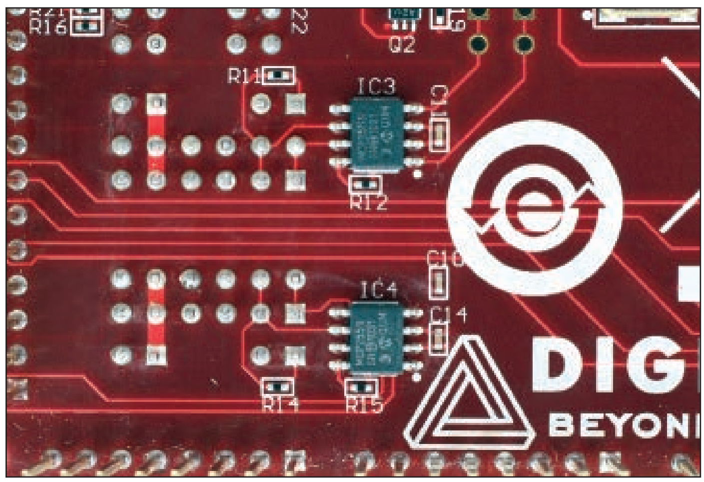
■ BY FRED EADY

YOU *CAN* DO IT WITH THE CHIPKIT MAX32

If you've ever designed an electronic gadget that interfaces with some part of your car, you know that the power system in automobiles is noisier than a Sunday afternoon NASCAR race. However, despite the abundance of electrical noise, the car maker has managed to fill your auto's cabin with a dazzling array of high tech instrumentation. If you were privy to your car's system schematic diagram, you would find that all of that gee-whiz automotive technology talks on a common data channel that coexists with the car's noisy power system. That common data channel is known as a Controller Area Network. That's CAN for short.

CAN is an asynchronous serial data communications protocol that excels in noisy environments. You can think of controller area networks as high speed intelligent serial communications networks with everything you wished you could have in a comparable RS-232 connection. The fact is, a CAN is just as easy to physically implement as a legacy RS-232 network. The plus of a controller area network is the intelligence that lies on the other side of the CAN transceivers.

CANs are not restricted to door panels in automobiles. Once upon a time, I used CAN to establish a communication link between a set of electronic toilets. So, the plan this month is to throw some electrons at the pair of CAN transceivers that reside on the chipKIT network shield. To get the electrons routed correctly, we'll have to do some bit twiddling on the chipKIT Max32's PIC32MX795F512L. In that we won't be directly designing a toilet CAN network, things shouldn't get too stinky.



■ PHOTO 1. Each of the chipKIT Max32's two CAN engines has its very own MCP2551 CAN transceiver. The transceiver is to a controller area network as the MAX232 is to an RS-232 link.

THE PIC32MX795F512L CAN ENGINE

The chipKIT Max32 does not natively support Microchip's MCP2551 CAN transceivers. However, housed within the chipKIT Max32's PIC32MX795F512L is a CAN module that encompasses two independent CAN engines: CAN1 and CAN2. Each CAN engine can access a controller area network bus via an external MCP2551 CAN transceiver. To facilitate the communications channels, two MCP2551 transceivers have been designed into the network shield and are the subject of **Photo 1**.

The transceiver is very easy to physically implement because it is housed in an industry standard eight-pin package. In its simplest implementation, this transceiver requires two connections for power and ground, two digital signal connections, and two CAN bus connections. MCP2551 transceivers at the extreme ends of the CAN bus must have their pins terminated with 120Ω resistors.

The chipKIT network shield's MCP2551 transceiver pair is wired as shown in **Schematic 1**. Although it isn't obvious, one of the PIC32MX795F512L's serial ports shares the CAN1 input signal lines. That's why the CAN1 engine's digital inputs can be jumpered in and out. Note that only six of the eight transceiver signals are used. Unlike the MAX232 RS-232 converter, the transceiver does not require charge pump capacitors. The absence of charge capacitors and only six physical connections makes the transceiver easier to physically implement than its RS-232 counterpart.

An RS-232's behind-the-scenes dedicated resources depend on the sophistication level of the UART. Nine-bit RS-232 messages are stretching out to the limits of the UART's protocol capability. Where data buffering is concerned, most modern microcontroller UARTs contain circuitry that implements double buffering for incoming or outgoing bytes of data. Any additional buffering must be set up and monitored in the application programming, and resides in a chunk of SRAM allocated as buffer area. Designed to be a point-to-point protocol, RS-232 doesn't warm up to the addressing of nodes and contains little (if any) native data filtering capability.

In addition to a protocol engine, the PIC32MX CAN module includes message acceptance filters and message assembly buffers. Incoming CAN messages are filtered by the message acceptance filters and masks. If the incoming CAN message meets the filter and mask requirements, the received messages can then be routed to the receive message assembly buffer. Conversely, an outgoing CAN message is assembled in the transmit message assembly buffer before being handed over to the protocol engine for transmission.

The PIC32MX CAN module contains absolutely zero buffer area. Like an extended RS-232 engine, all of the buffered data must reside within a block of preallocated SRAM. Unlike RS-232 — which needs supporting code to snatch and grab buffer data — the PIC32MX module can transfer data to and from the SRAM buffer area without any CPU intervention. In that controller area networks have been associated with automobiles, these easy-to-use networks have been underutilized in the embedded world. Microchip thought enough of CAN to include a couple of CAN engines in the 32-bit PIC32MX795F512L, and Digilent placed a pair of MCP2551 CAN transceivers on the chipKIT network shield. So, we're going to show that we care and sling some code into the CAN.

BRINGING UP CAN2

As far as initialization is concerned, both CAN1 and CAN2 are coded identically. Since the CAN2 interface is not shared with other PIC32MX peripherals, we'll concentrate our coding activity there. Activating CAN2 is a process that involves very intense bit twiddling among a number of 32-bit registers. The PIC32MX module registers can be corralled into four functional groups:

1. CAN Engine/CAN Module Bit Rate Configuration Registers
2. Interrupt and Status Registers
3. Mask and Filter Configuration Registers
4. FIFO Control Registers

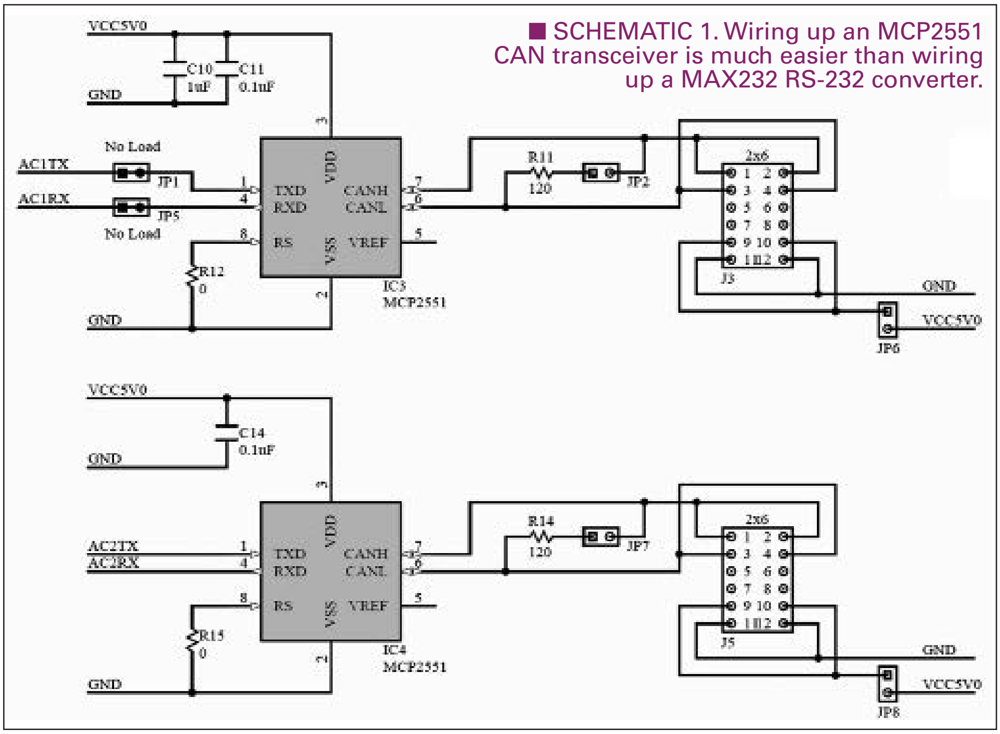
The PIC32MX module can be configured and activated by writing the correct bit patterns to each of the four sets of module registers. To that end, all of the registers have associated bit set and bit clear registers. The bit set and bit clear registers allow the individual bits within each config, interrupt, status, mask, filter, and FIFO register to be adjusted using a simple bit mask which is loaded into the target register's associated bit set or bit clear register. To prevent us from twiddling ourselves into the bit bucket abyss, the Microchip CAN coders have provided an easy to use factory-approved PIC32MX CAN module peripheral library. This library allows the CAN programmer to literally "talk" his or her way through the configuration and operational aspects of the PIC32MX module. For instance, this is the bit-bang way to enable the CAN1 engine:

```
C1CONSET = 0x00008000;      //set the ON bit
while(C1CONbits.CANBUSY == 1);
        //wait for operation to complete
```

I would rather enable CAN1 this way with the peripheral library call:

```
CANEnableModule(CAN1,TRUE);
```

The bit twiddling to push the CAN module into configuration mode isn't bad if you know beforehand that REQOP and OPMOD are sets of three consecutive bits and what bit patterns they need to have loaded. If you decide to bring up your controller area network caveman style, you'll need to carefully read Section 34 of the PIC32MX Family Reference Manual. Once you've done your homework, you won't have any trouble writing the



■ SCHEMATIC 1. Wiring up an MCP2551 CAN transceiver is much easier than wiring up a MAX232 RS-232 converter.

following lines of code:

```
C1CONbits.REQOP = 4; //enter configuration mode
while(C1CONbits.OPMOD != 4);
       //wait for operation to complete
```

Although reading Section 34 of the reference manual is something you should do if you're going to work with the PIC32MX CAN module, I think I would rather talk my way through. Plus, the library code tends to be self-commenting:

```
CANSetOperatingMode(CAN1, CAN_CONFIGURATION);
while(CANGetOperatingMode(CAN1) !=
CAN_CONFIGURATION);
```

There are six CAN module operation modes:

- Configuration Mode
- Normal Operation Mode
- Listen Only Mode
- Listen All Messages Mode
- Loopback Mode
- Disable Mode

Each operation mode is represented by a bit pattern placed in the Request Operation Mode (REQOP) bit block of the CAN Control register (CxCON). The CAN module acknowledges the successful entry into the requested mode by duplicating the REQOP bits in the Operation Mode (OPMOD) bit block which is also located in the CAN control register. The polling of the OPMOD bits is one way of verifying the change of operational modes. You can also detect an operation mode change using the Mode Change Interrupt which is enabled by the MODIE bit in the CAN interrupt register.

We're working on CAN2 hardware. So, our CAN2 initialization routine would begin by enabling the CAN2 engine and pushing it into configuration mode:

```
CANEnableModule(CAN2,TRUE);
CANSetOperatingMode(CAN2, CAN_CONFIGURATION);
while(CANGetOperatingMode(CAN2) !=
CAN_CONFIGURATION);
```

Just a walk in the park. I can see that you're already beginning to think about how you're going to deploy your chipKIT Max32-based controller area network.

The CAN module configuration register (C2CFG) cannot be modified outside of configuration mode. With the CAN2 engine enabled and configurable, the next step is to set up the clocking, whose bits lie inside of C2CFG.

CLOCKING THE CAN2 ENGINE

Figure 1 sums up the CAN module clocking options. A CAN bit time consists of four segments. Each segment is made up of a number of Time Quanta (T_Q) periods. For our purposes, the number of T_Q periods per bit (N) will be set to 10 which will be distributed as $3T_Q$ per phase segment. The synchronization segment will consist of a single T_Q. Our CAN will operate with a baud rate of 250 Kbps. Using the aforementioned number of T_Q periods per bit and the network baud rate, we can calculate the Time Quantum Frequency (FT_Q):

$$FT_Q = N * F_{BAUD} = 10 * 250Kbps = 2.5MHz$$

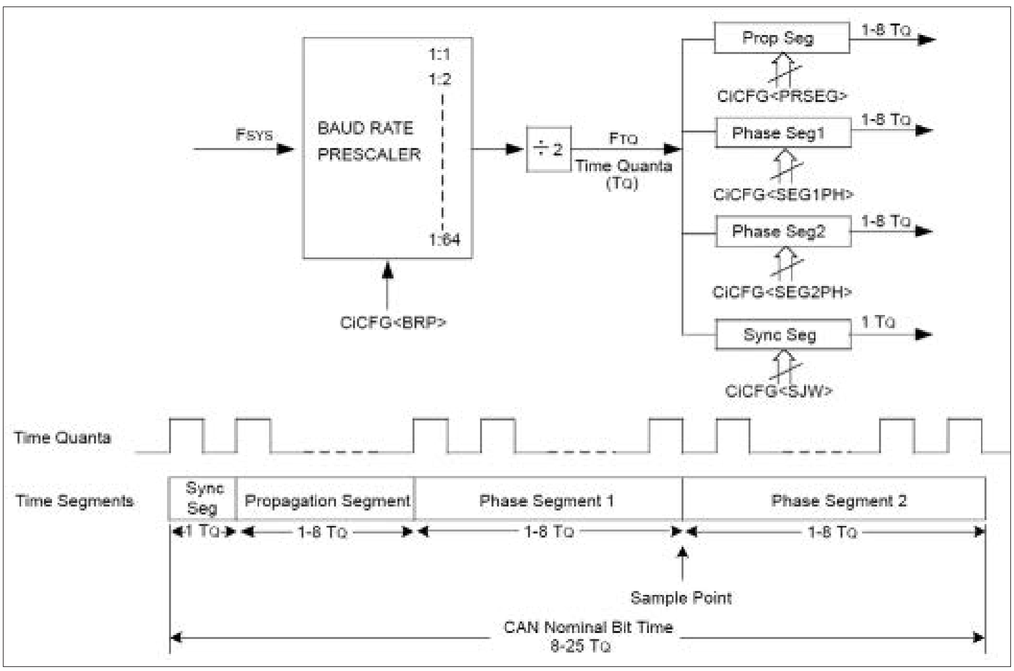
We need the Time Quantum Frequency to calculate the CAN module baud rate prescaler value. The chipKIT Max32's PIC32MX795F512L is running at 80 MHz. So, F_{SYS} is 80 MHz:

```
C2CFG<BRP> = (FSYS/(2 * FTQ)) - 1
C2CFG<BRP> = (80MHz/(2 * 2.5Mhz)) - 1 = 15
```

As a result of our calculations, we will drive these code stakes into the ground:

```
#define SYS_FREQ            (80000000L)
#define CAN_BUS_SPEED       250000
#define CAN2_BRPVAL         0x0F
```

Our mathematical exercise was intended to help you associate real values to the graphical set of clocking registers in **Figure 1**. The idea is to size the time segments to allow reliable operation of the CAN. The phase and propagation segments insure that any drift on the bus due to oscillator shift or propagation time are addressed. With the information you have, I'm sure you could fill in the C2CFG bit fields. However, the peripheral library fills the C2CFG bit fields



■ FIGURE 1. The four time segments in a bit time are used to compensate for any phase shifts due to oscillator drift or propagation delays.

using the elements of a structure:

```
canBitConfig.phaseSeg2Tq            = CAN_BIT_3TQ;
canBitConfig.phaseSeg1Tq            = CAN_BIT_3TQ;
canBitConfig.propagationSegT        = CAN_BIT_3TQ;
canBitConfig.phaseSeg2TimeSelect    = TRUE;
canBitConfig.sample3Time            = TRUE;
canBitConfig.syncJumpWidth          = CAN_BIT_2TQ;

CANSetSpeed(CAN2,&canBitConfig,SYSTEM_FREQ,CAN_
BUS_SPEED);
```

The *canBitConfig* structure was spawned from the *CAN_BIT_CONFIG* parent structure that is found in the peripheral library's *CAN.h* file. Note that all of the parameters we took into consideration for our calculations are used by the *CANSetSpeed* function. You can bet the results of the *CANSetSpeed* function match our manual calculations.

CARVING OUT THE MESSAGE BUFFER MEMORY AREA

As you become more familiar with the CAN module, you'll notice that it likes to do things for itself. All you have to do is decide what you want to happen and turn the module loose. With that, we can use the peripheral library functions to easily set up separate transmit and receive buffer areas in SRAM with a minimum of coding. Let's specify enough message buffer area for a transmit channel and a receive channel with each channel containing eight message buffers of 16 bytes each:

```
BYTE CAN2MessageFifoArea[2 * 8 * 16];
CANAssignMemoryBuffer(CAN2,CAN2MessageFifoArea,
2 * 8 * 16);
```

The CAN module automatically allocates the specified memory space for a transmit FIFO and a receive FIFO according to the arguments of the *CANAssign MemoryBuffer* function. You can get an idea of how the PIC32MX module organizes FIFO buffer area in **Figure 2**.

Once the message buffer memory is allocated, we can tell the CAN module to slice and dice it into addressable transmit and receive buffer areas:

```
CANConfigureChannelForTx(CAN2,CAN_CHANNEL0,8,CAN_
TX_RTR_DISABLED,CAN_LOW_MEDIUM_PRIORITY);

CANConfigureChannelForRx(CAN2,CAN_CHANNEL1,8,CAN_
RX_FULL_RECEIVE);
```

Okay. Now we've established that we will transmit CAN messages on Channel 0 and receive CAN messages on Channel 1. Each channel is supported by eight 16-byte message buffers with the receive message buffer able to capture the entire CAN message, which includes a time stamp, the message ID, and data payload. The Remote Transmit Request (RTR) feature is disabled. RTR allows a CAN node to request a transmission from another CAN node.

NO UNFILTERED TAP WATER, PLEASE

Every CAN message is a broadcast message. That means every CAN node on the wire has the ability to receive every message that is transmitted. We have the ability to only accept CAN messages that are of interest to us. We do this by setting up a message acceptance filter. Each CAN SID (Standard ID) message has an 11-bit ID field that we can sift through our filter. So, let's set up the first filter (CAN_FILTER0) to accept SID messages with an ID of 0x222:

```
CANConfigureFilter (CAN2, CAN_FILTER0, 0x222,
CAN_SID);
```

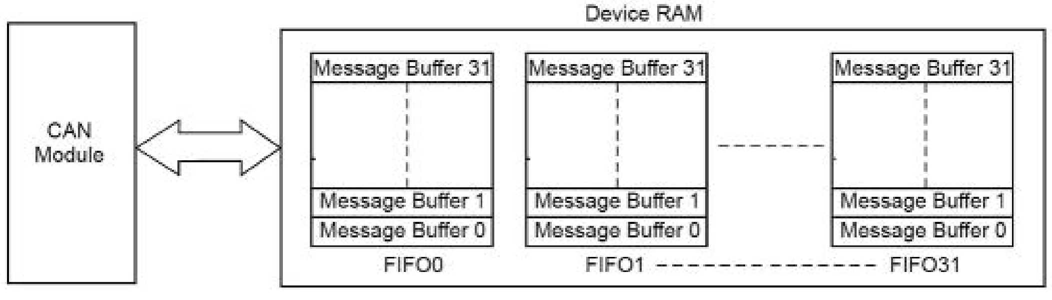
Since we're only interested in receiving SID messages, we want to trigger our filter on all 11 bits of the ID and reject EID (Extended ID) messages:

```
CANConfigureFilterMask  (CAN2, CAN_FILTER_MASK0,
0xFFF, CAN_SID,   CAN_FILTER_MASK_IDE_TYPE);
```

Our first CAN2 filter mask value of 0xFFF covers all 11 bits of the incoming SID message's ID field while the other arguments make sure that nothing but SID messages are allowed to flow to the receive buffer. CAN_FILTER0 is the first filter we defined and CAN_FILTER_MASK0 is the first filter mask we defined. We can specify up to 32 filters (CAN_FILTER0-CAN_FILTER31) and up to four filter masks (CAN_FILTER_MASK0-CAN_FILTER_MASK3). The zero in the names of the filter and masks we coded do not associate them with Channel 0. After all, Channel 0 is our transmit channel. We need to associate the filter and mask we just created to the receive channel, which happens to be Channel 1:

```
CANLinkFilterToChannel  (CAN2, CAN_FILTER0,
CAN_FILTER_MASK0, CAN_CHANNEL1);
```

Now that CAN_FILTER0 and CAN_FILTER_MASK0 are attached to the receive channel, we can activate



■ FIGURE 2. Our code will instruct the PIC32MX CAN module to build two FIFO areas with eight 16-byte message buffers per FIFO.

CAN_FILTER0:

```
CANEnableFilter        (CAN2, CAN_FILTER0, TRUE);
```

PARDON ME

Interrupts are good. So, we'll monitor the CAN2 receive activity using them:

```
CANEnableChannelEvent(CAN2, CAN_CHANNEL1,
CAN_RX_CHANNEL_NOT_EMPTY, TRUE);
CANEnableModuleEvent(CAN2, CAN_RX_EVENT, TRUE);
```

I don't think the interrupt triggers need any additional explanation. However, we can't use the resources contained within the peripheral library to configure and activate the PIC32MX795F512L's interrupt mechanism. For that, we must turn to a sister PIC32MX peripheral library that majors in interrupt handling: the PIC32MX Interrupt Peripheral Library:

```
INTSetVectorPriority(INT_CAN_2_VECTOR,
INT_PRIORITY_LEVEL_4);
INTSetVectorSubPriority(INT_CAN_2_VECTOR,
INT_SUB_PRIORITY_LEVEL_0);
INTEnable(INT_CAN2, INT_ENABLED);
```

Again, no translation is necessary as what you see is what you get as far as the interrupt setup code is concerned. With that, we can exit configuration mode and fall into normal operation:

```
CANSetOperatingMode(CAN2, CAN_NORMAL_OPERATION);
while(CANGetOperatingMode(CAN2) !=
CAN_NORMAL_OPERATION);
```

TRANSMITTING A CAN MESSAGE

The CAN module will transmit messages that are stacked into a transmit FIFO. However, we can't just throw data into the transmit FIFOs in an ad hoc fashion. To that end, the peripheral library has done much of the transmission grunt work for us by setting up transmit message structures, bit fields, and logic. To understand the ways of the library when it comes to transmitting CAN messages, you need to know how the bytes to be transmitted are organized. **Figure 3** will come in handy as we discuss the CAN message transmit code. Find the SID bit field in **Figure 3**. You'll see that the SID bit field is 11 bits long and lies in the least significant 11 bits. The rest of the 32 bits in the CMSGSID area are not used. The CMSGSID bits can be defined in a structure like this:

```
typedef        struct
{
       unsigned SID:11;      //standard ID field
                             //- 0x0-0x7FF
       unsigned :21;         //unused
}CAN_TX_MSG_SID;
```

The next bit field encountered in **Figure 3** is the CMSGEID word. Even though we won't be sending EID messages, we still need to twiddle some bits in the CMSGEID memory space. For instance, the DLC (Data Length Control) bits specify the size of the data payload section of the CAN packet. Remember RTR? Well, the bit to enable or disable RTR is also part of the CMSGEID bit field. Another bit that is important to us is the IDE bit. This bit needs to be clear to indicate SID message transmission. You can easily match up the CMSGEID word's bit fields with this EID structure:

```
typedef struct
{
   unsigned DLC:4;   //valid range 0x00-0x08

   unsigned RB0:1;   //reserved - clear to 0
   unsigned :3;

   unsigned RB1:1;   //reserved - clear to 0

   unsigned RTR:1;   //0 = RTR disabled

   unsigned EID:18;  //extended ID field –
                     //0x0 – 0x3FFFF

   unsigned IDE:1;   //clear for SID

   unsigned SRR:1;   //ignored for SID
   unsigned :2;      //unused bits

}CAN_MSG_EID;
```

Now that you know how the peripheral library transmit message structures are coded, I think you'll have no problem in interpreting the union that represents a CAN transmit message buffer:

```
typedef union {

   struct
   {
// This is SID portion of the CAN TX message.
       CAN_TX_MSG_SID msgSID;      //32 bits =
                                   //1 word

// This is EID portion of the CAN TX message.
       CAN_MSG_EID msgEID;         //32 bits =
                                   //1 word

// This is the data portion of the CAN TX
message.
       BYTE data[8];               //64 bits =
                                   //2 words
   };

// This is CAN TX message organized as a set of
//32 bit words.
   UINT32 messageWord[4];          //4 words

}CANTxMessageBuffer;
```

I counted words within the union to show you that the messageWord array can cover all of the words in the structure if you wish it to. The messageWord array can be used to quickly clear the message buffer. To use all of that pretty union and structure code, we've got to point to it. That's easily done and we'll call the pointer to the CANTxMessageBuffer structure *message*:

```
CANTxMessageBuffer * message;
```

Address Offset	Name		Bit 31/2315/7	Bit 30/22/14/6	Bit 29/21/13/5	Bit 28/20/12/4	Bit 27/19/11/3	Bit 26/18/10/2	Bit 25/17/9/1	Bit 24/16/8/0
00	CMSGSID	31:24	—	—	—	—	—	—	—	—
		23:16	—	—	—	—	—	—	—	—
		15:8	—	—	—	—	—	SID<10:8>		
		7:0	SID<7:0>							
04	CMSGEID	31:24	—	—	SRR	IDE	EID<17:14>			
		23:16	EID<13:6>							
		15:8	EID<5:0>						RTR	RB1
		7:0	—	—	—	RB0	DLC<3:0>			
08	CMSGDATA0	31:24	Transmit Buffer Data Byte 3							
		23:16	Transmit Buffer Data Byte 2							
		15:8	Transmit Buffer Data Byte 1							
		7:0	Transmit Buffer Data Byte 0							
0C	CMSGDATA1	31:24	Transmit Buffer Data Byte 7							
		23:16	Transmit Buffer Data Byte 6							
		15:8	Transmit Buffer Data Byte 5							
		7:0	Transmit Buffer Data Byte 4							

■ FIGURE 3. The trick to understanding how the PIC32MX CAN peripheral library-based CAN transmission mechanism works is to think in 32-bit words organized as four eight-bit bytes.

We're not pointing to anything yet. We've only assigned a pointer to the CANTxMessageBuffer structure. So, let's make sure we're pointing at a valid transmit message buffer:

```
message = CANGetTxMessageBuffer
(CAN2,CAN_CHANNEL0);
```

Now we're pointing at a message buffer in Channel 0 which happens to be our transmit channel. A NULL returned to *message* means that we don't have a valid message buffer in our grasp. If we are truly pointing to a transmit message buffer in Channel 0, we can proceed with our transmission process. The first order of business is to build a CAN SID message. Before we can do that, we should clear the land so to speak. That's where the messageWord array comes into play:

```
if(message != NULL)
{
//clear the Message Buffer
message->messageWord[0] = 0;
message->messageWord[1] = 0;
message->messageWord[2] = 0;
message->messageWord[3] = 0;
```

Let's send a SID CAN message that contains one byte of data payload to a CAN node with the address of 0x101. Just for grins, let's make the payload byte an ASCII character that we can print and read in a terminal emulator. How about 0x41, which is an ASCII 'A:'

```
message->msgSID.SID   = 0x101;
message->msgEID.IDE   = 0;
message->msgEID.DLC   = 1;
message->data[0]      = 0x41;
```

We are pointing to the members of the pointed-to structure CANTxMessageBuffer and filling the members with our desired data. Note that the IDE is cleared indicating a SID message and the DLC field reflects the data payload length of one byte. We've posted our CAN message in a valid message buffer. Before we do anything else, we need to update the message buffer's internal pointers and send the message:

```
     CANUpdateChannel(CAN2,CAN_CHANNEL0);
     CANFlushTxChannel(CAN2,CAN_CHANNEL0);
}
```

Ever hear the sound of bits travelling down a wire? WHOOSH!!!!

RECEIVING A CAN MESSAGE

The interrupt handler we mentioned earlier is the first to know that a valid CAN message has been received. After the CAN receive interrupt fires, the CAN receive interrupt handler determines what caused the interrupt and branches accordingly. In our case, Channel 1 will be found to be the cause of the interrupt receive event. To prevent the receive interrupt from triggering again before we have time to service the original receive event, we must disable the receive interrupt trigger. We can then inform the application that a CAN message has been received via a flag, clear the receive interrupt flag, and return to the application. Here is what I just said translated to code:

```
void __attribute__((vector(47), interrupt(ipl4),
nomips16)) CAN2InterruptHandler(void)
{

   if((CANGetModuleEvent(CAN2) & CAN_RX_EVENT)
   != 0)
   {

      if(CANGetPendingEventCode(CAN2) ==
      CAN_CHANNEL1_EVENT)
      {

          CANEnableChannelEvent(CAN2, CAN_CHANNEL1,
          CAN_RX_CHANNEL_NOT_EMPTY, FALSE);
             isCAN2MsgReceived = TRUE;
             }
      }

      INTClearFlag(INT_CAN2);


}
```

The CAN receive message algorithm is similar to the transmit message except we are taking instead of giving from a message buffer point of view. We still have to assign a pointer to the receive message buffer:

■ PHOTO 2. The Microchip CAN bus analyzer tool is akin to an Ethernet Sniffer. Everything that is thrown onto the CAN bus is captured for your reading entertainment.

```
CANRxMessageBuffer * message;
```

The CAN receive interrupt handler we just examined determined that a valid message had been posted and set the flag isCAN2MsgReceived to TRUE. So, we can clear the isCAN2MsgReceived flag and obtain the address of the newly received CAN message:

```
if(isCAN2MsgReceived == FALSE)
{
        return;
}

isCAN2MsgReceived = FALSE;

message = CANGetRxMessage(CAN2,CAN_CHANNEL1);
```

Now that we have access to the receive message buffer that contains the incoming data payload, we can assess the data payload using a pointer to the members of the pointed-to structure which is, in this case, CANRxMessageBuffer:

```
if(message->data[0] == 0x41)
{
   //Data is an 'A" -
   //Do something
}
```

Once we've done our thing with the data payload, we need to update the receive message buffer's internal pointers and enable the receive interrupt trigger:

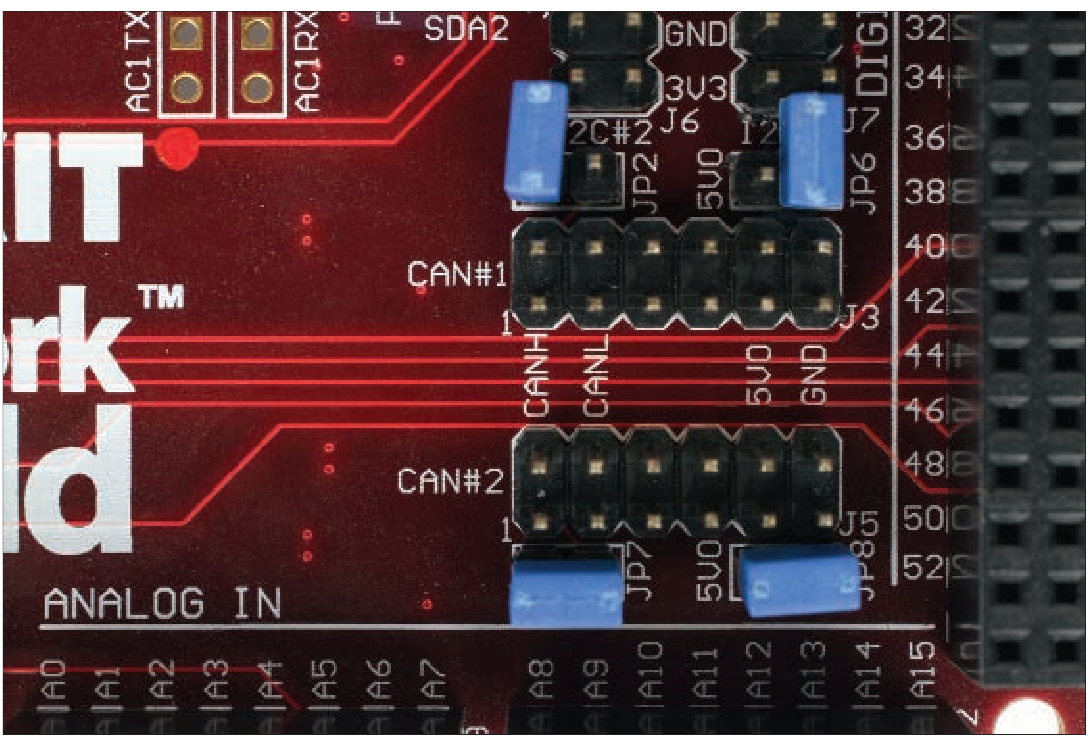
```
CANUpdateChannel(CAN2, CAN_CHANNEL1);
CANEnableChannelEvent(CAN2, CAN_CHANNEL1,
CAN_RX_CHANNEL_NOT_EMPTY, TRUE);
```

We're ready to receive the next CAN message.

CAN TO CAN

If you clone the CAN2 routines to CAN1 routines, you only need one chipKIT network shield to run the CAN transmit/receive code we've just discussed. I opted to use a pair of chipKIT Max32s. Each chipKIT Max32 was loaded with a chipKIT network shield. Using two CAN nodes allowed me to use the same CAN2 code on each node. To make sure that the desired bits were wobbling down the wire, I added the Microchip CAN bus analyzer tool you see in **Photo 2** to my chipKIT CAN. The bus analyzer tool provided an omnipresent view of the bits traversing between the CAN nodes.

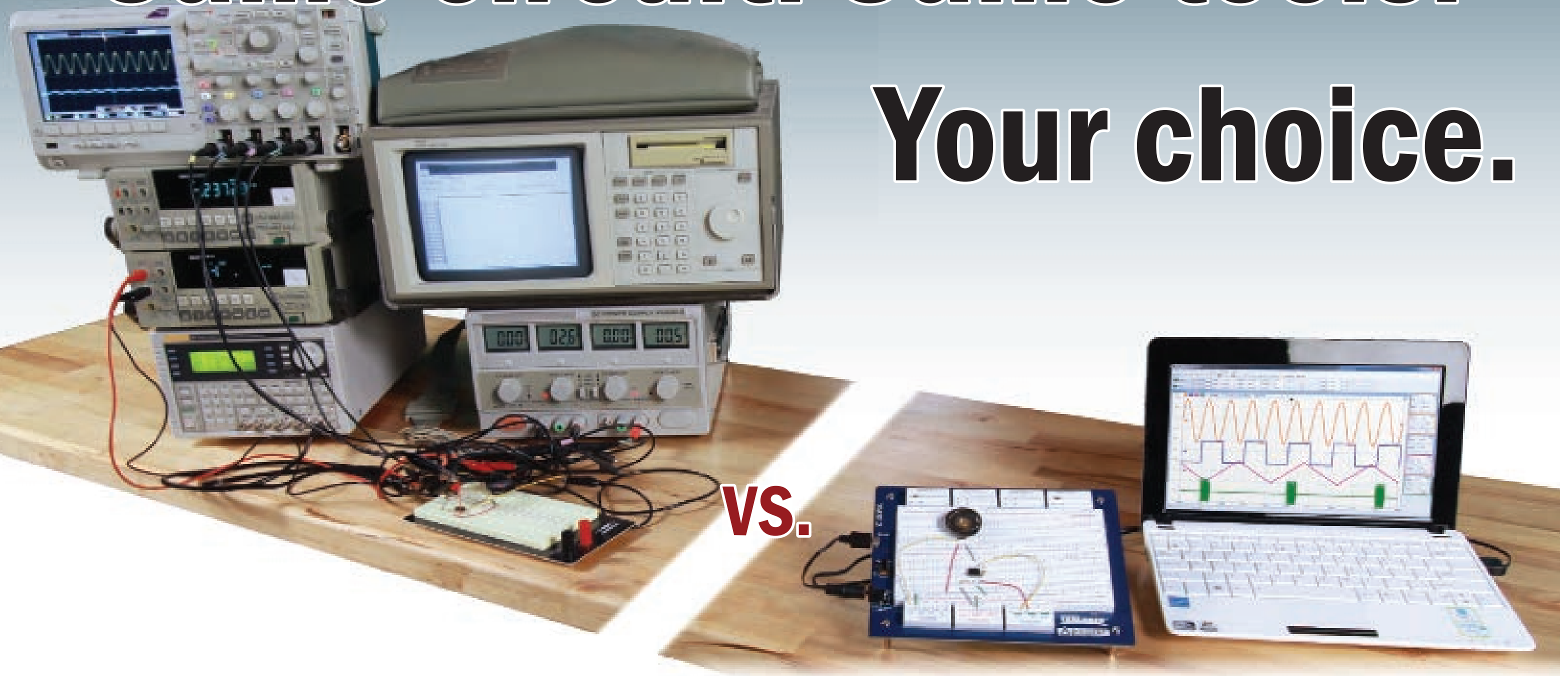
We started this project with a shot of the MCP2551 CAN transceivers. I'll wind up with an open shutter view of the chipKIT network shield's CAN interface in **Photo 3**. With the chipKIT Max32/chipKIT network shield combination, you're just a few connections away from adding CAN to your Design Cycle. **NV**



■ PHOTO 3. You can create a mini CAN network right here between the chipKIT network shield's CAN1 and CAN2 interfaces.

Same circuit. Same tools.

Your choice.



ELECTRONICS EXPLORER™

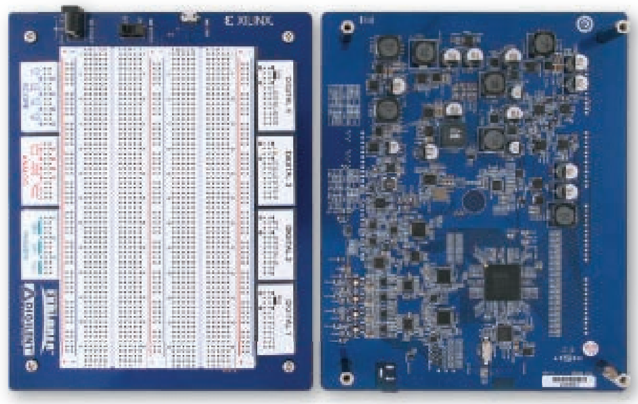
Integrated Analog/Digital Circuit Design Station

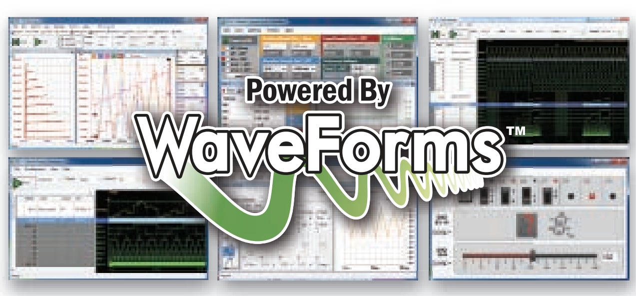
4-channel, 40MSa Oscilloscope
4-channel voltmeter
2 programmable reference voltages
2-channel Arbitrary Waveform Generator
Triple-Output Power Supply (two programmable)
32-Channel Logic Analyzer
32-Channel Pattern Generator
Discrete digital I/O's (buttons, switches, LEDs, etc)

The Digilent Electronics Explorer™ board (EE board) is a complete, all-in-one circuit design station that can turn any PC into a powerful test and measurement system. It combines everything needed to build and test analog and digital circuits into a single, simplified product: a large solderless breadboard, three programmable power supplies, and six test and measurement devices, all accessed using simple jumper wires. The free PC-based Waveforms™ software drives EE Board's high-speed USB2 port to create a powerful, high-bandwidth test and measurement system that responds in near real-time.

The waveform generators support standard and custom waveforms with sweeps, envelopes and modulation. The scope channels offer real-time FFTs, complex math functions, complete cursor and measurement features, and X-Y plots. The digital pattern generator and logic analyzer offer all the standard features and include cross-triggering with the analog instruments. The power supplies include full current and voltage control, and can be actively driven from the waveform generators to create new and interesting stimulus not possible with conventional equipment. These impressive features, together with real-time Bode plots, connection to a PC's sound system, and a host of other features create a truly remarkable piece of equipment.

Now you can quickly and easily build and test analog circuits right on the desktop, and change forever the way you approach analog design.





$399
(Academic)

Complete System!
Includes EE Board + Software

DIGILENT®
BEYOND THEORY

(509) 334-6306   www.digilentinc.com

CLASSIFIEDS

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

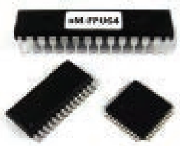
No Minimum Order.
Credit Cards and PAYPAL Accepted.
Flat $4.95 per order USA Shipping.

COMPONENTS

RF PARTS™ CO.

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

New **uM-FPU64**
64-bit Floating Point Coprocessor



64-bit and 32-bit IEEE 754 compatible
SPI or I2C interface, 3.3V Supply, 5V Tolerant I/O
Extensive floating point support, FFT, matrix operations
GPS input, local device support, Flash functions, IDE

Robotics
Navigation
Sensor Modules
Embedded Systems

Additional products...
uM-FPU V3.1 32-bit FPU
uM-PWM1 Servo Coprocessor

DIP-28, SOIC-28,TQFP-44

www.micromegacorp.com

www.Alan-Parekh.com/Store

KITS/PLANS

QKITS.COM

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

Electronic Kits

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

www.bakatronics.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

JOB OPPORTUNITIES

Senior High Precision Prototype Machinist

(Posting # Machinist-201109). XCOR Aerospace is seeking a senior and accomplished prototype precision machinist with ten plus (10+) years experience. US citizenship or current and valid Resident Alien status (i.e., Green Card) required. Candidate must be proficient in spoken and written standard American English and must be able to lift up to 50 pounds and climb / perform work on an 8 foot tall ladder. **Salary & Benefits:** Salary will be dependent on experience. Stock options, vacation / holidays and medical benefits plans are in place. Send resume and any accompanying information or web links by email to Aleta Jackson at jobs@xcor.com, and reference in the Subject Line "Job Posting Machinist-201109." References required.

Electrical/Electronics Engineer: XCOR Aerospace is seeking a hands-on electronics/electrical engineer with a BS engineering and five years experience (or non-engineering science degree plus three years additional equivalent in training and work experience). US citizenship or current and valid Resident Alien status (i.e., Green Card) required. Candidate must be proficient in spoken, and written, standard American English and must be able to lift up to 50 pounds and climb / perform work on an 8 foot tall ladder. **Salary & Benefits:** Salary will be dependent on experience. Stock options, vacation / holidays and medical benefits plans are in place. Send resume and any accompanying information or web links by email to Aleta Jackson at jobs@xcor.com, and reference in the Subject Line "Job Posting EE-201109." References required.

Structural Engineer: XCOR Aerospace is seeking a hands-on structural engineer with a BS engineering degree (MS preferred) and five years experience (or non-engineering science degree plus three years additional equivalent in training and work experience). US citizenship or current and valid Resident Alien status (i.e., Green Card) required. Candidate must be proficient in spoken and written standard American English and must be able to lift up to 50 pounds and climb / perform work on an 8 foot tall ladder. **Salary & Benefits:** Salary will be dependent on experience. Stock options, vacation / holidays and medical benefits plans are in place. **Responding & References**: Send resume and any accompanying information or web links by email to Aleta Jackson at jobs@xcor.com, and reference in the Subject Line "Job Posting Structural-201109." References required.

Electronics company seeking part-time account representatives, sales payment and bookkeepers. Applicants must be computer literate with access to the Internet, Send resume to:
moore1719@gmail.com

ENERGY SOLUTIONS

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

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)

Looking for robot stuff and kits?
www.servo magazine.com

HARDWARE WANTED

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

INDICATORS

The Smartest Indicator You Will Ever Buy
The LSI-55 Load Status Indicator

Turns Green when power is available, and Red when the load is active. Operates on AC or DC from 10 to 300 V. Visit our web site LSI-55.COM to learn more.

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

Continued from page 28

NEW ECONOMICAL 5/50 MHz SIGNAL GENERATORS

Saelig Company, Inc., has introduced two new, budget-priced, dual-channel function/arbitrary waveform generators — the SDG1005 and SDG1050 — which feature DDS (Direct Digital Synthesis) technology, providing stable, high precision, low distortion signals. In addition to sine waves, they also provide square waves with fast rising and falling edges, pulse and ramp waveforms, white noise, and arbitrary waveforms. The SDG Series has a clear, simple front panel, with a user-friendly layout and built-in help menu to simplify operation and adjustment. Also featured is built-in AM, FM, PM, PWM, and FSK modulation, without requiring an external modulating source. Both units can function as a 200 MHz frequency counter. USB device/host I/O allows for storage of waveforms and setups. SDG Series signal generators have two independent output channels with adjustable relative phase.

With a 125 MSa/s sample rate, 14-bit resolution, and 16 Kpts waveform record length, the SDG signal generators create precise waveforms. Modulation, sweep, and burst output modes are also provided. An extremely useful feature of the SDG Series is that they can interconnect with matching SDS1000 digital oscilloscopes for remote controlled testing and for directly reading and reconstructing stored scope waveforms. Housed in a rugged 11" x 9" x 4" case with built-in prop stand, the SDG1005 and SDG1050 AWGs are available now for US $399 and $599, respectively.

For more information, contact:
Saelig Company, Inc
Tel: **1-888-7SAELIG**
Email: **info@saelig.com**
Web: **www.saelig.com**

NEW WEBSITE — LIBSTOCK

MikroElektronika presents Libstock — a community website that allows users to share their projects and libraries. Libstock was created to provide the community with the necessary infrastructure to do this.

Libstock encapsulates many useful features for easier navigation, flexibility in code presentation, and mechanisms to get what users are searching for, using categories, search, sorting, and filters. Libstock allows participants to stay in touch with fellow contributors, to be notified of code changes, to discuss code implementation, and to express wishes for future development.

Libstock allows sharing of three major code types: Libraries, Projects, and Visual TFT/GLCD projects. Within those types, participants are allowed to share whatever is necessary, or whatever they find suitable and helpful to the end user. For example, libraries, examples, connections, schematics, help files, datasheets, additional documentation, and even PCB designs can be included.

For more information, contact:
mikroElektronika
Web: **www.libstock.com**

TECH FORUM
READER-TO-READER

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.*

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!***

>>> QUESTIONS

Single-Stroke AC Bell

We would like to operate a single-stroke AC bell that would ring once every time the phone rings in cadence. The telephone line power — 40 to 120 VAC at 15 to 60 Hz — should power the bell. We prefer no external power supply. A typical single-stroke bell has a coil voltage of 24 VAC drawing 0.5 amps. Coil resistance is 10 ohms.

#11111 **Michael Lenihan**
Southampton, NY

Better Radio Communications

I've been a reader for some years, and electronics is my daily work. Now, I have to work with the Motorola PTP 600 radio. The system I am working now has three sets of PTP 600. They were set up the same way at three different locations to communicate to the main control hub. One of the stations has kept the connection pretty well since the first day, but the other two sometimes show slow or very slow data transmit. Looking at the status — as they are all set up with i_DFS — the link capacity sometimes drops to 20, the transmit in teens, and the vector error goes up positive. Please show me how I can get them to work more stably. I am working in the war zone of Afghanistan!

#11112 **PhuocThanhLe**
via email

Frequency Changes In Cold Weather

I built the "Mail Delivered Detector" published in the June '06 issue of *N&V* (**http://nutsvolts.texterity.com/nutsvolts/200606/#pg44**) and was quite satisfied with the results. However, I found that the device stopped working in the cold weather. Adjusting the 25K pot on the receiver's 567 tone detector restored operation until the temperature changed and the device stopped working again.

As an example, I measured the frequency of the transmitter's 555 timer at 68 degrees F to be 320 Hz, and at 20 degrees F it was 280 Hz.

Can someone suggest any modification which will keep the 555 timer circuit in the transmitter on frequency as temperature varies between minus 10 degrees and 95 F, or a way to broaden the frequency range of the tone detector in the receiver?

#11113 **J. G. Jones**
via email

Passive Mixer Problems

I've built this passive audio mixer that I really like. The only problem is that anything going through it sounds like it's in a stream of water. Lots of white noise.

After the mixer, it goes into the line level input of an old Teac audio cassette machine. Anything plugged into the cassette machine without going through the little mixer sounds great. The signal to noise is great. Very little white noise is present. What type of pre-amp do I need on each input to et the signal up high enough to override the white noise that my passive mixer generates?

#11114 **Robert V.**
via email

Power Conversion

I would like to make a special power supply/converter with a difference. It can be supplied from:

- A nominal 12 VDC (nine to 15 actual) from a vehicle supply.
- Or by a nominal 24/28 VDC supply (20 to 32) from a vehicle or aircraft supply.
- Or, by international mains (90 to 250 VAC).
- All three inputs need to be isolated and capable of being accidentally or deliberately connected at the same time.
- Have all three inputs tolerant to transients, e.g., mains derived from generator.

The unit needs to have four outputs, all of which are DC and each of which is configurable internally by a trim pot to deliver four output voltages between 10 and 24 VDC (e.g., 12V, 15V, 18V, and 22V).

- Output to be unaffected by change of input source.
- Once set, each output voltage needs to maintain a tolerance of ±0.5 VDC, regardless of input changes.
- Each output to be capable of delivering 120 watts.
- Robust, portable unit.

I understand that these parameters are often mutually exclusive, but the following considerations are also desirable:

- Low weight.
- Small size.
- Low heat dissipation.
- Low noise.
- Low interference.
- High quality.

If the overall concept is too big, perhaps someone could direct me to previous power conversion solutions that may be married together to give a solution, and highlight the isolation issues that may apply regarding multiple input connections.

#11115 **Kevin Dickinson**
Mudgee, NSW Australia

Power Failure Circuit

Our church has analog controlled dimmer modules. The controller has four scenes learned in some type of memory. After a power failure, the controller does not know the state it was in at the time of the failure. The default setting is that the controller selects scene 4 after the power is restored. Since most of the time the power interruptions are at night when the church is not occupied, the system is wasting energy. For safety reasons, this was acceptable at one time, but the cost of energy is a concern. The four scenes and off modes are selected by a momentary contact closure. The manufacturer solution is to upgrade to digital control. Is there a circuit design using a microcontroller that could capture the state the controller was in at the time of the power failure and restore the controller to the mode after power is available?

#11116 **Philip Popiel**
Thornton, PA

BASIC Stamp Help Needed

I am a beginner using a Parallax BASIC Stamp kit #555-28158. How do I wire seven LEDs and program them to come on and off in certain orders or patterns? Is it possible with this kit?

#11117 **Saul**
Odessa, TX

Long Range Wireless RS-232

How can a long range wireless RS-232 link between two computers be built? I'd be very interested in how to get an effective range of 3-5 miles.

#11118 **Todd Norvell**
via email

Loudspeaker/CB Combination

I was wondering if it would be possible to cheaply build a system in which I speak into a CB type radio, and have the signal sent to a loudspeaker about 1,000 feet away or slightly more? The current system I have is a bullhorn, and I have to stand a good distance back from the crowd to accomplish my task. It kills my voice. I was thinking if I could buy a loudspeaker (what wattage?) and a set of CBs that I should be able to modify the other CB to feed into the amplified loudspeaker so I can simply talk into it.

Surely there is a commercial version, but I'd like to be able to do it on the cheap if possible.

#11119 **Daryl McIntire**
Seneca, SC

Building a "Recording" Warning Sign

I'd like a circuit to power LEDs or an electro-luminescent display to be used as a "Recording" light in a small studio. Ideally, the sign would come on fully for several seconds at first, and then flash on and off slowly, ramping the voltage to the display or LEDs up and down, so as to create a soft blinking display.

#11110 **Al Parry**
Preston, MD

Transformer Needed

I am looking for an AC/DC transformer with a variable voltage input of 47 VAC to 277 VAC, with a secondary output of 12 VDC.

Does anyone know where I can find one or have one made?

#11111 **Richard Ashoff**
via email

>>> ANSWERS

[#10111 - October 2011]
PIC16F690

What is the easiest or best way to PWM a PIC16F690? I've seen Chuck Hellebuyck's book, but he uses an external pot to manually do it. I need to do it in software.

I have posted an 11 page PWM tutorial, complete with code for the 16F690 as it relates to driving an LED. I hope this helps.

http://igen.eetimes.com/tutorials/Vary_LED_Brightness.pdf

Jon Titus
Herriman, UT

Following is an excerpt from Jon's excellent tutorial. Download and read the full document for the complete explanation.

"Suppose you want a microcontroller (MCU) to adjust the intensity of LED light. You could use a motor to turn a potentiometer that adjusts a transistor's base current, but that approach doesn't make sense, and many MCUs offer a better way to control intensity.

Those MCUs include at least one pulse-width modulator (PWM) output. This output creates a signal that varies between, say, three volts and zero volts at a preset pulse period, as shown in **Figure 2**. Software varies the pulse width. If the MCU creates a PWM signal that looks like a square wave, the voltage exists at three volts for 50 percent of the time and at ground for 50 percent of the time.

The MCU can adjust the pulse width — thus it modulates the pulse width — so you could have a series of pulses at three volts for 10 percent of the time and at ground 90 percent of the time. The percentages of on and off times always add to 100 percent.

If you use this signal to control a transistor that operates as a switch, the LED would turn on only 10% of the time. Because your eye cannot respond quickly enough to the frequency of the pulses, the LED simply appears dimmer.

You can use a MCU such as the Microchip Technology PIC16F690 in the PICDEM Lab Development Board kit (DM163035) to generate a PWM signal controlled by software. Then, a program will vary the brightness of one or more LEDs between off and full on.

Here's an overview of how to use the 16F690 PWM signal "generator." This description applies only to this MCU. Other MCUs also have PWM sections, but require different settings.

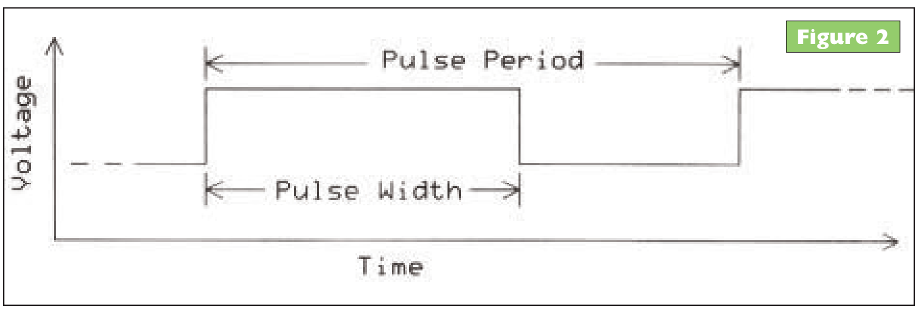


Figure 2

Microchip Technology has labeled the PWM section of the PIC16F690 MCU, "Enhanced Capture/Compare/PWM Module," but I'll refer only to its PWM capabilities that let you set the pulse period (or frequency) and the pulse width. You can read the PWM Operations section below and then the PWM Setup & Use section, or simply jump ahead to the latter section if you just want to use the PWM and don't care how it works.

PWM Setup & Use

In the PIC16F690 MCU, you direct the PWM signal to the P1A (pin 5), the P1B pin (pin 6), the P1C pin (pin 7), or the P1D pin (pin 14). The information that follows will use the P1A output which, according to the MCU's datasheet, has the combined functions RC5/CCP1/P1A. So, this pin shares functions between the PWM output and port C, bit RC5. I'll use the pin solely as the PWM output.

To simplify use of the PWM output, I recommend you start with the PICDEM Lab 1 experiment that sets on on-off pattern on eight LEDs connected to the eight port C pins on the 16F690 MCUs. When you can successfully run this program, add the PWM program steps as explained next.

For the Lab 1 information, refer to the Microchip document, "PICDEM Lab Development Board User's Guide," DS41369B, available for download at: **http://ww1.microchip.com/downloads/en/DeviceDoc/41369B.pdf**."

Give the Gift of Nuts & Volts!

Give a one year (12 issues) subscription to a friend and they will receive an extra THREE FREE ISSUES! That's right! A total of 15 issues in all!

U.S. Price: 1 Yr – $26.95

Subscribe online at: www.nutsvolts.com
or call:
877-525-2539 (toll free)
818-487-4545 (outside US)

Not only will they get 15 great issues, but they will also receive:

- ***Access to the digital edition***
- ***Discounts in the Webstore***
- ***Online only content and downloads***
- ***And so much more!***

Go now to www.nutsvolts.com to enter your gift order!

*Be sure to use promotion code **Y1WXMS** when ordering.*

AMATEUR RADIO AND TV
Ramsey Electronics, Inc. 20-21
V-Module 60

BATTERIES/CHARGERS
Cunard Associates 29
PowerBotix 39

BUYING ELECTRONIC SURPLUS
Jaycar Electronics 61
Weirdstuff Warehouse 29

CCD CAMERAS/VIDEO
4ATV.com 29
Circuit Specialists, Inc. 82-83
Ramsey Electronics, Inc. 20-21

CIRCUIT BOARDS
AP Circuits 63
Cunard Associates 29
Digilent 75
Dimension Engineering 33
ExpressPCB 9
Front Panel Express LLC 60
Futurlec 19
PCB Pool 46
R.E. Smith Inc. 8
Saelig Company Inc. 63
V-Module 60

COMPONENTS
Cana Kit Corp. 53
Electronix Express 59
Jameco 5
Fun Gizmos 29
Futurlec 19
Noritake 39
PowerBotix 39
V-Module 60

COMPUTER
Hardware
Noritake 39
Weirdstuff Warehouse 29

Microcontrollers / I/O Boards
Abacom Technologies 39
Bitscope 4
Chipino 29
Fun Gizmos 29
microEngineering Labs 43
MikroElektronika 3
Parallax, Inc. ....Back Cover
Pololu Robotics & Electronics 47
Solarbotics/HVW 62

DESIGN/ENGINEERING/REPAIR SERVICES
Cana Kit Corp. 53
ExpressPCB 9
Front Panel Express LLC 60
PCB Pool 46

EDUCATION
BaneBots 62
Bitscope 4
Blue Wolf 27
Command Productions 27
Digilent 75
Global Specialties 7
NKC Electronics 29
Poscope 62

EMBEDDED TOOLS
NetBurner 2

ENCLOSURES
Front Panel Express LLC 60
Integrated Ideas & Tech. 60

KITS & PLANS
Cana Kit Corp. 53
Jaycar Electronics 61
NetBurner 2
NKC Electronics 29
QKITS 29
Ramsey Electronics, Inc. 20-21
Solarbotics/HVW 62

MISC./SURPLUS
All Electronics Corp. 81
Front Panel Express LLC 60
Weirdstuff Warehouse 29

MOTORS
BaneBots 62
Jameco 5

OPTICS
Noritake 39

PROTOTYPING & TRAINERS
Global Specialties 7

PROGRAMMERS
Futurlec 19
microEngineering Labs 43
MikroElektronika 3

RF TRANSMITTERS/RECEIVERS
4ATV.com 29
Abacom Technologies 39
Blue Wolf 27

ROBOTICS
BaneBots 62
Blue Wolf 27
Digilent 75
Fun Gizmos 29
Jameco 5
Lemos International Co., Inc. 29
Lynxmotion, Inc. 63
Pololu Robotics & Electronics 47
PowerBotix 39
Robot Power 29
Solarbotics/HVW 62

SATELLITE
Lemos International Co., Inc. 29

SECURITY
4ATV.com 29

TEST EQUIPMENT
Bitscope 4
Circuit Specialists, Inc. 82-83
Dimension Engineering 33
Global Specialties 7
Jaycar Electronics 61
NKC Electronics 29
Pico Technology 13
Poscope 62
Saelig Company Inc. 63

TOOLS
MikroElektronika 3
NetBurner 2
PanaVise 33
Poscope 62

4ATV.com 29
Abacom Technologies 39
All Electronics Corp. 81
AP Circuits 63
BaneBots 62
Bitscope 4
Blue Wolf 27
Cana Kit Corp. 53
Chipino 29
Circuit Specialists, Inc. 82-83
Command Productions 27
Cunard Associates 29
Digilent 75
Dimension Engineering 33
Electronix Express 59
ExpressPCB 9
Front Panel Express LLC 60
Fun Gizmos 29
Futurlec 19
Global Specialties 7
Integrated Ideas & Tech. 60
Jameco 5
Jaycar Electronics 61
Lemos International Co., Inc. 29
Lynxmotion, Inc. 63
microEngineering Labs 43
MikroElektronika 3
NetBurner 2
NKC Electronics 29
Noritake 39
PanaVise 33
Parallax, Inc. ....Back Cover
PCB Pool 46
Pico Technology 13
Pololu Robotics & Electronics 47
Poscope 62
PowerBotix 39
QKITS 29
Ramsey Electronics, Inc. 20-21
R.E. Smith Inc. 8
Robot Power 29
Saelig Company Inc. 63
Solarbotics/HVW 62
V-Module 60
Weirdstuff Warehouse 29

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.

RGB COLOR-CHANGING LED

5mm (T1-3/4) led cycles through, red - green - blue and combinations of those colors, yielding white, purple and other hues. Changes color every 3 or 4 seconds. Water-clear in off-state. Great for attention getting displays, costumes or jewelry.

CAT# LED-158

10 for 70¢ ea. • 100 for 50¢ ea.

75¢ each

9 VDC BUZZER

Mechanical, medium-loud buzzer. Ideal for school projects. 16.9mm x 23mm (33.38mm base mounting tabs, 1.1" centers) x 15.39mm body. 9 Vdc, can operate @ 3 Vdc. 4.5" long leads.

CAT# BZ-90

$1.25 each

20 for $1.15 each

LIGHTWEIGHT STEREO HEADPHONES

Lightweight stereo headphones for audio and computer applications. Adjustable headband. 3.5mm phone plug with 4' shielded cord.

CAT# HP-100

100 for $2.50 each

$3.35 each

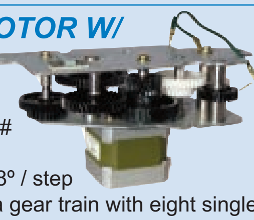
MINI-STEREO AUDIO AMPLIFIER W/ SPEAKERS

Miniature 4W (2 x 2W) stereo amplifier with speakers and battery holder. 3.5mm stereo phone plug input connects to many portable audio sources, MP3s, iPods etc. The on-off switch and volume control are in a 34mm square module attached to the amplifier with a 29" flat cable. The speakers included with the amp are an interesting pair of 1.30" x 1.45" x 0.36" flat-panel speakers incorporating a unique cone-less technology. We don't know for what application these speakers are intended; they might be better for voice or sound effects, but the amplifier sounds a lot better with traditional 4 Ohm cone-type speakers. Operates on 4 AA batteries, not included.

CAT# AMP-5

$8.50 each

STEPPER MOTOR W/ GEAR TRAIN



Japan Servo Motor# KH42JM2-038. 6-pin connector, 1.8º / step motor attached to a gear train with eight single and compound gears. Motor is 42mm square (1.63") x 1.57" long with a 5mm dia. shaft with a brass gear attached. The gear train is 6" x 1.45" overall and is removable. Requires an 11-pin socket connector, 2mm pitch for connection.

CAT# SMT-107

$10.00 each

18 GAUGE TEFLON TUBING, NATURAL

PTFE 18 TW NATURAL. 18 Gauge, thin-wall Teflon tubing. Natural (white). TFE-TW-300. Type VW-1. Rated 200C Degrees. 300V rated. Nominal I.D. 0.042". Wall Thickness: 0.012". CSA. 5' min.

CAT# PTFE-18

5 ft. for $1.50

100' for 25¢ per ft. • 1000' for 18¢ per ft.

MINI-PANCAKE VIBRATING MOTOR

LG Innotek Co.# TA09-T3001459AA / Spec MVMF-A346T3. 10mm dia. x 3mm thick. Operates on 1.5 - 4 Vdc. Two 12mm wire leads. Prepped with adhesive patch on one side.

CAT# DCM-707

$1.00 each

50 for 80¢ each • 100 for 75¢ each

12VDC 1A POWER SUPPLY

Switching power supply. Input: 100-240V, 50-60Hz, 0.3A. Output: 12Vdc, 1Amp. Right-angle coax power plug. 5.5mm od, 2.1mm id, center+. cULus, CE.

CAT# PS-1219

$8.95 each

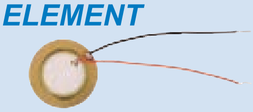
PRECISION DC GEAR MOTOR, USED

FAULHABER #1624E024SNP305. Small, powerful-for-its-size, very-low current, Swiss made gear motor. No-load Ratings: 320 RPM @ 12Vdc/ 2.5mA. 545 RPM @ 20Vdc / 3.9mA. 17mm diameter x 40mm long overall. 2mm diameter x 10mm shaft with attached 11.7mm diameter pulley for round, 2mm belt. Motor face has 4 tapped mounting holes. Two wire leads, 45mm. Used, removed from equipment in good condition.

CAT# DCM-705

$8.85 each

21MM PIEZO ELEMENT



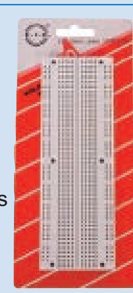
50mm wire leads.

CAT# PE-56

$1.00 each

10 for 85¢ each

BREADBOARD, 840 CONTACTS

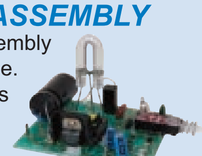


Breadboards accommodate all sizes of dips and discrete components. Interconnect with solid hook-up wire (#22 AWG recommended). Wires and components can be used and re-used many times without damage to board or components. Dual row of buss terminals on each side of terminal strip.

CAT# PB-840

$7.65 each

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

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.

Big Stepper Motor Sale!

CircuitSpecialists carries a large selection of Stepper Motors and Controllers. Stepper motors are available in NEMA 11, NEMA 14, NEMA 16, NEMA 17, NEMA 23, & NEMA 34 Frame Sizes.

NEMA 11 Stepper Motor .44 kg-cm 6 Wire
28BYG201
Price: $ 11.95

NEMA 11 Stepper Motor .61 kg-cm 4 Wire
28BYG301
Price: $ 12.95

NEMA 11 Stepper Motor .76 kg-cm 6 Wire
28BYG401
Price: $ 13.95

NEMA 11 Stepper Motor 1 kg-cm 4 Wire
28BYG501
Price: $ 14.95

NEMA 14 Stepper Motor .5 kg-cm 6 Wire
35BYG101
Price: $ 10.95

NEMA 14 Stepper Motor .5 kg-cm 6 Wire
35BYG202
Price: $ 10.95

NEMA 14 Stepper Motor .7 kg-cm 6 Wire
35BYG307
Price: $ 11.75

NEMA 14 Stepper Motor 1 kg-cm 6 Wire
35BYG305
Price: $ 11.75

NEMA 14 Stepper Motor 1.4 kg-cm 6 Wire
35BYG409
Price: $ 11.75

NEMA 16 Stepper Motor .66 kg-cm 4 Wire
39BYG101
Price: $ 10.95

NEMA 16 Stepper Motor .82 kg-cm 6 Wire
39BYG105
Price: $ 10.95

NEMA 16 Stepper Motor 1.0 kg-cm 4 Wire
39BYG302
Price: $ 10.95

NEMA 16 Stepper Motor 1.3 kg-cm 6 Wire
39BYG403
Price: $ 10.95

NEMA 16 Stepper Motor 1.8 kg-cm 4 Wire
39BYG407
Price: $ 10.95

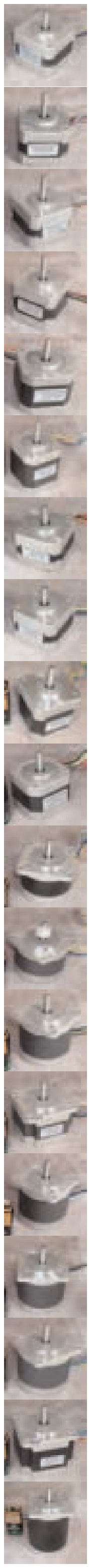
NEMA 16 Stepper Motor 2.0 kg-cm 6 Wire
39BYG504
Price: $ 11.75

NEMA 17 Stepper Motor 1.3 kg-cm 6 Wire
42BYG205
Price: $ 10.49

NEMA 17 Stepper Motor 1.5 kg-cm 6 Wire
42BYGH3404
Price: $ 9.75

NEMA 17 Stepper Motor 1.6 kg-cm 6 Wire
42BYGH007
Price: $ 9.75

NEMA 17 Stepper Motor 1.7 kg-cm 6 Wire
42BYG020
Price: $ 9.95



NEMA 17 Stepper Motor 1.8 kg-cm 6 Wire
42BYGH019
Price: $ 9.75

NEMA 17 Stepper Motor 2.0 kg-cm 6 Wire
42BYG228
Price: $ 10.49

NEMA 17 Stepper Motor 2.4 kg-cm 4 Wire
42BYGH011
Price: $ 9.75

NEMA 17 Stepper Motor 2.4 kg-cm 6 Wire
42BYGH102
Price: $ 10.49

NEMA 17 Stepper Motor 3.2 kg-cm 6 Wire
42BYGH3906
Price: $ 10.49

NEMA 17 Stepper Motor 4.2 kg-cm 4 Wire
42BYGH4807
Price: $ 10.95

NEMA 17 Stepper Motor 1.25 kg-cm 6 Wire
42BYG015
Price: $ 9.95

NEMA 17 Stepper Motor 1.0 kg-cm 6 Wire
42BYG013
Price: $ 9.95

NEMA 17 Stepper Motor 3.0 kg-cm 4 Wire
42BYGH207
Price: $ 10.95

NEMA 17 Stepper Motor 3.4 kg-cm 6 Wire
42BYGH404
Price: $ 10.95

NEMA 23 Stepper Motor 3.0 kg-cm 6 Wire
57BYG007
Price: $ 14.75

NEMA 23 Stepper Motor 3.0 kg-cm 6 Wire
57BYG201
Price: $ 14.75

NEMA 23 Stepper Motor 4.2 kg-cm 6 Wire
57BYG066
Price: $ 15.25

NEMA 23 Stepper Motor 4.4 kg-cm 6 Wire
57BYGH006
Price: $ 14.75

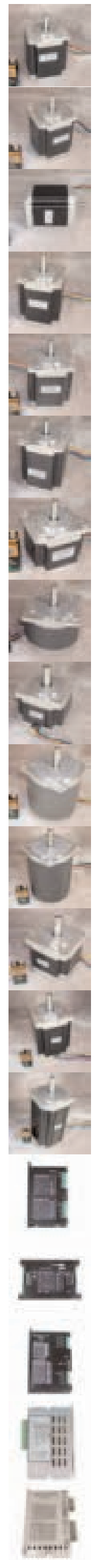
NEMA 23 Stepper Motor 5.0 kg-cm 6 Wire
57BYG008
Price: $ 15.25

NEMA 23 Stepper Motor 5.8 kg-cm 6 Wire
57BYG210
Price: $ 15.59

NEMA 23 Stepper Motor 7.6 kg-cm 6 Wire
57BYG081
Price: $ 15.25

NEMA 23 Stepper Motor 8.2 kg-cm 6 Wire
57BYGH104
Price: $ 15.25

NEMA 23 Stepper Motor 10.0 kg-cm 6 Wire
57BYG320
Price: $ 21.49



NEMA 23 Stepper Motor 13.0 kg-cm 6 Wire
57BYGH302
Price: $ 20.89

NEMA 23 Stepper Motor 15.0 kg-cm 6 Wire
57BYGH311
Price: $ 20.89

NEMA 23 Stepper Motor 18.0 kg-cm 6 Wire
57BYGH317
Price: $ 20.89

NEMA 23 Stepper Motor 16.0 kg-cm 6 Wire
57BYGH303
Price: $ 19.95

NEMA 23 Stepper Motor 24.0 kg-cm 6 Wire
57BYGH310
Price: $ 20.89

NEMA 23 Stepper Motor 21.0 kg-cm 6 Wire
57BYGH405A
Price: $ 22.50

NEMA 23 Stepper Motor 8.0 kg-cm 6 Wire
57BYGH207
Price: $ 13.95

NEMA 34 Stepper Motor 11.8 kg-cm 8 Wire
86BYG450A-01
Price: $ 42.89

NEMA 34 Stepper Motor 11.8 kg-cm 6 Wire
85BYGH450A-04
Price: $ 48.95

NEMA 34 Stepper Motor 28.0 kg-cm 8 Wire
86BYG450B-02
Price: $ 63.50

NEMA 34 Stepper Motor 30.0 kg-cm 8 Wire
86BYG450C-05
Price: $ 84.95

NEMA 34 Stepper Motor 42.0 kg-cm 6 Wire
85BYGH450A-08
Price: $ 48.95

NEMA 34 Stepper Motor 48.0 kg-cm 8 Wire
85BYGH450B-03
Price: $ 49.50

NEMA 34 Stepper Motor 63.0 kg-cm 8 Wire
85BYGH450C-03
Price: $ 69.50

24V~36V DC Stepper Motor Controller
CW230
Price: $39.50

20V~60V DC Stepper Motor Controller
CW250
Price: $42.00

24V~70V DC Stepper Motor Controller
CW860
Price: $79.00

24V~36V DC Stepper Motor Controller
XCW220
Price: $29.50

12V~36V DC Stepper Motor Controller
QJ-215
Price: $42.00

www.CircuitSpecialists.com/stepper-motors-and-controllers

CircuitSpecialists.com

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

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

60 Watt Digital Soldering Station

For use with traditional or Lead Free Soldering

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

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

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

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

Programmable DC Electronic Loads

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

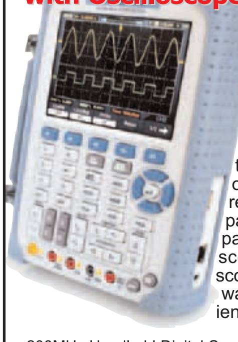
360V/150W (CSI3710A) $349.00

www.circuitspecialists.com/csi3710a

360V/300W (CSI3711A) $499.00

www.circuitspecialists.com/csi3711a

200MHz Hand Held Scopemeter with Oscilloscope & DMM Functions



Includes 1 Year USA Warranty

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

- 200MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 200MHz Bandwidth with 2 Channels
- 500MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # **DSO1200** *New Low Price!* **$589.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

- 60MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 60MHz Bandwidth with 2 Channels
- 150MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # **DSO1060** *New Low Price!* **$429.00**

www.circuitspecialists.com/DSO1200

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

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

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

www.circuitspecialists.com/DSO-8060

Programmable DC Power Supplies

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

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

www.CircuitSpecialists.com/inspection-cameras

Ideal for Law Enforcement, Post Fire Inspection, Plumbing, Facilities Maintenence, Security Companies, & Many Other Uses!

Aardvark II

Dual Camera Wireless Inspection Camera With Color 3.5" LCD Recordable Monitor

Your Extended Eyes & Hands!

See It! Clearly in narrow spots, even in total darkness or underwater.

Find It! Fast. No more struggling with a mirror & flash light.

Solve It! Easily, speed up the solution with extended accessories.

Record It! With the 3.5" LCD recordable monitor, you can capture pictures or record video for documentation.

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

Item # **AARDVARK II** **$199.00**

www.CircuitSpecialists.com/aardvark-ii

Aardvark Nine

9mm Wireless Inspection Camera With Color 3.5" LCD Recordable Monitor

Your Extended Eyes & Hands!

Same great Aardvark Wireless Inspection Camera System, but with only the 9mm Camera for a lower cost option!

Item # **AARDVARK NINE** **$149.00**

www.CircuitSpecialists.com/aardvark-nine

Aardvark Jr

9mm Wireless Inspection Camera With Color LCD Monitor

With its small 9mm camera head, the Aardvark Jr allows for easy visual inspection in hard-to-reach areas. Lightweight, handheld design to easily find, diagnose and solve problems with the flexible extended tube and useful accessories.

Item # **AARDVARK JR** **$79.00**

www.CircuitSpecialists.com/aardvark-jr

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210

Phone: 800-528-1417 / 480-464-2485 / Fax: 480-464-5824

2011 Gift Guide

For all your holiday gift giving (and gift getting!) needs, here is a tailored group from our vast selection of microcontrollers, robots, kits, sensors and accessories. For complete product catalog, visit www.parallax.com *(Clockwise from upper left)*

Boe-Bot Robot Kit (USB Version; #28832; $159.99) Learn programming and robotics with this BASIC Stamp-controlled robot kit. Serial with USB adapter version also available (#28132)

PING))) Ultrasonic Sensor (#28015; $29.99) Easy method of distance measurement for robotics, security, and infrared replacement applications.

S2 (Scribbler 2) Robot (#28136; $129.99) The S2 is pre-programmed with 8 demo modesand has a colorful GUI programming interface for your PC.

VPN1513 GPS Receiver module (#28506; $59.99) An open source, customizable GPS solution that can track up to 20 satellites.

Memsic 2125 Dual-axis Accelerometer (#28017; $29.99) A dual-axis thermal accelerometer to measure tilt, acceleration, rotation, and vibration; range of ±3 g.

BASIC Stamp Activity Kit (#90005; $79.99) Learn circuit-building and programming at the same time with the BASIC Stamp microcontroller!

PIR Sensor (#555-28027; $10.99) A passive infrared motion sensor for your microcontroller project.

RFID Reader and Tag Sampler Kit (Serial; #32390; $42.99) Easily read passive RFID transponder tags.

Order online anytime at **www.parallax.com** or call toll-free at 888-512-1024 (M-F, 7AM-5PM, PDT).

Friendly microcontrollers, legendary resources.™

Prices subject to change without notice. BASIC Stamp, and Boe-Bot are trademarks of Parallax Inc. Parallax and the Parallax logo are trademarks of Parallax Inc.

PARALLAX INC

www.**parallax**.com

"ParallaxInc" on Twitter, Facebook, and YouTube