PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

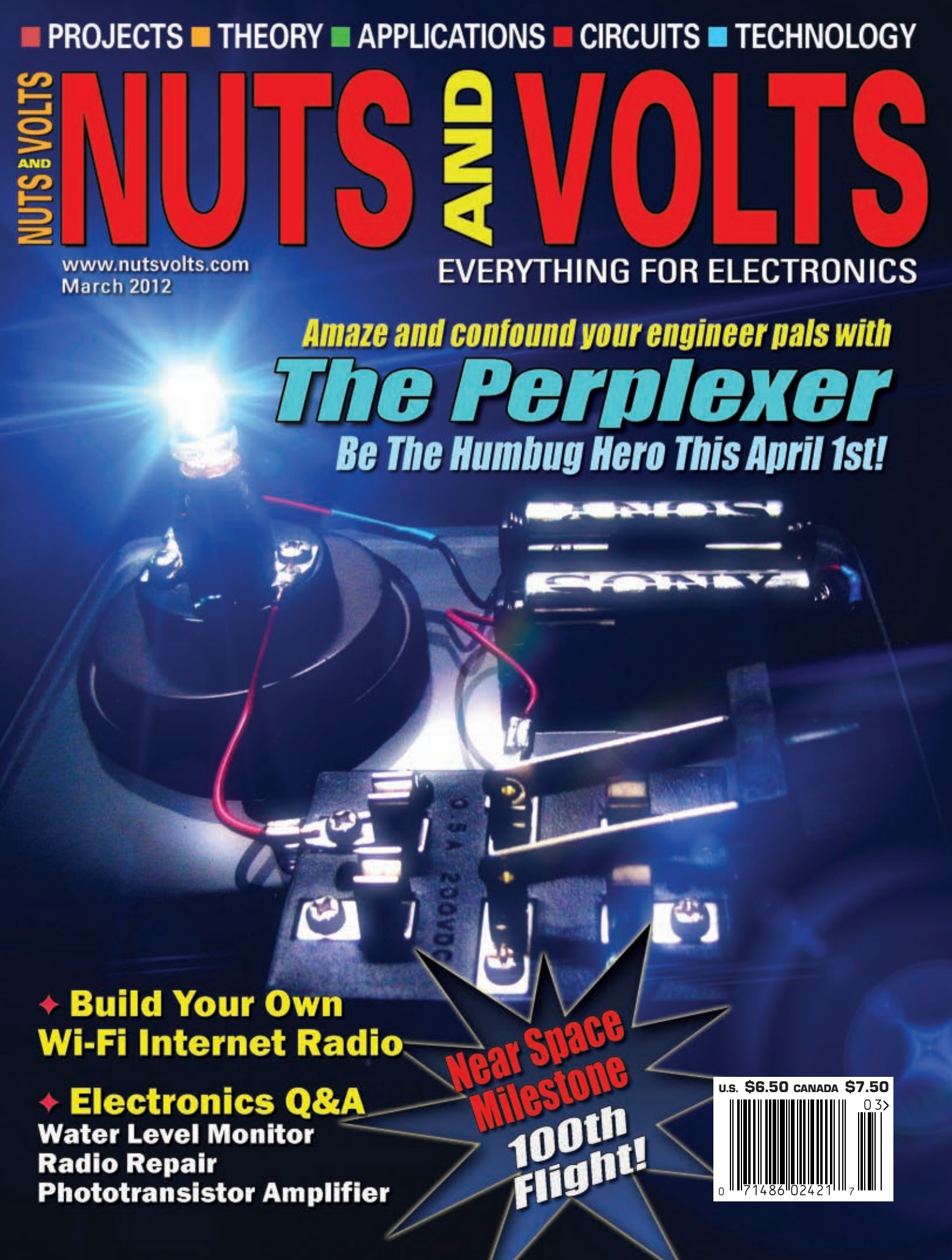
NUTS AND VOLTS

NUTS AND VOLTS

www.nutsvolts.com
March 2012

EVERYTHING FOR ELECTRONICS

Amaze and confound your engineer pals with
The Perplexer
Be The Humbug Hero This April 1st!



- **Build Your Own Wi-Fi Internet Radio**
- **Electronics Q&A**
  - Water Level Monitor
  - Radio Repair
  - Phototransistor Amplifier

Near Space Milestone 100th Flight!

U.S. $6.50 CANADA $7.50
03
0 71486 02421 7

The NetBurner SB70LC

$49.00
Qty. 100
SB70LC Board

The complete hardware and software solution

- Low-cost
- 10/100 Ethernet
- Two Serial Ports
- 32-bit Performance
- Digital I/O
- SSH/SSL Option
- Flash Card Ready
- I²C • SPI Interface
- Example applications

$99.00
SB70LC Development Kit

The SB70LC Development Kit

The NetBurner SB70 LC Development Kit is available to customize any aspect of operation including web pages, data filtering, or custom network applications. The kit includes platform hardware, ANSI C/C++ compiler, TCP/IP stack, web server, e-mail protocols, RTOS, flash file system, Eclipse IDE, debugger, and cables. The kit enables you to communicate with peripherals that use SD/MMC Flash Card (including SDHC), SPI, I²C, or the general purpose digital I/O interface. The NetBurner security suite option includes SSH v1, v2 and SSL support.

NetBurner
Networking in One Day!

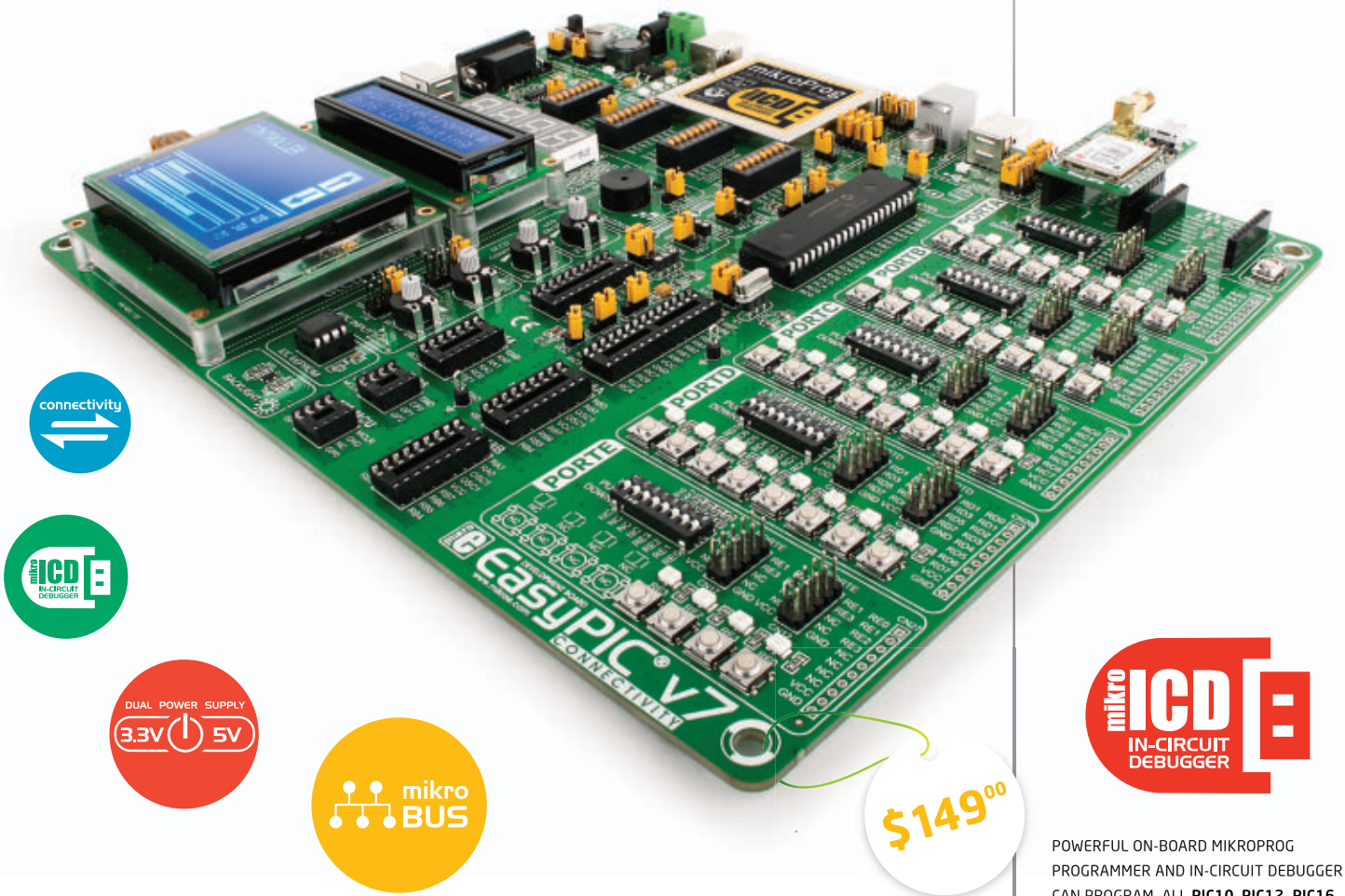
Board Part Number | SB70LC-100IR
Development Kit Part Number | NNDK-SB70LC-KIT
Information and Sales | sales@netburner.com
Web | www.netburner.com
Telephone | 1-800-695-6828

freescale™
Alliance Member

EasyPIC v7 connectivity

mikro BUS

JUST PLUG IN ONE OF YOUR **CLICK BOARD™**, AND IT'S READY TO WORK. SPECIALIZED **MIKROBUS™ COMMUNICATION INTERFACE** MAKES YOUR DEVELOPMENT EASIER, AND ALLOWS SIMPLE, YET HIGHLY EFFECTIVE CONNECTIVITY. EVERYTHING IS NOW **JUST A CLICK AWAY!**



mikro ICD IN-CIRCUIT DEBUGGER

POWERFUL ON-BOARD MIKROPROG PROGRAMMER AND IN-CIRCUIT DEBUGGER CAN PROGRAM ALL **PIC10**, **PIC12**, **PIC16** AND **PIC18 MICROCONTROLLERS**. OUTSTANDING PERFORMANCE AND EASY OPERATION WILL BLOW YOUR MIND. YOU WILL NEED IT, WHETHER YOU ARE A PROFESSIONAL OR A BEGINNER.

Best selling PIC development board in the world enters it's 7th generation of development. It is state of the art in design, functionality and quality. With 4 connectors for each port EasyPIC v7 has **amazing connectivity**. Ports are logically grouped with their corresponding LEDs and Buttons. Powerful on-board **mikroProg** In-Circuit Debugger and programmer supports over 250, both **3.3V and 5V devices**. Three types of displays, Serial EEPROM, two temperature sensors, Piezo Buzzer, USB connector, RS-232 and FTDI, Oscilloscope GND pins, as well as **mikroBus support** make this board an irreplaceable PIC development station.

DUAL POWER SUPPLY

3.3V 5V

EASYPIC V7 IS THE ONLY DEVELOPMENT BOARD IN THE WORLD TO SUPPORT BOTH 3.3V AND 5V MICROCONTROLLERS. REVOLUTIONARY ENGINEERING ALLOWED US TO SUPPORT **OVER 250 MICROCONTROLLERS** IN A SINGLE BOARD. IT'S LIKE HAVING TWO BOARDS INSTEAD OF ONE!

MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS

GET IT NOW
www.mikroe.com

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.

STRIPPER, CRIMPER AND BOLT CUTTER

GB / Gardner Bender #GS-65. Strips 18 - 6 AWG cable. Crimps insulated and non-insulated terminals. Cut and rethread untempered bolts in common non-metric sizes. Plier nose for tightening or loosening small nuts. Ream 1/2" to 1" conduit. Spring-return. Cushioned handles.
CAT# CT-16
$5.95 each

8 CHARACTER X 2 LINE LCD

Crystalfontz #CFAH0802A-NYG-JT. 8x2 character LCD. Yellow/Green LED Backlight, STN Positive, Transflective. 8-bit or 4-bit parallel interface. Industry-standard HD44780 compatible controller. -20°C - +70°C. Module size: 58.0 x 32.0 x 8.9mm. Viewing area: 38.0 x 16.0mm. Character size: 2.96 x 5.56mm. RoHS Compliant.
CAT# LCD-812
10 for $5.00 each
$5.50 each

9V BATTERY CLIP

Heavy duty molded plastic 9 Vdc battery clip. 6" leads.
CAT# BST-7
100 for $35.00
2 for $1.00

DOOR LOCK ACTUATOR

12 Vdc motor-drive actuator for automotive door locks. Nylon plunger moves 0.75". Push or pull, depending on polarity. Includes mounting hardware and a 10" metal extension rod which fits through the hole in the end of the plunger. Overall dimensions of actuator assembly (retracted): 8.42" x 2.35" x 1.15". Rubber boot protects against moisture and dust. Pigtail leads.
CAT# DLA-1
$5.50 each

BLUE LED INDICATOR, CHROME ASSEMBLY

Good-looking chrome indicator assembly with blue LED. 3Vdc LED will operate on any voltage when used with appropriate resistor. Threaded bushing mount in 8mm dia. hole. 10mm dia. chrome bezel. 24" color-coded leads.
CAT# IND-16B
$1.75 each

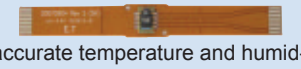
10-LED BARGRAPH

Ledtronics #LB2512-10R3 QG. 10 red rectangular LEDs in a white surround. 635nm. 120° viewing angle. Overall size, 65 x 6 x 11mm high. Leads on 0.1" centers.
CAT# BG-10R3
$1.00 each

10K LINEAR PRECISION POT

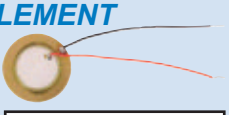
High-quality, 10K Ohm, 1/4W carbon film pot. Smooth, precise rotation, designed for 500,000 cycles. 6mm dia. x 5mm long flatted shaft. 9mm threaded bushing. 24mm diameter body. Solder-lug terminals. **CAT# LPT-10K**
$2.50 each
10 for $2.25 each
100 for $1.90 each

TEMPERATURE / HUMIDITY SENSOR



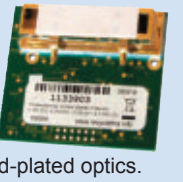
Reliable and accurate temperature and humidity sensor coupled to a 14bit A/D converter and a serial interface circuit. Sensirion SHT-15 chip is mounted on a 80 x 10mm ribbon cable with connecting fingers on 0.1" centers.
CAT# THS-15
$10.00 each

21MM PIEZO ELEMENT



50mm wire leads.
CAT# PE-56
$1.00 each
10 for 85¢ each

NDIR CARBON DIOXIDE SENSOR



GE, Telaire T6004. Compact Carbon Dioxide sensing module designed to integrate into existing controls and equipment. NDIR (Non-dispersive infrared) gold-plated optics. Diffusion or Flow-through sampling. Module size: 57 x 51 x 19mm.
CAT# CDS-1
$15.00 each

5VDC 25MM COOLING FAN

Sunon MagLev #GM0502PFV2-8. 5 Vdc, 0.4W. 25 x 25 x 10mm. 3.0 CFM. 16 dBA. Two 5.5" leads with 2-pin socket connector. cULus.
CAT# CF-393
$3.00 each

12 VDC 5.83A SWITCHING POWER SUPPLY

Phihong Model PSA80U-120. Input: 100-240V 50-60Hz 2.0A. Output: 12.1V 5.83A. Table-top model, 5.93" x 2.78" x 1.54". 46" output cord two ferrite bead EMI suppressors. 4-pin mini-DIN connector. Detachable grounded IEC power cord. cULus, CE, TUV.
CAT# PS-12583
10 for $17.00 each
$18.50 each

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

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.

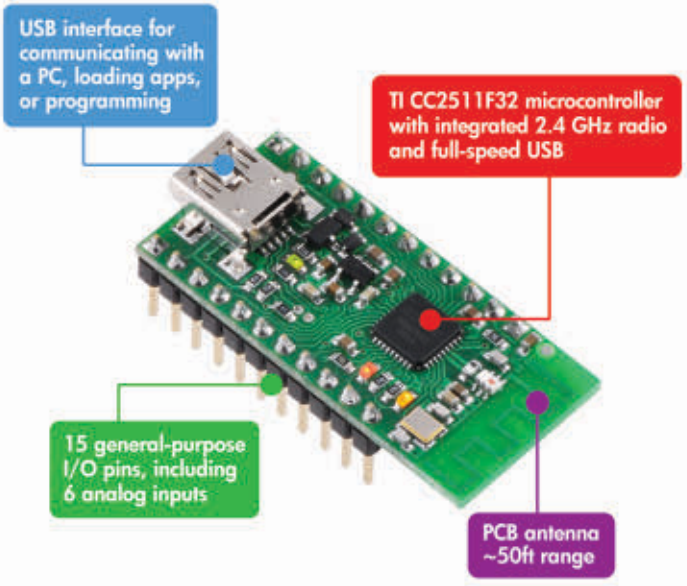
MANUFACTURERS - We Purchase EXCESS INVENTORIES... Call, Write, E-MAIL or Fax YOUR LIST.

DIY Projects:

Wild Thumper-Based Robot

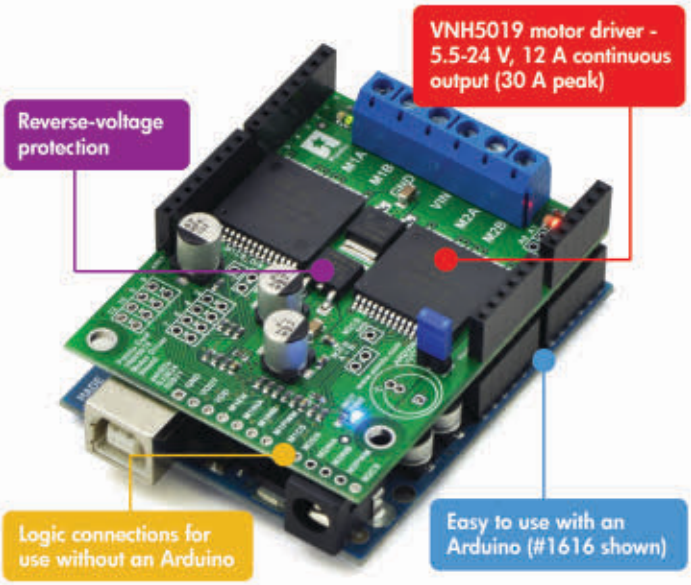
Programmable Controllers:

Item #1336: Wixel Programmable USB Wireless Module



Motor Drivers:

Item #2502: Dual VNH5019 Motor Driver Shield for Arduino



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**

March 2012

www.nutsvolts.com

Projects & Features

30 Build Your Own Wi-Fi Internet Radio

Get access to literally thousands of radio stations world wide to customize your very own play list. Plus, you get to control the unit from the comfort of your armchair with an iPod Touch.

■ By Craig A. Lindley

38 Build A Little Electronic Mischief

Try one or both of these two fun devices to astound and confound your engineering pals this April Fool's Day.

■ By Walter Noon III

44 How To Succeed At Circuit Design By Learning From These Mistakes

Getting better at a craft often requires you to learn from your mistakes. Follow along with this circuit design to see where the problems and pitfalls occurred, so that you can accelerate your learning from someone else's errors.

■ By Bob Colwell

Columns

10 TechKnowledgey 2012

Events, Advances, and News

Read about plugs that seem to defy physics, a DIY PC, a high-def surveillance camera, plus a camera you can attach to your dog, and some other interesting stuff.

14 The Spin Zone

Adventures in Propeller Programming

CAN We Talk?

22 Q & A

Reader Questions Answered Here

Some of the topics covered this month include a water level monitor, radio repair, and a phototransistor amplifier.

52 Near Space

Approaching the Final Frontier

Flight 100: A Report and a Reflection.

58 The Design Cycle

Advanced Techniques for Design Engineers

It's All About the Uno32 Hardware.

69 Smiley's Workshop

Programming • Hardware • Projects

Simple Chaser Lights Kit.

FUNdamentals For Beginners

76 Build an IC Electronic Organ

Departments

08	DEVELOPING PERSPECTIVES	66	NV WEBSTORE
28	NEW PRODUCTS	77	CLASSIFIEDS
29	SHOWCASE	78	TECH FORUM
65	ELECTRO-NET	81	AD INDEX

Cover photo provided by Matthew Roddy

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

Prototyping Breadboards

Externally Powered Breadboard

PB-10

840 Tie-points, with plastic backplate
$23.00

PB-104

3060 Tie-points, w/ aluminum backplate
$75.00

PB-101T

1260 Tie-points, w/ aluminum backplate
$19.50

PB-103

2250 Tie-points, w/ aluminum backplate
$50.00

PB-105

4560 Tie-points, w/ aluminum backplate
$100.00

PB-70E

1260 Tie-points
$32.00

PB-83E

830 Tie-points
$17.00

Bus Strip

QT-35B

60 Tie-points
$4.00

QT-47B

80 Tie-points
$5.00

QT-59B

100 Tie-points
$6.00

GS-060

60 Tie-points
$2.50

GS-080

80 Tie-points
$3.00

GS-090

90 Tie-points
$3.50

GS-100

100 Tie-points
$3.25

GS-100T

100 Tie-points
$4.25

Solderless Breadboard

EXP-300

550 Tie-points
$9.00

EXP-350

270 Tie-points
$7.00

PB-60

1680 Tie-points
$51.00

QT-35S

350 Tie-points
$6.00

QT-47S

470 Tie-points
$8.00

QT-59S

590 Tie-points
$10.00

GS-351

350 Tie-points
$3.75

GS-400

400 Tie-points
$5.50

GS-470

470 Tie-points
$5.00

GS-590

590 Tie-points
$6.50

GS-630

630 Tie-points
$5.50

GS-630T

630 Tie-points
$6.50

GS-830

830 Tie-points
$8.00

GS-830T

830 Tie-points
$9.00

USB-100

840 Tie-points
$13.00

DEVELOPING PERSPECTIVES

Don't Cut The Blue Wire — Or Is It The Red Wire?

Ever notice in the movies how the bomb squad expert somehow knows the color of insulation used by the bomb builder? Apparently, the expert has a copy of *Bomb Building for Dummies* which documents wire color. Cut the wrong color wire and 'BOOM!' — you're a goner. Or, so the screenplay writer would have you believe.

I don't know about you, but other than consistently using red and black for (+) and (-) DC power, respectively, I don't usually care about wire color. What I do care about is varying the color of wire from one connection to the next. I avoid working from a single spool of wire because that would make visually tracing the resulting circuit difficult. Visual is the key word here. I keep an inexpensive digital camera on my workbench and document most projects with a dozen or so high resolution images.

In addition to photographs, I document my projects with a rough hand-drawn schematic that I later feed into my scanner. However, the schematic — whether in traditional paper form or as a PDF — provides only one limited view of a circuit. A schematic is handy if you have a circuit in front of you, and you have a DMM or other means of tracing the connections and signals. In contrast, as a record of how to build a device from scratch, most schematics fall miserably short. Consider that schematics often bear no resemblance to the physical circuit. For example, a microcontroller chip with dozens of connections might take up most of a schematic and yet consume less than 10 percent of the real estate on a circuit board.

In addition to photographing circuitry, I use my camera to capture metalwork such as cutouts on panels for switches and potentiometers. It may seem trivial now, but seven or eight months after you've finished a device — when you've forgotten how you managed to mount everything in a small aluminum chassis — you'd give anything for a visual record of how you mounted the devices, the length of the standoffs, and other forgotten details. Lacking the photos, you'll have to repeat the original trial and error fitting process.

In essence, creating a photographic record is like replicating one of the better articles in *Nuts & Volts* – lots of close-up images. But whereas publication space is limited, digital images are easy to store and index. When you need to replicate a circuit, just open the file folder and review the images. Need to share a design with a friend? Email the images along with the schematic. Or, post them to the Web.

Another tool in my documentation arsenal is Fritzing: an open source documentation/sharing/teaching program from the University of Applied Sciences Potsdam, Germany (**Fritzing.org**). The free software is especially useful for documenting Arduino projects, in part because Arduino boards are included in the editable parts library. It's worth checking out the website and downloading the easy to learn and use software to your PC, Mac, or Linux computer.

In brief, Fritzing is a circuit board design package on steroids. There's a schematic view and a PCB view. An auto-routing function converts your schematic into a circuit board. And — as with other circuit board editing packages — you can send the resulting file off for production. However, because the service is based in Germany, it's not cost-effective in the US for single board runs.

What makes Fritzing especially useful is the third breadboard view. In this environment, you position realistic looking components on a breadboard. The software takes care of converting the breadboard to a schematic and PCB. The downside of this software — regardless of how powerful

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
Joe Pardue
Jon Williams
Walt Noon
Bob Colwell
Russ Kincaid
Fred Eady
Paul Verhage
Craig Lindley

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 © 2012 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.

— is that it's typically useful only after the fact, once you have a rough prototype in hand. That's why most of my prototype work is documented with a rough schematic and lots of photographs.

If you decide to use a camera as well, don't forget to make your layout visually apparent. Use internally consistent colors for power, signal, ground, and a variety of colors for other connections. And take photos at major stages along the way, as opposed to only at the end. Happy shooting! **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, email us:
fcc@CommandProductions.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: fcc@CommandProductions.com

TECH KNOWLEDGEY 2012

EVENTS, ADVANCES, AND NEWS

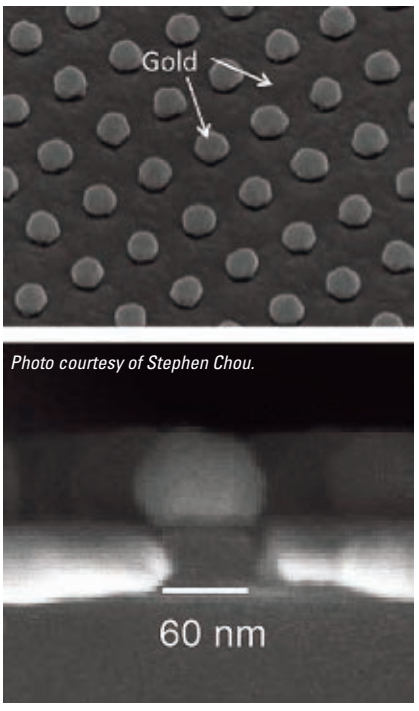
■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

PLUGS SEEM TO DEFY PHYSICS

If you have a hole in the wall that lets in unwanted light, you would expect that slapping an opaque patch over it would solve the problem. But what if the patch actually amplified the amount of light passing through? As counterintuitive as it may seem, some Princeton University (**www.princeton.edu**) engineers have stumbled upon such a phenomenon. Prof. Stephen Chou and some associates first created tiny perforations in a piece of thin metal film, then blocked each hole with an opaque metal cap. Upon shining light into the holes, they discovered that much more light passed through than before the holes were blocked. The surprising discovery came as they were working to develop ultrasensitive chemical detectors for such purposes as medical diagnostics, explosives detection, etc.

These detectors use a thin metal film with an array of holes and metal disks to boost the signals that result from a laser contacting a molecule under scrutiny. In this case, we're talking about a 40 nm thick film with 60 nm holes spaced 200 nm apart. They capped each hole with a gold disk that was 40 percent larger than the hole, and each disk sat atop its hole with a slight gap between the two. Oddly enough, regardless of which side of the film was illuminated, the total light transmission to the other side was 70 percent higher than without the disks. This appears to occur because the disk acts like an antenna of sorts, picking up light from one side and radiating the electromagnetic waves to the opposite side.



■ Electron microscope images showing (top) an array of holes with gold caps and (bottom) a cross-sectional view of one capped hole.

The phenomenon is of practical interest in two ways. First, it has ramifications for various types of optical instruments (e.g., microscopes, spectrometers) that use metal film coatings on glass to block light. The film deposition process unavoidably involves picking up dust particles that create tiny holes in the film, but no one worries much about that, assuming that the dust plugs its own holes. This may not be the case, however. More interestingly, this amplifying effect may prove beneficial in technologies such as near-field microscopy where scientists view extremely fine details of a subject by passing light through a hole of only a few nanometers in diameter. The increase in transmitted light could boost the amount of observable data. Chou's research group is continuing to investigate the effect and how it could be applied to enhance detector performance. ▲

CIRCUIT, HEAL THYSELF

With circuits getting ever more dense, failures become increasingly problematic both in terms of (1) a higher propensity to fail as a result of temperature cycling and other stress factors, and (2) the difficulty (or impossibility) of implementing repairs. You just can't open up a multilayer IC and slap some solder on a broken circuit, and it's not practical to travel into space to effect repairs in person. However, a team at the University of Illinois (**www.illinois.edu**) — having previously developed self-healing polymers for structural repairs in electrical systems — have extended the concept to a technology that "restores electrical conductivity to a cracked circuit in less time than it takes to blink."

Led by Profs. Scott White and Nancy Sottos, the researchers recently published their results in the journal *Advanced Materials*. The feat is accomplished by dispersing tiny (10 dia) microcapsules atop a gold circuit line. When a crack propagates at that location, the microcapsules break open and release liquid metal that fills the circuit gap and immediately restores electrical flow. The researchers reported that 90 percent of their samples healed to 99 percent of original conductivity, even using a "small number" of microcapsules. The important aspect is that the repair is localized and autonomous.

As noted by Sottos, "In an aircraft — especially a defense-based aircraft — there are miles and miles of conductive wire. You don't often know where the break occurs. The autonomous part is nice — it knows where it broke, even if we don't." Ongoing research is aimed at applying the self-healing system to batteries to increase safety and longevity. ▲

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

COMPUTERS AND NETWORKING

DIY PC

If you're on a budget but still want a taste of ultracompact desktop computing, you might take a look at the ARTiGO A1150 PC kit from Taiwan's VIA Technologies (**www.via.com.tw**). The machine fits in a highly compact (5.7 x 3.9 x 2 in, or 14.6 x 9.9 x 5.2 cm) box and is powered by a 1.0 GHz dual-core VIA Eden X2 processor. The X2 is joined by the VIA VX900H media system processor which features hardware acceleration for some popular HD video codecs, providing multimedia functionality. Included in the package is HD video support, HDMI and VGA display connectivity, gigabit networking, Wi-Fi support, and five USB ports, plus three audio jacks. Wireless IEEE 802.11 b/g/n and SD card reader modules are optional. The machine supports Windows 7 and XP.

■ The VIA ARTiGO A1150 brings dual-core processing to an ultra compact desktop.

The good news is that about all you need to do to "build" the A1150 is drop in some RAM (up to 4 GB) and a hard drive. This means that even if you're technically incompetent, you can still brag to your friends about having assembled your own computer. The fine print, however, notes that the $259.99 list price does not include the hard drive, compact Flash module, solid-state drive, SD card, wireless module, antenna, system memory, or operating system, so you'll need to cruise eBay for the extras. ▲

■ Gelid's DarkForce tower case provides for up to eight cooling fans.

TOWER CASE FOR GAMING MACHINES

Gelid Solutions Ltd. (**www.gelidsolutions.com**) has been around since 2008, providing CPU coolers, fans, and other thermal management hardware, largely devoted to the relatively extreme requirements of gaming computers and to "silent" equipment designs. Now, you can get all of their eggs in one basket in the form of the DarkForce tower case, representing the first product in a product line designed specifically for gamers. The solid black case — as you might expect — offers extensive cooling options, with locations for mounting up to eight fans. Two silent 120 mm fans (front and back) come preinstalled, and you can also mount an 80 mm or 120 mm fan onto the side panel, and a 120 mm or 240 mm radiator on the bottom. The box provides six individual HDD trays and room for a large CPU cooler (up to 165 mm in height) and is compatible with both MicroATX and full ATX motherboards. It's anything but petite, with dimensions of 20.9 x 8.1 x 9.9 in (530 x 207 x 505 mm), and the 7 mm (0.28 in) thick steel construction weighs in at about 20 lb (9.2 kg). According to Gelid, "No compromises were made in the design of this case, no costs were cut in order to provide PC enthusiasts looking to upgrade or replace their desktops with a high quality build." The case is RoHS and WEEE conformant, comes with a two year warranty, and will run you about $120. ▲

A MONUMENTAL TRIBUTE TO YOURSELF

If you haven't been able to satiate your narcissistic tendencies by posting endless Facebook messages about every detail of your life, you'll like this. The folks at Intel — who obviously had some slack time to deal with — have put together a website called the Museum of Me that allows you to hang your personal info on the walls of a virtual museum and invite friends to wallow in all of the wonders of you. Just log onto **www.intel.com/museumofme/r/index.htm**, give the site access to your Facebook data, and let 'er rip. The site assembles a moving display of your friends, photos, videos, favorite words, and other items, and generates a virtual museum, complete with a satellite photo of where you live, complex graphics, and choral background music. After viewing the result, you can share it with all of your Facebook buddies with just a mouse click. Like wow. ▲

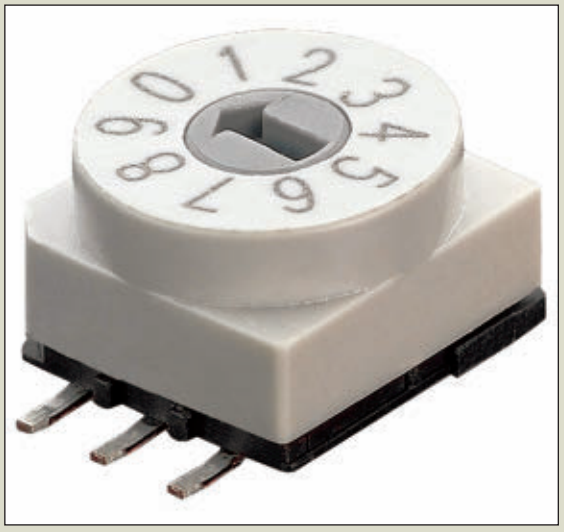
CIRCUITS AND DEVICES

HIGH-DEF SURVEILLANCE CAMERA

■ Toshiba's IK-WD14A surveillance camera offers 1920 x 1080 resolution.

Surveillance cameras generally go for about $50, but — as you can tell from the usual videos of 7-11 robberies — the resolution is pretty poor. For applications requiring something significantly better, Toshiba Surveillance & IP Video (**www.toshibasecurity.com**) has introduced the IK-WD14A dome camera. The device is specifically designed for securing areas where extremely sharp video detail is required — like for identifying facial features or license plates. It also offers built-in infrared LEDs to capture images in nearly complete darkness, along with a wide dynamic range for difficult backlighting environments. The IK-WD14A offers simultaneous H.264/MPEG4/JPEG streaming for automatic bandwidth prioritization, enabling 1920 x 1080 video at up to 30 frames per second for both live viewing and recording. It also offers a 3x optical zoom, remote focus, and broad-angle pan and tilt. The unit is Open Network Video Interface Forum (ONVIF) compliant, making it simpler to integrate into existing networks. It also offers motion detection, day/night imaging, and anti-tampering features. The catch is that each unit will run you upwards of $550 at current street prices. ▲

HIGH-TEMP CODE SWITCH

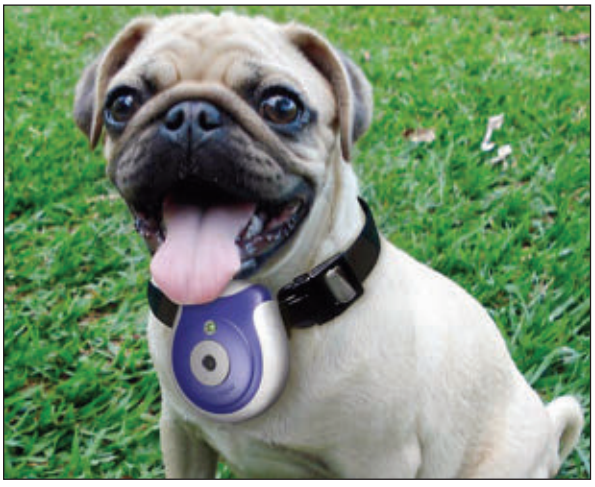


■ APEM's PT65 code switch withstands high soldering temperatures.

It's getting tougher all the time to find components that can be hand soldered, but if your project includes rotary code switches, take a look at the PT65 line of DIP units from APEM Components (**www.apem.com**). Although available in SMT configurations as well, you can get through-hole versions for lower-tech assembly techniques. In addition, this is a high-temp component that will withstand solder temperatures of 260°C (500°F) for 10 seconds (reflow), 280°C (536) for five seconds (wave), or 340°C (644°F) for two seconds (iron soldering). The PT65 switches are specified for a wide range of applications including automotive, communication, consumer, and defense markets, as well as medical devices. The contacts have abrasion-resistant gold plating, providing a mechanical lifetime of 30,000 steps. Versions are available with four, six, 10, and 16 positions. ▲

WHERE OH WHERE HAS MY LITTLE DOG GONE?

This month's most dubious product award goes to the Pet's Eye View digital camera which clips to a pet collar to provide a digital diary of your pet's daily travels. It can be set to record a shot every one, five, or 15 min, and it works like a thumb drive so you don't need any software to load it into the computer. Features include 8 MB of internal memory (not expandable), a capacity of 40 JPGs (640 x 480), and a lithium-ion battery that can be recharged via the included USB cord. As of this writing, you can order one online for about $45. However — especially with springtime in the air — do you really want photos of everywhere your dog sticks his nose? ▲



■ Fido fitted out with a Pet's Eye digital camera.

INDUSTRY AND THE PROFESSION

UPDATE YOUR PERIODIC TABLE

In June '11, the International Union of Pure and Applied Chemistry (IUPAC, **www.iupac.org**) finally got around to accepting elements 114 and 116 as the heaviest elements — more than 10 years after they were discovered by scientists from the Joint Institute for Nuclear Research (Dubna, Russia) and chemists at the Lawrence Livermore Lab. Last December, the IUPAC proposed to call them, respectively, Flerovium (atomic symbol Fl) and Livermorium (Lv) in honor of physicist Georgiy N. Flerov (1913-1990) and the Livermore Lab. The names won't become official until the public comment period is over, so you have about a month left to register any objections. In case you're wondering, the elements were created by smashing calcium ions (with 20 protons each) into a curium target (96 protons) to create element 116, which decayed almost immediately into element 114. You can also create Flerovium by replacing curium with a plutonium target (94 protons). Details about all 118 elements can be found at **www.webelements.com**. **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 CORP. 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
MODEL WLC 100
0603WLC100
$39.99

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 – 3½ 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 $6.50 10+
SUPER ECONOMY
MODEL 820B
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

PBP3
PICBASIC PRO™ Compiler

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

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

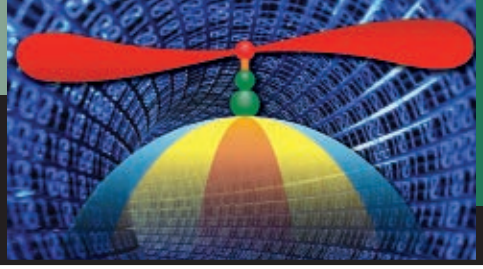
Multi-Seat Licensing
for Educational Institutions

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.



SPIN ZONE

ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

CAN WE TALK?

There are many interesting mechanisms that allow small micros to communicate with each other, and one of the more interesting that I've been working with lately is CAN (Controller Area Network). Originally designed for the harsh environment of automotive applications, CAN is very robust and — using a simple interface chip — very easy to implement with the Propeller. With its simplicity and durability, CAN is finding its way out of our cars and into many industrial and hobbyist applications.

CAN: THE WILD WILD WEST

CAN is referred to as a message-based or "broadcast" protocol; that is, nodes on a CAN buss may transmit messages (called frames) at will, and may be configured to listen for and react to specific frames from other nodes. It's the Wild West: There is no master/slave paradigm; CAN is an open network for chatty-Cathy microcontrollers that speak whenever they want to. In a car, for example, the digital dash doesn't have to ask for the state of the doors; a module in the door will automatically broadcast its state when it changes.

All of this works because the architecture of CAN frames and the physical communications layer allow CAN devices to detect and deal with collisions; higher priority frames will finish first. In most cases, the CAN protocol engine will rebroadcast the lower priority frame as soon as the buss is free.

If you've read anything about CAN, you probably know that there are two ways to identify frames: with the standard 11-bit ID, or with an extended 29-bit ID. The Propeller object that I've written and will discuss here deals with frames using 11-bit IDs. That said, the protocol chip I use supports extended IDs so the object could be updated to handle them.

THE MCP2515

While it is possible to write a native protocol driver for the Propeller, there is no way in heaven or on earth to justify the time required — outside a large commercial application — when there is a simple, off-the-shelf solution: the Microchip MCP2515. This nifty (and inexpensive) little chip handles all of the gory details of CAN transmission and reception, and connects to any microcontroller using an SPI buss. In addition to the SPI buss, there are other I/Os available that may be employed if deemed appropriate. In low bandwidth applications, four pins (CS, SCK, MOSI, and MISO) are all that is required.

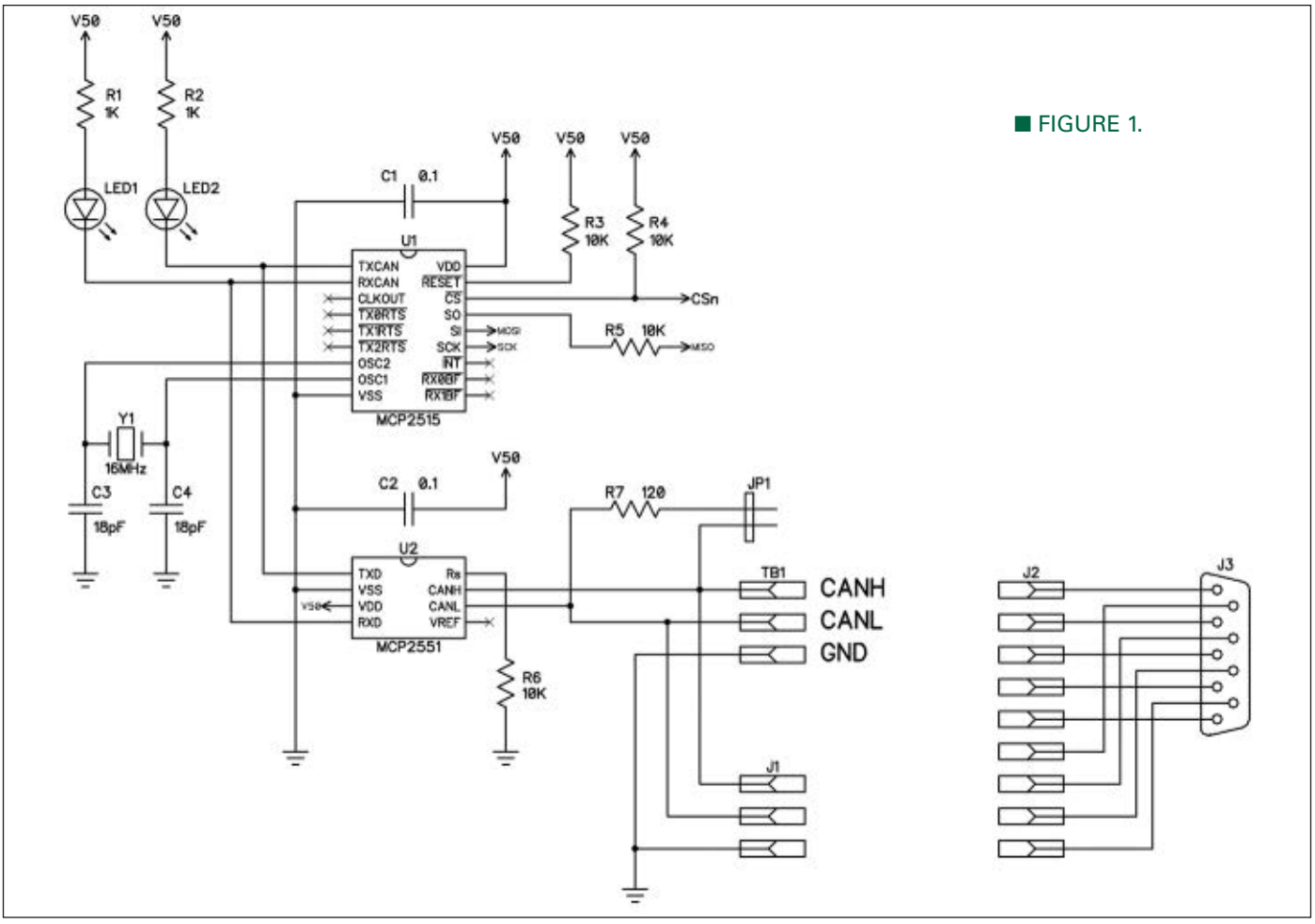
Figure 1 shows the schematic for my Propeller Platform CAN Shield and prototyping board. You'll see that the MCP2515 connects to the Propeller through the SPI buss pins and to the CAN buss through the MCP2551 transceiver chip. A 16 MHz crystal drives the MCP2515 for bit rate generation. My MCP2515 object is coded for 16 MHz and has been tested for standard CAN bit rates from 10 Kbps to 1 Mbps. If you want to use a different crystal, there is a link in the object code to a website that will calculate the proper values for the bit timing control registers (this is one of the hairier aspects of CAN and the online calculator is a godsend).

Figure 2 shows the completed PCB (printed circuit board) mounted on a Gadget Gangster Propeller Platform USB. I wanted to make sure that my standard size Propeller Platform board would work on Nick's shorter variant; as you can see, it does. The PCB includes a terminal block for connecting to a CAN buss and a DB-9M for those that may want to use a DB9-to-OBD2 cable for automotive experiments. Female headers behind the connectors allow us to configure the DB-9 to match cable connections. You'll also note that there are pads for the extra MCP2515 I/Os and a bunch of prototyping space for any custom apps we might want to develop using the board.

GETTING CONNECTED

As with most Propeller objects, we will use the ***start()*** method to connect to the MCP2515. The method expects the I/O pins used for the SPI buss, as well as an ID value if that buss is to be shared with other cogs (more on this later). Typically, we'd start the object like this:

```
can.start(CAN_CS, SCK, MOSI, MISO, -1)
```



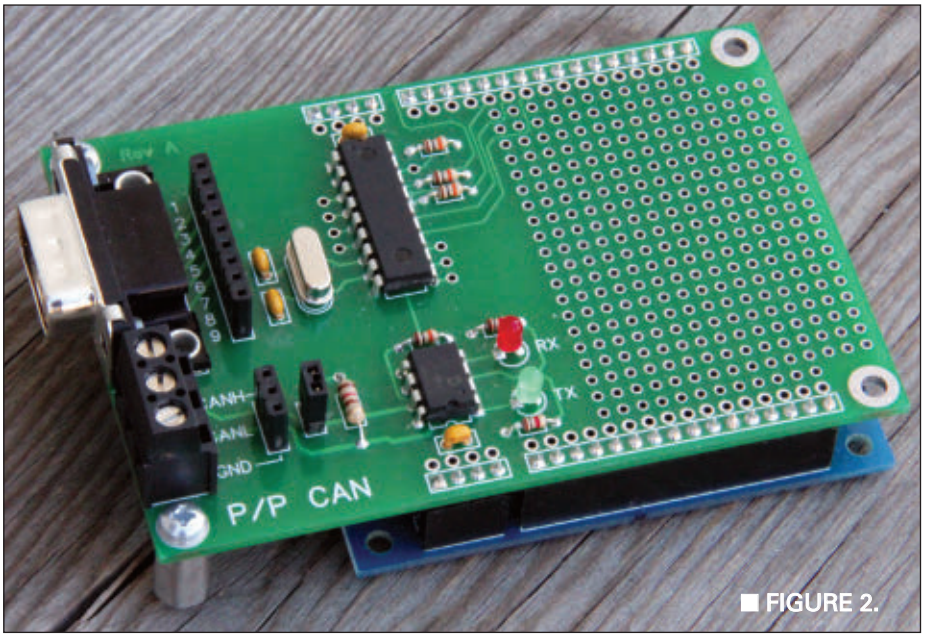
■ FIGURE 1.

The first four parameters define the SPI buss pins with CAN_CS (chip select) being the only pin that is not shared. The final parameter is the lock ID if the buss is to be shared between cogs. In this case, -1 indicates that our code has exclusive control of the buss.

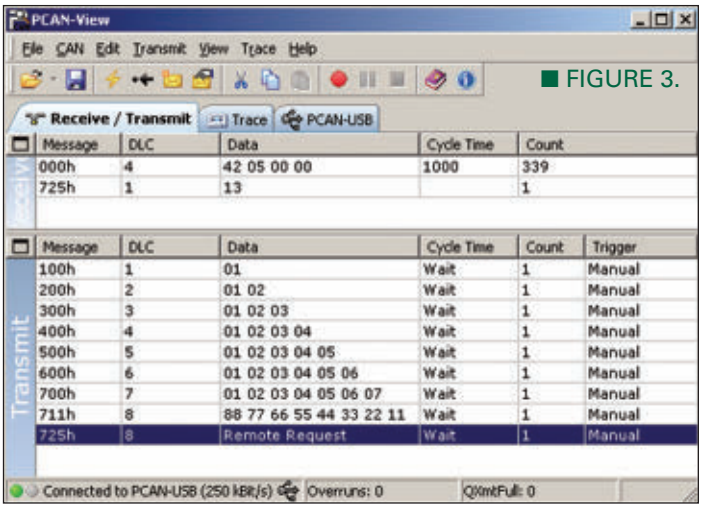
Getting the MCP2515 ready for use takes a bit of code, but it's pretty straightforward given the methods and defined constants in the object. Our demo code will be a simple "buss sniffer" that displays traffic on the CAN buss. Our only responsibility is to set the correct bit rate. Here's the setup code:

```
can.reset
can.set_mode(can#REQOP_CONFIG)
can.set_baud(CAN_SPD)
can.write(can#TXB0CTRL, 0)
can.write(can#TXB1CTRL, 0)
can.write(can#TXB2CTRL, 0)
can.write(can#TXRTSCTRL, 0)
can.write(can#CANINTE, 0)
can.write(can#CANINTF, 0)
can.write(can#BFPCTRL, 0)
can.set_rxb0_filters(0, 0, 0)
can.set_rxb1_filters(0, 0, 0, 0, 0)
can.set_mode(can#REQOP_NORMAL)
```

After resetting the MCP2515, put it into configuration mode which is required for changing certain registers —



■ FIGURE 2.



■ FIGURE 3.

especially those having to do with the CAN bit rate. In general, this setup establishes the desired bit rate, clears the chip for use with the SPI buss, disables the external outputs, and clears the frame filters such that we can receive any (standard) frame on the buss.

So, let's do a little spying on a CAN buss, shall we? Since we are not using the interrupt or buffer status outputs from the MCP2515, there is a method in the object that allows us to determine if frame data is available in either of the receive buffers. We will pass the buffer to check (0 or 1), and pointers to variables that will hold the frame contents:

```
ftype := (can.rx_stdframe(0, @sid, @dlc, @canbuf))
```

This method will return a 1 or 2 if a frame is available. A standard data frame (with up to eight data bytes) will have a return value of 1. An RTR frame will return a value of 2.

Early, I described the CAN buss as the Wild West in that nodes transmit when they choose. There is a mechanism in CAN that allows a node to request a transmission from another node; this is called Remote Transmission Request (RTR). An RTR frame still has a DLC which means it can be used for a specific request from a node that provides more than one type of information.

Most of the frames we deal with are standard data frames. Within the frame, we can have from zero to eight data bytes. The number of data bytes in the frame is specified by the DLC (data length control) byte. It is up to us as system architects to determine what these bytes signify when part of a CAN frame.

When ***rx_stdframe()*** returns 1 or 2, we'll want to release the buffer so that it's available to receive another frame. Remember, the call to that method copied the buffer contents to our specified holding variables; nothing is lost. In the sniffer demo, we can demonstrate the response to an RTR frame by sending the seconds value of a software RTC back to the buss using the ID in the RTR frame. (Note: If you're connecting to an active system, I suggest you comment-out this code so as not to interfere with that system.) Finally, we can display a frame on a terminal:

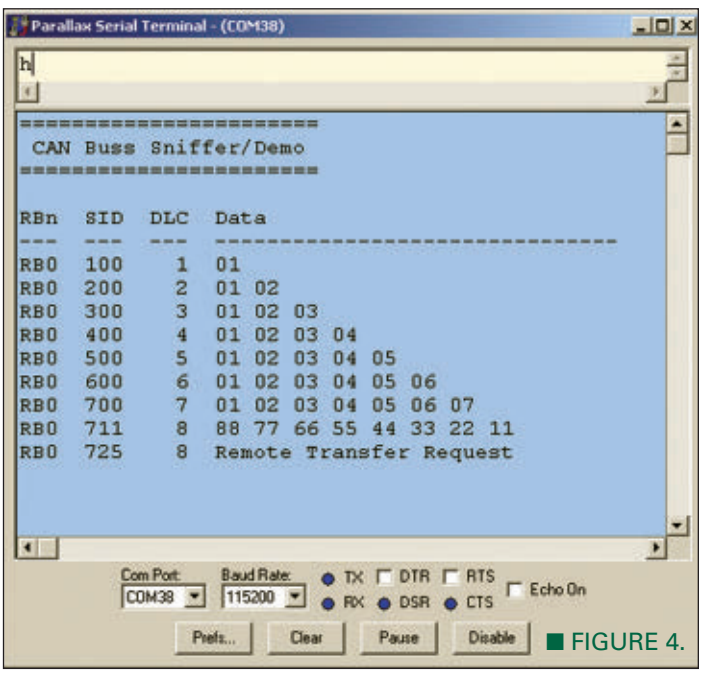
```
if (ftype)
   can.clear_rx_intf(0)
   if (ftype == can#FRAME_REMOTE)
     canbuf[0] := dec2bcd(scs)
     can.tx_stdframe(0, sid, 1, @canbuf,
     can#PRI_HIGH)
   display_frame(0, ftype, style)
```

For testing, I used a commercial device called PCAN-USB. In **Figure 3**, you can see the messages I set up for simple testing (bottom pane). In the top pane of that program, you'll see two received messages. The first is the RTC registers that are being sent every 1,000 ms; the other is a response to the RTR frame. **Figure 4** shows the corresponding output from the Propeller.

Sending a message to the CAN buss is as straightforward as receiving:

```
can.tx_stdframe(0, $000, 4, @canbuf,
can#PRI_HIGH)
```

In this example, frame $000 is sending four bytes (stored in *canbuf*) using transmit buffer 0. As this is a very low bandwidth transmission, we can assume that the transmit buffer is available. In some applications, we may want to check first; we can do this with the ***tx_buf_ready()*** method.



■ FIGURE 4.

FRAME FILTERS

As you can imagine, in a complex system there could be any number of frames flying around the buss — and most of them we don't care about. Thankfully, the MCP2515 allows us to filter incoming frames so that we only receive those that have meaning for our application.

For each buffer, there is a mask and acceptance filters.

The mask defines which bits in a frame ID that we want to pay attention to. For buffer 0, there are two acceptance filters (0 and 1). These define the desired state of the masked bits for a filter match. For buffer 1, there is a mask and four acceptance filters (2 through 5). Since the filters are handled in order, we will want to specify higher priority frame IDs first.

Let's say we want to create a couple of nodes: one node type monitors a set of buttons; the second type will reflect the state of those buttons at some remote location on the buss. To keep things very simple, we'll use a frame ID of $100 for the digital nodes. In the receiver module, we could set the mask and acceptance filters like this:

```
can.set_rxb0_filters($7FF, $100, 0)
can.set_rxb1_filters($7FF, 0, 0, 0, 0)
```

By setting the mask to $7FF, we are forcing all 11 bits of the frame ID to be a match. In this example, the only match is $100 and all other frames would be excluded. This feature of the CAN engine in the MCP2515 removes a huge burden from the application.

This is a fairly rigid example. In a work-related project, I'm using the upper three bits of the ID to specify the node type, and the lower eight bits of the ID to be the address (0 to 255) for a node. This allows me to have multiple transmitters and receivers of the same type on the CAN buss, and I can match one to another using the eight-bit address. For node type 1, the filter setup would be:

```
can.set_rxb0_filters($700, $100, 0)
```

In this case, I'm only filtering on the upper three bits (node type); the lower eight bits of the mask value is $00, so they can be anything. When a frame is received, I strip the upper three bits from the ID and compare what's left to the local address switch. If there is a match, then I know the frame was intended for this node. I think this is pretty cool; the MCP2515 did most of the work. It was a very simply matter to extract the address from the CAN ID and act accordingly.

SHARING IS A GOOD THING

Last fall I wrote, produced, and acted in a spec commercial for the Doritos Super Bowl contest. Sadly, we didn't make it to the finals but we did make a nice little commercial with the theme that sharing is a good thing. The project was my creativity lashing out at the cynicism in so many commercials that have the "get your own" theme. When I was a kid, we were taught to share; sharing is good.

We see this in the Propeller: Sharing the **cnt** register lets us sync cogs; sharing RAM lets cogs provide data for each other; sharing I/O pins lets multiple cogs communicate which minimizes pin count in a project ... Whoops! While that last statement is absolutely true, it does come with a caveat: If two or more cogs are going to share the same piece of hardware (or I/O pins like an SPI or I²C buss), and if each creates its own hardware interface, we must be careful when sharing.

Cogs run independently of each other and if two cogs attempt to access the same I/O pins at the same time, there could be a collision that wreaks havoc in the application. While there are many ways to solve this problem with custom code, there is a built-in solution that is easy to apply.

In the hub, RAM is a set of "locks" that can be used to support mutually exclusive access to some resource which could be memory or I/O pins. We'll start by checking out a lock from the system:

```
lockid := locknew
```

In this example, *lockid* will be assigned a value of 0 to 7 if a lock is available; -1 if they are all being used (which you'll probably never run into). At this point, the lock is available to our application but not being used. The next bit of code will seem peculiar, but this is what we do to set the lock before accessing the shared resource:

```
repeat until not lockset(lockid)
```

If you're scratching your head, don't worry. You're in good company. Most of us mortals have to think about this for a minute. Here's what's happening: The **lockset** instruction sets the lock and then returns the state of the lock (true or false) before it was set. If the lock was clear before the instruction, then the return value is false which gets inverted by the **not** operator in that line of code. The final result is true which allows us to escape from the **repeat** loop and proceed to using the shared resource knowing that other [well-behaved] cogs will not step on us.

This may seem a bit obtuse at first but the logic is

BILL OF MATERIALS

Item	Description	Mouser Part #
C1-C2	0.1 µF	80-C315C104M5U
C3-C4	18 pF	80-C315C180J1G
J1-J2	0.1" female	517-929974-01-36-RK
J3	DB-9 male	571-5747250-4
JP1, X101-X104	0.1" male	517-6111TG
Jumper	0.1" shunt	517-9691020000DA
LED1	3 mm red	606-4303F1
LED2	3 mm green	606-4303F5
R1-R2	1K, 1/8W	299-1K-RC
R3-R6	10K, 1/8W	299-10K-RC
R7	120, 1/4W	291-120-RC
TB1	0.2", 3-pos	571-7969493
U1	MCP2515	579-MCP2515-I/P
U2	MCP2551	579-MCP2551-I/P
Y1	16 MHz	520-HCU1600-20X
PCB		

Easy ordering of parts (less PCB) from Mouser:
http://bit.ly/jm_can_shield_parts

quite sound. With things flying fast and furiously in an application, we want to gain access to a shared resource as quickly as we can. This bit of code takes care of that in one line; the lock gets set and we know we can proceed if it was clear (i.e., the resource is not in use) prior to the call.

Of course, our application must be well-behaved, too; as soon as we're done with the shared resource, we should clear the lock:

```
lockclr(lockid)
```

This step is critical: If we forget to clear the lock, then other cogs will not have access to the shared resource.

Let's consider a practical example. We may want to create a device that monitors a couple analog channels, averaging the readings as it goes, then transmitting that data on a CAN buss at a set interval. For the sake of discussion, let's use an MCP3202 connected to the shared SPI buss used by the MCP2515.

If the MCP2515 and MCP3202 were started and running in the same cog, there is no worry. However, if we decide to launch the '3202 into its own cog so that it can handle averaging "behind the scenes," now we have to be careful. Spin cogs run independent of each other, so we need a mechanism for sharing resources — this is where using a lock comes in.

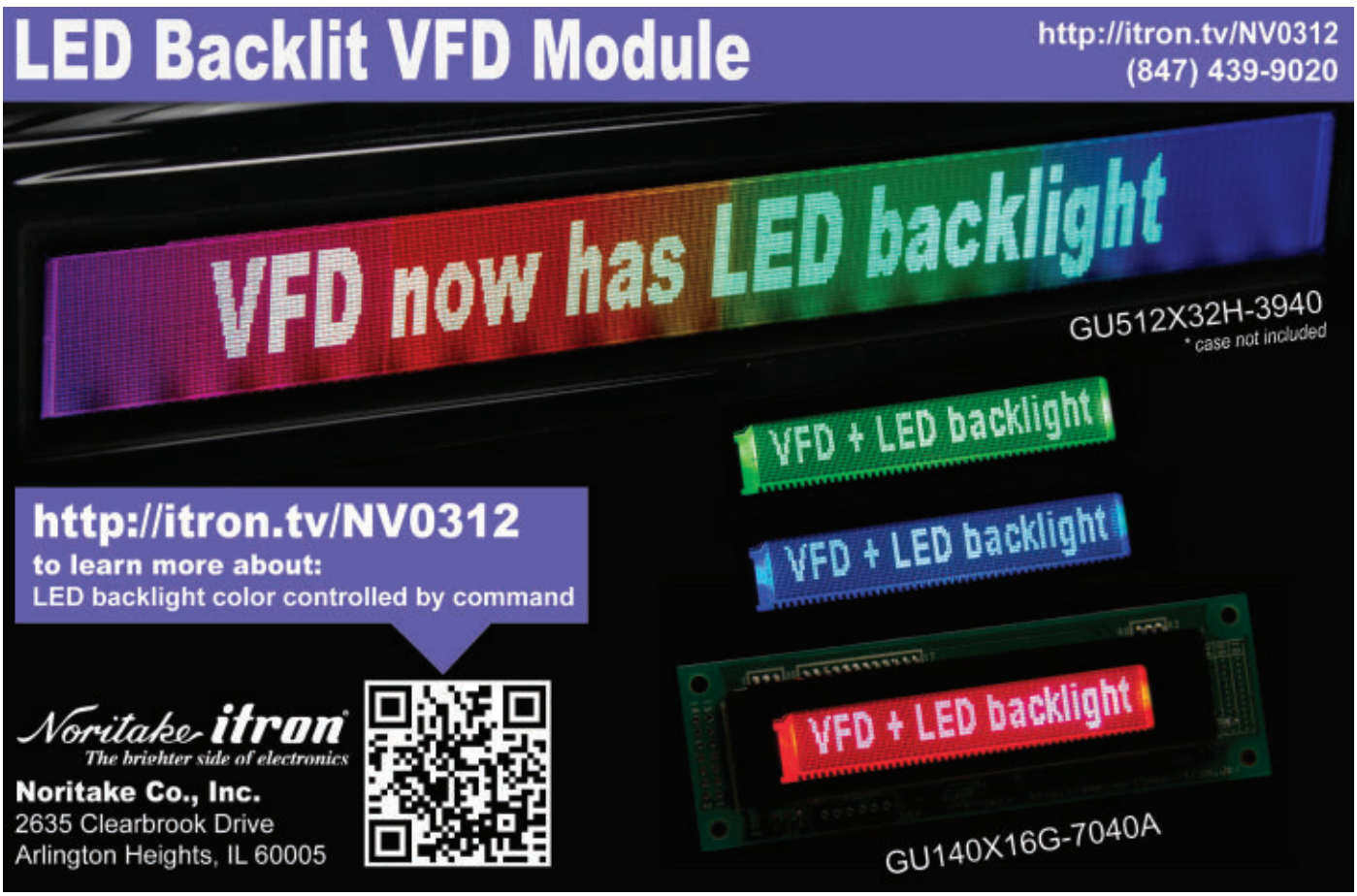
At the top of the program, we define a variable and assign a lock to it. In my MCP2515 and MCP3202 objects, we can specify the lock id as a parameter and use that to share the buss using the commands illustrated above. Pretty easy, and very useful. Have a look through the MCP2515 object code to see this in operation. No lock required? No problem! We simply specify the lock ID as -1 and the object uses the buss as free as a bird.

RESOURCES

JON "JONNYMAC" WILLIAMS
jon@jonmcphalen.com
www.jonmcphalen.com

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

GOLDPHOENIXPCB
Low cost, high quality, quick-turn PCBs
www.goldphoenixpcb.biz



One final note on sharing a set of I/O pins among multiple cogs: If the interface is built into the Spin code — as is the case for the MCP2515 driver — we must start the object in the cog where it lives. The reason for this is that each cog has its own direction registers for the I/O pins and they must be set in the cog where they're used. This is a subtle thing, and can sneak up on us if we're not careful. (Ask me how I know.)

A NEW YEAR, NEW PCB TOOLS

In the downloads, you'll notice a change in the schematic and PCB files. Yep, I thought that for the new year it was time I put on some big boy pants and use a production-ready PCB tool. After some checking around, I decided to go with DipTrace. My friends at Parallax use it (for their open-source projects), many Propeller developers that I respect use it, and I just found it fit, so we adopted it at EFX-TEK too. The great news is that I can now provide Gerbers to get boards made anywhere.

Case in point: When I used one company in particular, it would cost me about $100 to get three production quality boards (with silkscreen and solder mask) and it would take about a week. Don't get me wrong, this is fantastic but if I wanted to move a board to production quantities — at prices I could afford — I would have to purchase Gerbers (another $60) or have the board redone. For this project, I created the schematic and board in DipTrace. And yes, it was tough getting used to a new product; change is rarely easy for human beings.

The payoff, however, is worthwhile. I sent the Gerbers to GoldPhoenixPCB and for $110, I got 16 boards and they arrived in eight days (I could have got 10 boards for a $100, but the six extra boards for $10 was too good to pass on). They even helped when I found an error in the original drill file that I provided; I alerted them to the problem, sent the new file, and they worked it into the system so I didn't have a wasted order. Customer service is a big thing for me, and this is another area where I think GoldPhoenixPCB shines.

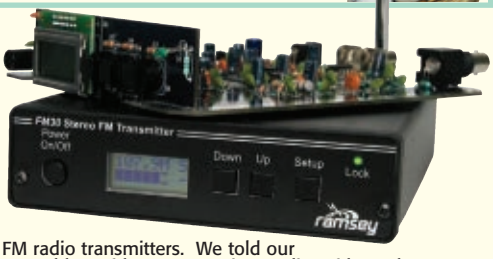
After you've got your boards and parts on order, do download and have a read through the MCP2515 docs since we could only scratch the surface here. Microchip has also produced a couple interesting app notes that may be helpful getting the hang of the CAN mentality. I found AN212 particularly useful in understanding how to implement CAN in a custom application.

Well, that's a wrap for this time. Have fun with the CAN shield; I expect to have all sorts of unexpected fun with mine.

Until next time, keep spinning and wining with the Propeller! **NV**

IT'S SPRINGTIME AT RAMSEY!

Synthesized FM Stereo Transmitter



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

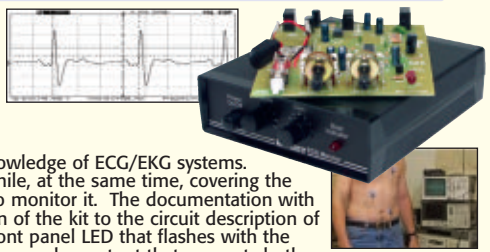
A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use!

The design includes EMI filters on line level audio and power inputs and a state of the art microstrip PCB inductor to reduce microphonics for the ultimate in alignment free operation. RF output is brought out to a professional, well shielded rear panel BNC connector for a perfect antenna match. Standard RCA connectors are used for left and right line level audio inputs. Both the FM30B and FM35BWT operate on 13.8 to 16VDC and include a 15VDC plug in power supply.

(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.

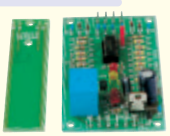
MK134 **Steam Engine & Whistle Kit** **$11.95**

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**

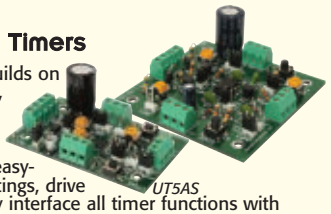
Liquid Level Controller



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**

Ultimate 555 Timers

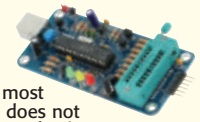


This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

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**

USB PIC Programmer



Finally, a compact USB PIC Programmer with a 20 pin ZIF socket for easy programming of most Microchip PIC Flash devices that does not require low voltage programming. Plus it uses USB therefore no more RS232 compatibility blues!

CK1301 **USB PIC Programmer Kit** **$34.95**

Doppler Direction Finder

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

DDF1 **Doppler Direction Finder Kit** **$169.95**

Retro Nixie Tube Clocks

Genuine Nixie tubes popular in the 50's brought back in the the neatest digital clocks around today!

Enjoy yesterday's high tech marvels today with our complete line of Nixie Tube Clocks! 6-digit hand-crafted teak hardwood base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Or a mini 4-digit version in a similar hand rubbed teak base, a fill size 6-digit clock with face mounted Nixies in a modern aluminum enclosure, or the mini in a high tech plexiglass enclosure. Visit our web site for details and specs on all models plus a video of the display!

NIXIE **Nixie Tube Clock Kits** **from $139.95**

HV Plasma Generator

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

PG13 **HV Plasma Generator Kit** **$64.95**

Broadband RF Preamp

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

PR2 **Broadband RF Preamp** **$69.95**

3-In-1 Multifunction Lab

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

LAB1U **3-In1 Multifunction Solder Lab** **$134.95**

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 Vehicular Keyless Entry Test Set

"HANDIEST THING IN MY SHOP"

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

Testing your system is easy. To test the complete key fob-to-vehicle and vehicle-to-key fob communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery (not included).

WCT3 **Four Mode Keyless Entry Test Set Kit** **$59.95**

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.

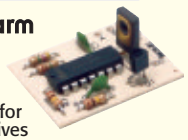
SA7 **RF Preamp Kit** **$19.95**

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**

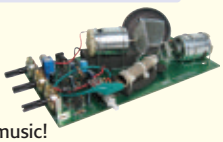
Mad Blaster Warble Alarm



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**

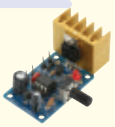
Laser Light Show



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 handy controller uses a pulse width modulated output to control the speed of a motor without sacrificing torque! Handles a continuous current of 5A and includes LED to indicate speed as well as an oversized gold heatsink! Also available factory assembled.

CK1102 **5A PWM Motor Controller Kit** **$14.95**

Digital LED Thermometer

This handy thermometer reads Celsius or Fahrenheit on an eye-catching .56" LED display! Based on the DS18B20 sensor and controlled by a PIC, it has a range of -67°F to 257°F (-55°C to 125°C) with a wired remote range of 325 feet!

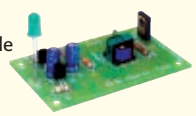
CK127 **Digital LED Thermometer Kit** **$29.95**

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** **$9.95**

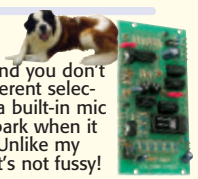
Tri-Field Meter Kit

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**	**$84.95**
PL300	**300-In-One Lab Kit**	**$109.95**
PL500	**500-In-One Lab Kit**	**$249.95**
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 brand new 2012 Ramsey Hobby Catalog today! Filled with some of the neatest goodies around! Order yours today... Or download the PDF at *www.ramseykits.com/catalog!*

800-446-2295

www.ramseykits.com

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

Prices, availability, and specifications are subject to change. Not responsible for typos, mistakes, stupids, or confusion that Spring is even approaching! Robin gave me an extra week to dig out of the snow and prepare this Spring ad! How ironic is that! Visit www.ramseykits.com for the latest pricing, specials, terms and conditions. Copyright 2012 Ramsey Electronics®.. so there!

Q&A

WHAT'S UP:

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

- ✓ **Phototransistor Amplifier**
- ✓ **Water Level Monitor**
- ✓ **Mail Bag**

■ 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**

EQUATIONS FOR LM317T

Q I have this power supply kit which was modified to also regulate current (I) and I found it to be very easy to build. Unfortunately, I don't know the algebraic equation in order to generate the desired regulated voltage output based on various input AC to DC power transformers that I'd like to experiment with. I also don't know if R2 (220 ohms) should actually be 240 ohms.

Please specify the algebraic expression associated with LM317T and show calculations for the following situations:

1) 12.6 VAC at one amp input power transformer while the desired regulated output voltage is fixed at 12 VDC at 184 mA.

2) 24 VAC at 800 mA input power transformer while the desired variable regulated output voltage is 0-12 VDC at 10 mA.

— Don Franklin

A The LM317T is not very sensitive to variations in input voltage. A one volt change in input can result in a 40 mV change in output, maximum. One way to reduce this output variation is to put a second LM317T in front of the output IC. Since each LM317T requires up to three volts of head room to operate at 1.5 amps, the input voltage will have to be raised.

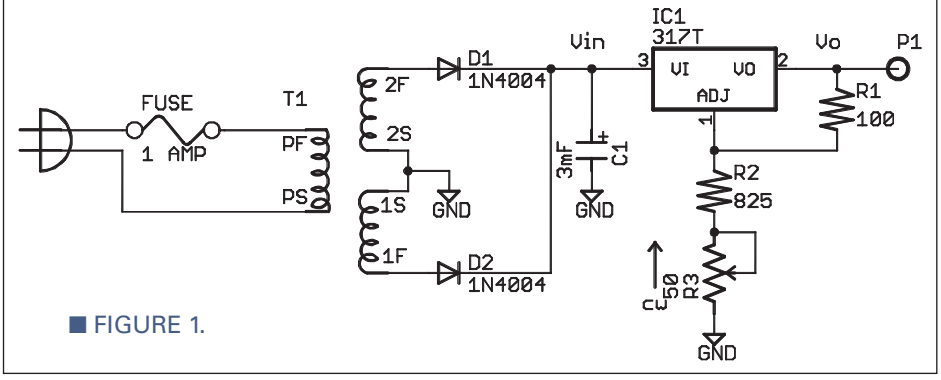
The LM317T operates by virtue of the fact that the voltage between Vo and Vadj is fixed at 1.25 ±.05 volts. The adjust current is less than 100 µA, so as long as the current through R1 and R2 (see **Figure 1**) is greater than 1 mA, the adjust current can be neglected. Since the LM317T needs a 12 mA load to regulate, it makes sense to set the current through R1 at 10 or 12 mA. R1 = 1.25V/12 mA = approximately 100 ohms. You can make R1 = 240 ohms but regulation may be lost for low load currents.

From the datasheet: Vo = 1.25(1+R2/R1), neglecting the adjust current. You can choose R1, then: R2 = R1(Vo/1.25-1).

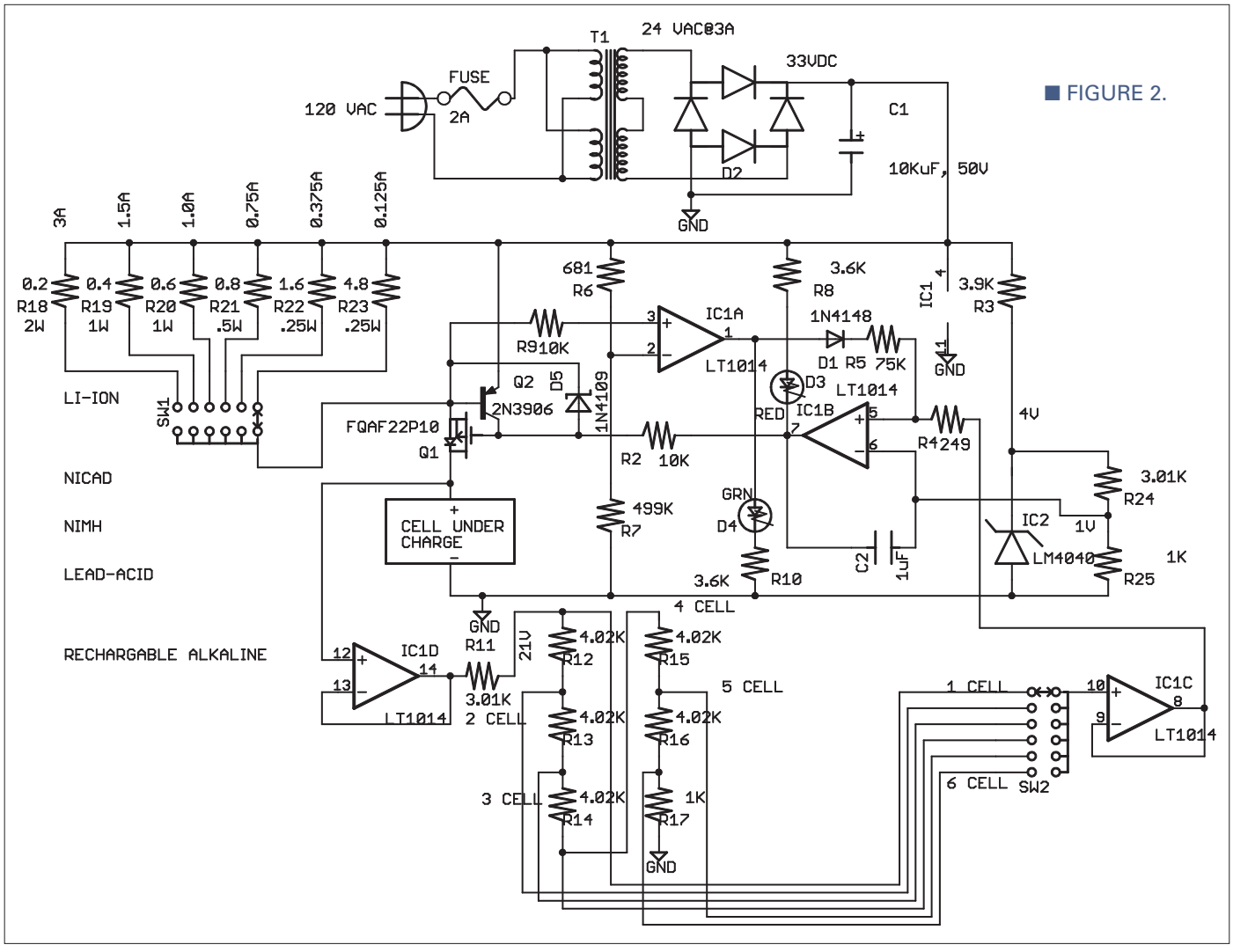
In the first case — 12 VDC out at 184 mA — I would calculate the filter cap from ripple voltage = dE = I*dT/C. If we set the ripple voltage at one volt and since this is a full wave rectifier, the ripple frequency is 120 Hz and the time between pulses (dT) is 8.3 mS. Now, C = I*dT/1 = .184*8.3 mF = 1.53 mF. Since this is just an approximation, you should at least double to 3,000 µF. Choose R1 = 100 ohms, then R2 = 860 ohms except that a pot is needed to trim the tolerance of the reference voltage. Since the tolerance is 4%, a 50 ohm pot will just about do it. Subtracting half the pot value, then R2 = 835 ohms; 825 or 845 are close standard values.

In the second case, the cap calculates to be 80 µF, so use 160 µF or better, 470 µF. For good reliability, the cap voltage rating should be double the rectified voltage. The DC from a 24 VAC transformer will be 1.4*24 = 34 VDC. The LM317T is rated to 37 VDC so it is okay. The filter cap rating should be 63V.

There is no point in limiting the output voltage to 12 volts when there is so much head room available, so make it variable from 1.25V to 24V. In the schematic in **Figure 1**, eliminate R2 and make R3 = 100(24/1.25-1) = 1.82K; use a 2K pot. If you want a fine adjustment of the output voltage, put a 200 ohm pot in series with the 2K pot.



■ FIGURE 1.



■ FIGURE 2.

RADIO REPAIR

Q When I got my first job as a teenager, I purchased a Panasonic RF-2600 with my first pay check. Unfortunately, I left it connected to an outside antenna while it rained and thundered (electrical/static discharge)! As a consequence, the AM as well as the four SW bands don't function at all, only the FM band is still working. Also, since I don't know how to troubleshoot, I replaced all the electrolytic capacitors and tested every diode for continuity.

Please indicate where the problem may exist. (Files showing the original schematic are available at the article download link.)

— Don Franklin

A There is no doubt the AM RF transistor (Q6) is toast; I would replace it. If that doesn't fix it, replace the RF gain transistor, Q4. Even though the FM is working, I would replace the FM RF transistor, Q1. I could not find a substitute or datasheet for the AM RF transistor, 2SK104, but the FM RF transistor, 2SK49, should work in both places. Also, NTE 312 is a substitute for 2SK104, but neither Digi-Key or Mouser stock it. The substitute is 2N5484. Q4 is a general-purpose NPN; 2N5088 is a substitute.

LITHIUM-ION BATTERY CHARGER

Q I saw the lithium-ion battery charger in your November '11 column.

I have three old Skil 2735 drills in which the old 12 volt Nicad batteries went bad. I have changed out the batteries with lithium-ion cells. However, if I leave them on a charge too long, they will pop open and leak, like they are over-charged. The lithium-ion battery voltage is 14.4 volts; the charger is a Skil #92900 one hour quick charger.

Is there a way to make the circuit from November work with different voltages, like three volts to 15 volts, have LEDs to tell when the battery is fully charged, and operate on 120 VAC?

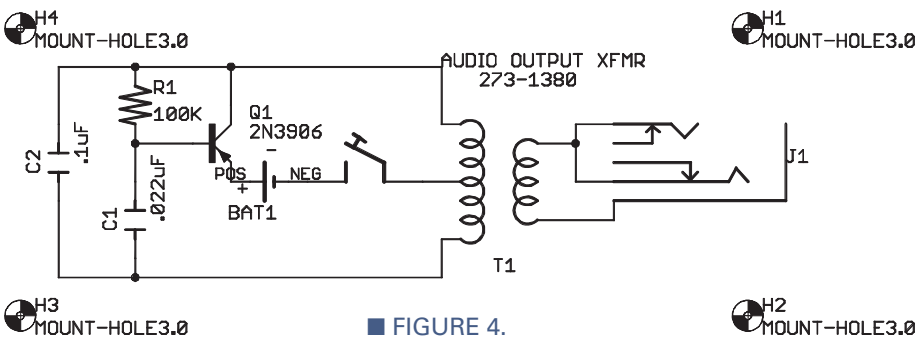
— Cletus Bell

A The circuit of **Figure 2** will charge battery packs of one to six cells to a maximum voltage of four volts per cell at constant current, then switch to constant voltage until the current drops to 7% of the initial

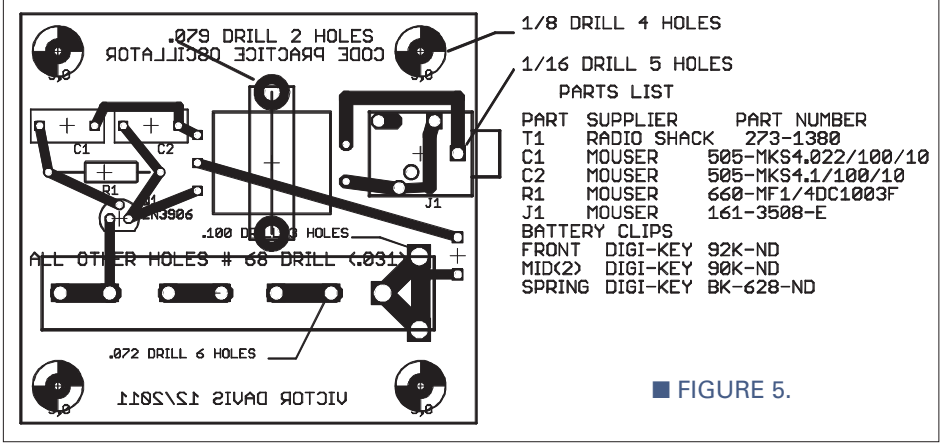
LITHIUM-ION BATTERY CHARGER PARTS LIST

■ FIGURE 3.

PART	DESCRIPTION	PKG	MOUSER PART #
SW1, SW2	1P6T, NON-SHORTING		611-A10605RNCQ
C1	10,000 µF, 63V	35MM	598-SLP103M063H9P3
C2	1 µF, 50V, 10%	RADIAL	5989-100V1.0-F
R18	0.2 OHMS, 2W, 5%	AXIAL	594-AC03W0R200J
R19	0.39 OHMS, 1W, 5%	AXIAL	72-RWM410-R39-5
R20	0.5 OHMS, 1W, 5%	AXIAL	594-AC01W0R500J
R21	0.75 OHMS, 1W, 5%	AXIAL	594-AC01W0R750J
R22	1.5 OHMS, 1W, 5%	AXIAL	594-AC01W1R500J
R23	4.7 OHMS, 1W, 5%	AXIAL	594-AC01W4R700J
R6	681, 1/4W, 1%	AXIAL	660-MF1/4DC6810F
R8, R10	3.65K, 1/4W, 1%	AXIAL	660-MF1/4DC3651F
R3	3.92K, 1/4W, 1%	AXIAL	660-MF1/4DC3921F
R2, R9	10K, 1/4W, 1%	AXIAL	660-MF1/4DC1002F
R5	75K, 1/4W, 1%	AXIAL	660-MF1/4DC7502F
R4	249, 1/4W, 1%	AXIAL	660-MF1/4DC2490F
R7	499K, 1/4W, 1%	AXIAL	660-MF1/4DC4993F
R24, R11	3.01K, 1/4W, 1%	AXIAL	660-MF1/4DC3011F
R25, R17	1K, 1/4W, 1%	AXIAL	660-MF1/4DC1001F
R12, R13, R14, R15, R16	4.02K, 1/4W, 1%	AXIAL	660-MF1/4DC4021F
T1	120 VAC/24 VAC @ 3A		553-FB-24
D2	DIODE BR, 100V, 6A	PB610	833-PB610-BP
D3	LED, RED, 5 MM	T1-3/4	604-1.53SRDG
D4	LED, GRN, 5 MM	T1-3/4	604-APT2012PGW
D5	15V ZENER 1/4W	DO-35	610-1N4109
IC1	QUAD OP-AMP LT1014	DIP14	595-LT1014CN
IC2	4V REF, LM4040	TO-92	926-LM4040DIZ41NOPB
Q1	P-MOS, 100V, 16A	TO220	512-FQAF22P10
Q2	PNP GEN-PURP 2N3906	TO-92	512-2N3906TA
OPTIONAL SERIES RESISTORS			
	3.3 OHMS, 50W	HS50	284-HS50-3.3F
	7.5 OHMS, 100W	HS100	284-HS100-7.5F



■ FIGURE 4.



■ FIGURE 5.

current, at which point the charger shuts off and remains off until the battery drops to 3.6 volts per cell.

Here is how it works: The constant current is regulated by Q2 and the resistors R18-R23. When the drop across the resistor reaches 0.6 volts, Q2 is turned on which reduces the drive to Q1. IC1A monitors the voltage on Q2 base and as long as Vbe is greater than the drop across R6, the output of IC1A is low and has no effect due to D1 being reverse-biased. The battery voltage is monitored by IC1D and the voltage divider R11-R17. The voltage divider reduces the full charge battery voltage to one volt, to be compared with the one volt reference from IC2 at IC1B. When the battery voltage gets to four volts per cell, IC1B will tend to turn off Q1 but that will allow the battery voltage to drop and turn Q1 on again.

To prevent the system from oscillating in that manner — which would cause IC1A to shut the charger down — I added a capacitor from pin 7 to pin 6 of IC1A. When Vbe of Q2 drops to less than the drop across R6, the output of IC1A goes high, lighting the green LED, D4, which drives IC1B's output high and stops the charge cycle. Zener diode D5 prevents the gate voltage of Q1 from exceeding its rating.

The 1" diameter by 2.5" long cell would have an amp-hour rating of about three and a maximum charge rate of three amps. All batteries and cells that are on the open market must have protection circuitry included to prevent overcharging, but as Mr. Bell discovered, it is not wise to depend on that. The lithium-ion battery heats when charged, and can go into thermal runaway and explode, so I recommend not exceeding the maximum rate.

Figure 3 is the Parts List.

PHOTOTRANSISTOR AMPLIFIER

Q I have a few questions; one is about speaker polarity. Does it really matter? It's an AC signal reaching the

MAILBAG

Dear Russell: Re: Telephone Remote Control, December '11, page 23. I noticed the questioner didn't specify whether he has analog or electronic or digital station ports on his "internal phone system." If they are electronic or digital, there is no 90V ring voltage (except on the Avaya [AT&T] Partner). If he has analog extensions, there will be the needed ring voltage, but there is the possibility the "on hook" extension voltage is 24 instead of 48 volts. Some of your component values may need adjusting. First, of course, the relay coil voltage. Also, analog extensions are always current limited to prevent damage from accidental (or intentional) overloading. The relay must activate at about 10 mA current through the coil.

The owner of the phone system should also look at the installation manual for his system; some have a relay already installed for this purpose.

— Dennis Hewett

Response: Thanks for the feedback, Dennis. Phone systems have changed a lot since I was a lad.

Dear Russell: Re: Timer, December '11, page 23. Ken Brown was looking for a way to time the stoppage of a rotating shaft. You tried to follow his line of thought and came up with a very complicated approach. I think there is a much simpler way.

You can monitor pulses from the encoder and compare them to a one shot timer. The timer starts when the light curtain is breached and stops 0.231 seconds later (ideally, the timer would be programmable for different distances to the machine). If pulses are still being received when the timer times out, the test has failed. If no pulses are detected, the test has passed. One could play with the timer setting to determine the stoppage time (adjust the time until you find the pass/fail break point), but this isn't necessary. The actual time isn't as important as knowing that you don't exceed the time allowed by law.

— Mike Callahan

Response: Yeah, why didn't I think of that? I was thinking about a normal stop where the shaft turns slower and slower until it stops, but .231 seconds is real sudden and no way is dynamic braking going to do that. Thanks for writing.

Dear Russell: Re: Computer Fault Finder, December '11, page 22. I was reading through the latest issue of *Nuts & Volts* and found your "Computer Fault Finder" very intriguing. I commonly use an old analog scope to plot I and Q signals from demodulation circuits but the thought never crossed my mind to use them to check components.

I'm a little confused though on what you are labeling as "VERT" and "HORIZ." If I were to hook up this circuit, I would set my oscilloscope into X-Y deflection and hook up my channel 1 and 2 to what you are calling "probes" after the voltage divider (assuming you are stepping down the voltage to not blast components with a large 12V). What is the VERT and HORIZ used for?

— Pantelis

Response: Thanks for writing. I never used the circuit and looking at it now, I see several errors. The open and short patterns are reversed and the resistor labeled 1K should be an open circuit. This no doubt has contributed to your confusion.

To answer your question: The scope measures the phase angle between voltage and current. The top of the circuit is always 12 VAC and is fed to the vertical input. The bottom of the 15K resistor responds to the current through the circuit and is fed to the horizontal input. The probes connect to the circuit under test. This idea is commercially available; see **www.huntron.com/products/2800.htm**.

Dear Russell: Re: Timer, December '11, page 23. If he starts a counter running at a fixed rate when power to the shaft is dropped and gates the count to the display register each time there is a pulse from the shaft, then the display will always show the time of the last pulse. This can all be done in a small micro.

— Ed Schick

Response: An elegant solution; thanks for writing.

speaker, right? Is there some crossover or speaker configuration that operates better with the correct phase?

The other question is I am trying to get the full dynamic range of a phototransistor (mounted on my roof) into a five volt swing to feed to an ADC. The phototransistor is an old FTP-100A that I pulled out of the junk box. During the day, I plug in a 1K pull-up resistor on the collector (emitter to ground, five volt circuit). Today it is overcast in Toronto, so the voltage drops to about 1V; I guess when it's sunny it will drop even more. At night, I need to put in a 47K pull-up because the current drops off so much. With the 47K, I get about four volts when it is dusk and five volts at night. I want to add the ability to record the brightness and length of the days, hence the ADC.

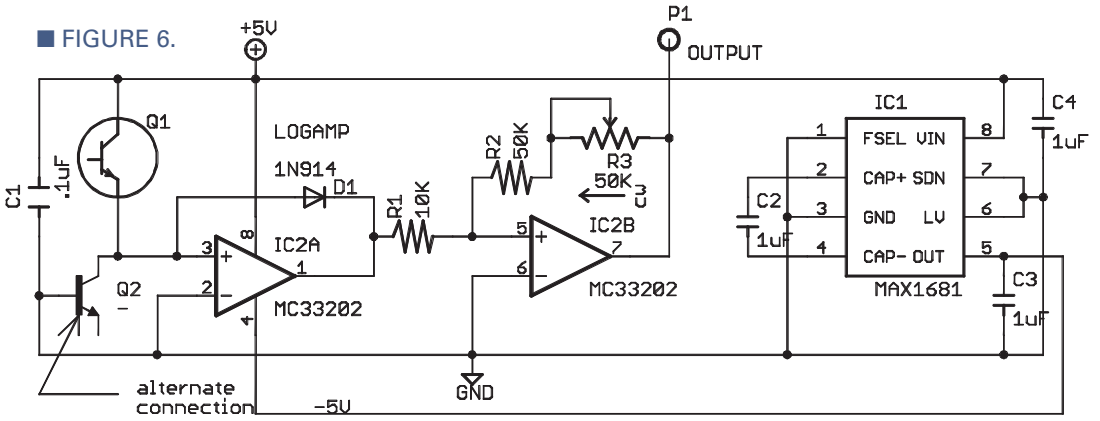
I am good to go on the ADC and computer recording end of things, but I can't figure out how to get such a large range of current into a smaller voltage swing. Also, do you know if the phototransistor output is linear or logarithmic?

— Josh Bensadon

A First, the speaker polarity. I think it should make a difference if one speaker is pulling in while the other is pushing out. However, I never paid attention to polarity and don't notice any difference, but I am not an audiophile.

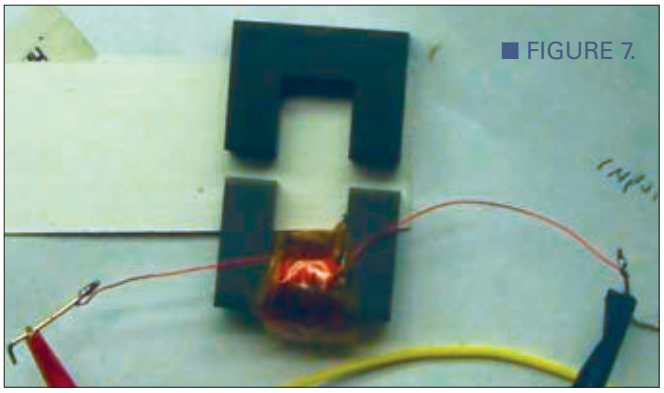
According to Wikipedia, the response of the phototransistor is linear, relative to irradiance. The typical means to compress a signal is to use a log amp. The 1N914 diode voltage is perfectly logarithmic up to 10 mA, according to the datasheet. **Figure 6** uses that feature but requires a negative supply. The second stage inverts the signal to be positive again. The minimum output will be at night and may be affected by the leakage (dark current) of the phototransistor. The pot, R3, can be adjusted to set the maximum output in bright sunlight. The 1N914 diode has a temperature coefficient of -3 mV/degree C which should not be a problem if the circuit is in the house. If you do want a temperature

■ FIGURE 6.



compensated log amp, you will find a schematic in National Semiconductor Application Note AN29, Figure 23.

The dark current problem can be alleviated by connecting the phototransistor as a diode (I don't know how well a transistor would work with no bias) across the op-amp input with no pull-up resistor. With no voltage across it, there will be no leakage current. A solar cell could also be used; you could shade the solar cell to limit the current to 10 mA or less.



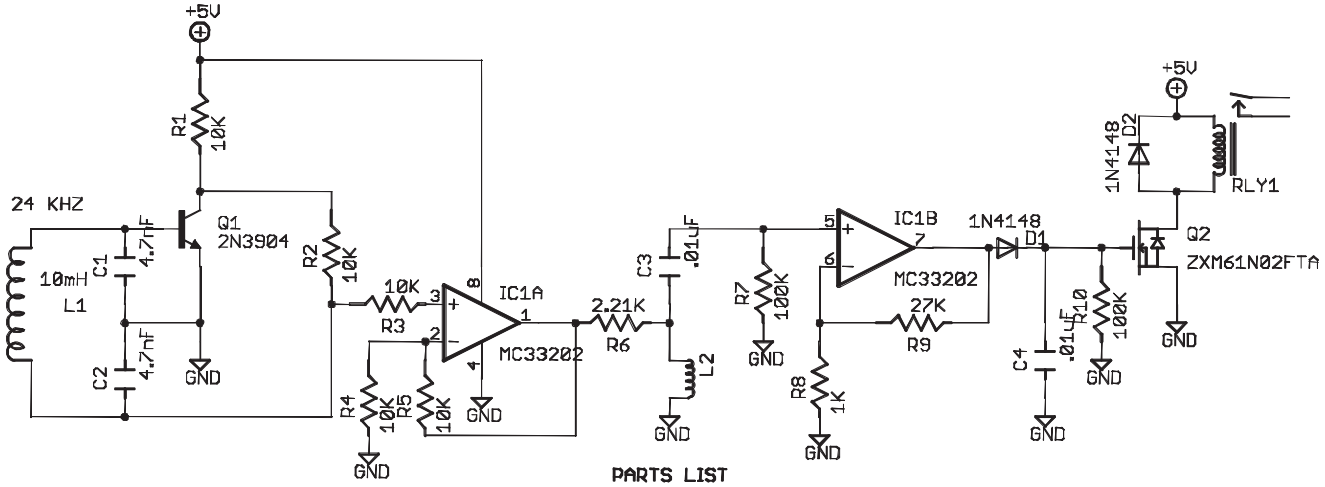
■ FIGURE 7.

WATER LEVEL MONITOR

Q My "store bought" Christmas tree water level indicator bit the dust last year and I'd like to make one myself. I have experimented with a few designs, but all seem to have the same problem: The electrodes corrode very quickly due to the plating effect present with DC current. Can you suggest a circuit that does not have this issue?

— Mike Gerstweiler

A A variable inductor comes to mind. I wound 100 turns of #30 wire on a RadioShack core, 273-104 (see **Figure 7**). The idea is that when both core halves are together, the inductance is high and the voltage drop will be high enough to turn on a switch. When the cores are separated, the inductance is low and the switch will not be activated. Nothing needs to be in the water; only a float to move one half up and down. In order to test this idea, I breadboarded the circuit of **Figure 8**;



PARTS LIST

PART	DESCRIPTION	PKG	MOUSER PART NUMBER	
L1	10mH 5% LOW CURRENT	RADIAL	580-19R106C	
C1, C2	4700pF, 5%, 50V	5.0LS	5005-FKP24700/63/2.5	
Q1	NPN 60V, 100mA, GP	TO-92	863-2N3904RLRAG	
R1, R2, R3, R4, R5	10K, 1/8W, 1%	1206	660-RK73H2BTTD1002F	OTHER RESISTORS SIMILAR
IC1	OPAMP, 12V, R/R	DIP-8	863-MC33202PG	
L2	100TURNS ON R.S. CORE		273-104 RADIO SHACK	
C3, C4	.01uF, 10%, 50V	5.0LS	505-MKS2.01/63/10	
D1, D2	1N4148/1N914, 50V, 200mA		78-1N4148	
Q2	NMOS, LOGIC LVL20V, 1.7A	SOT23	522-ZXM61N02FTA	
RLY1	5V RELAY, SPST	FTR	817-FTR-K2AK005T	

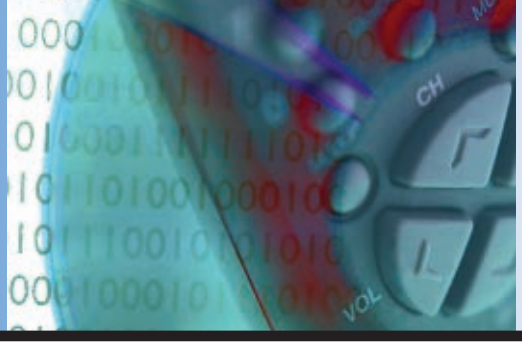
■ FIGURE 8.

although I used a green LED at the output instead of the MOSFET and relay.

In **Figure 8**, Q1 is in an LC oscillator circuit which has a good sine wave output at the junction of C2 and L1. A good sine wave is essential because harmonics will raise the voltage at low inductance, making it difficult to differentiate between high inductance and low inductance. IC1A is a buffer with a gain of two, driving L2. IC1B is AC coupled to minimize offset and has just enough gain to turn on Q2.

CODE PRACTICE OSCILLATOR

Q Back in February, I published a schematic based on a simulation. I decided to build it because I was once fairly proficient in Morse code. Alas, it did not work. My simulated transformer had no resistance but the actual transformer has 70 ohms. I reduced R1 to 100K and trimmed C1 such that the blocking oscillation coincided with the resonance of C2 and the transformer primary, about 600 Hz. The wave form is not very sinusoidal but works great and the values are almost exactly those Victor Davis sent me (see **Figure 4**). **Figure 5** is the layout and Parts List. I mounted an AAA battery and miniature phone jack on the printed ciruit board. NV



NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

BI-POLAR CHOPPER STEPPER MOTOR DRIVE KIT

Global Specialties new GSK-187 bipolar chopper stepper motor drive kit will drive bipolar stepper motors up to 2A per phase with a 9-35V supply. The kit features full and half stepping. All signals (step, direction, enable) can be interfaced to external +5V logic or a microcontroller. Components and an instruction manual included. Global Specialties has added six new kits, expanding their line to 17 kits. Each kit comes complete with detailed assembly instructions and all necessary parts.Other new kits include the Temperature Meter Kit, Basic Power Supply Kit, Fiber Optic Audio Link Kit, 3-1/2 Digit Panel Meter Kit, and the Step Up DC Converter Kit.

For more information, contact:
Global Specialties, LLC
Web: **www.globalspecialties.com**

USB TO SPI PROTOCOL CONVERTER

Microchip Technology Inc., has announced the HID-class MCP2210 USB to SPI protocol converter, which offers a simple, and cost-effective option for adding USB-certified connectivity to SPI-based systems in a small footprint. Microchip also provides free downloads of supporting software drivers, DLLs, and a PC configuration tool — in addition to an evaluation board — to make it fast and simple for designers without USB expertise to add USB connectivity.

The converter comes in small 20-pin SSOP and 5x5 mm QFN packages for space-constrained applications. Additionally, the MCP2210 has nine flexible general-purpose I/O that can be configured via a PC as standard digital I/O pins or in alternate configurations, providing additional system I/O that simplifies designs and supports a wide range of applications. While most PCs have standardized on USB as the primary protocol for connecting to other devices, many of those devices still utilize the SPI protocol. In combination with the above features, software, and tools, the MCP2210 converter utilizes the USB HID class which is supported by the Windows®, Linux, and Mac OS® operating systems, and is a plug-and-play solution for adding USB to existing designs for data collection, transfer, and analysis, along with many other USB functions. The MCP2210 evaluation kit (part #ADM00421) is available today for $29.99. Additionally, its free software drivers, DLLs, and PC configuration tool are available for download.

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

USB 60 MHz OSCILLOSCOPE/ LOGIC ANALYZER

Saelig Company, Inc., announces the availability of the MSO-28 — a new, USB powered, entry-level mixed signal 60 MHz oscilloscope adapter for PCs. This lightweight, economical scope adapter combines a two channel oscilloscope with a synchronous eight channel logic analyzer, sampling at 200 MSa/s (5 ns), all in one compact, extremely portable USB instrument. Simultaneously-clocked analog waveforms and digital data can now be displayed in phase on the same screen with the efficient and easy-to-use Front Panel software. The MSO-28's advanced triggering options include an oscilloscope (analog) trigger with rising/falling edge and pulse width; logic analyzer trigger with eight-bit trigger word; SPI trigger (32-bit trigger word); I^2C trigger (32-bit trigger word), or any of the logic lines. The 200 MSa/s sample rate and 60 MHz bandwidth allows capturing a 60 MHz signal in single shot mode (or faster repetitive signals) with an effective repetitive sampling rate of 1 GSa/s. The FFT spectrum analyzer shows frequency spectrum information up to 100 MHz for

analog input signals, and has controls for FFT window, FFT type, and FFT resolution.

The software also supports averaging, memory, and plot subtraction. This allows for a whole range of spectral analysis, including frequency response and power supply noise analysis. Averaging 100 captured signals reveals fundamental and harmonic frequencies, with random noise greatly suppressed. Standard automatic waveform measurements (frequency, period, cycles, max/min, pk-pk, rise/fall time, etc.) can be displayed next to traces, and FFT data can be saved to disk or exported to Excel, MathCAD, etc.

SPI and I²C serial bus protocols can be displayed and decoded, or used as 32-bit wide trigger sources. SPI and I²C signals can be viewed as timing waveforms or a state list display. The Front Panel software provides simple controls and auto setup which makes operation intuitive, yet allows sophisticated operations not possible with a bench DSO. Default setups can be saved to disk for easy recall at a future date. Screenshots can be pasted into documents and annotated as needed for reports and presentations.

The MSO-28 allows multiple signals to be seen on an LCD or projection screen or on dual monitor PCs. Since the MSO-28's high speed samplers and buffers perform all the high speed data acquisition, the actual PC speed is not a performance limiter. The MSO-28 acquires and stores data at up to 1 GSa/s, transferring data from the high speed buffers when full to the PC. Lightweight (2.5 oz/70 g) and compact (4.0" x 2.4" x 0.8"; 102 mm x 61 mm x 20 mm), the MSO-28 is supplied complete with two passive x1/x10 probes, a logic cable with test hooks, and a USB cable. The MSO-28 is made by Link Instruments is available now for $325 from Saelig.

For more information, contact:
SAELIG
Web: **www.saelig.com**

Continued on page 50

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

100 MHz Digital
Oscilloscopes
$399
Buy online @ Rigolna.com
DS1102E
• 2 analog channels
• 1 million points deep memory
• 1 GSa/sec max sample rate
• 5.7" display
RIGOL Beyond Measure

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

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

NKC ELECTRONICS .com
$119.95
USB Logic Analyzer
Zeroplus LAP-C 16032
16-channel - 100MHz - USB 2.0
SPI - i2c - UART - 7-segment
30 free additional protocols
Digital Storage Oscilloscope
OWON SDS7102V
100MHz - up to 1GSa/s
10 M points deep memory
8" TFT LCD 800x640 pixels
USB - LAN - VGA
$599.95
ARDUINO UNO $29.95
ARDUINO MEGA 2560
ARDUINO ADK for Android
FREEDUINO - SEEEDUINO
DSO Nano / Quad
ARDUINO Shields - Ethernet
RGB LCD - XBee
Large selection of ARDUINO products
Special price for distributors

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

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

By Craig A. Lindley

BUILD YOUR OWN WI-FI INTERNET RADIO

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

I am writing this article while sitting in my living room listening to music over my Wi-Fi network streamed from a radio station in Europe. With my iPod Touch, I can select the station I am listening to, I can see the name of the artist and song being played, I can control the volume of the music, and I can even mute the music altogether if I get a phone call. And, I can do all this without having to touch the Wi-Fi Internet Radio (WIR) I've just finished building. Ah, life is good.

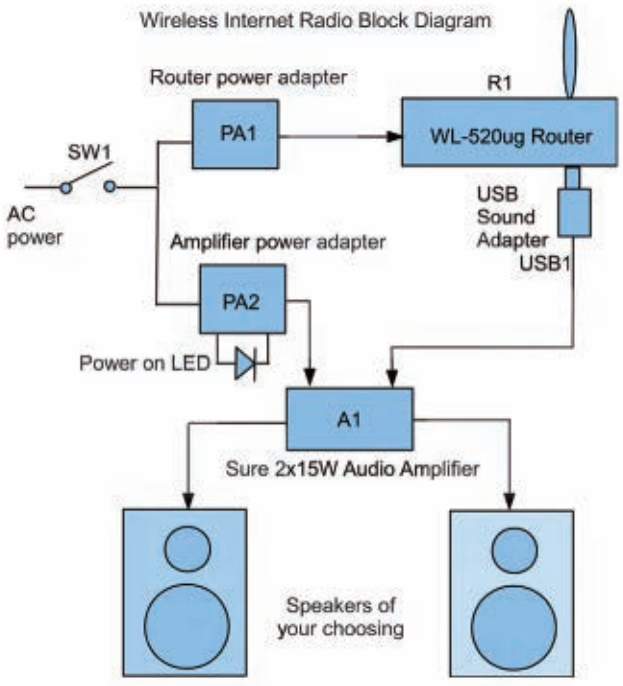


FIGURE 1. Schematic/block diagram of the WIR.

I had never listened to Internet radio, so I didn't know what I was missing. Since completing my WIR, it has played continuously whenever I am at home. With WIR, you are not limited to radio stations you can pull in over the air from your location. Instead, you have access to hundreds — if not thousands — of stations world wide playing a wide variety of program material including music in every genre, news, talk radio, religious broadcasts, sports, comedy, and probably other things I haven't yet discovered. While flipping through the stations on my WIR, it occurred to me that this is just like the listening I used to do late at night with my father on his short-wave radio. I had the world available at my fingertips then and with WIR, I do again.

When I caught the urge to listen to Internet radio, I first thought of buying a ready-made unit but after some research on the Internet, I decided I should build one instead. Besides saving money, building instead of buying a WIR would add substantially to my creds as a serious builder and as everyone knows, builders/makers are the new rockstars.

In researching WIR, I came across **mightyohm.com** (see **Resources**) and its WIR build. I would like to thank Jeff at **mightyohm.com** for providing the information and

PARTS LIST

■ FIGURE 2.

DESIGNATION	DESCRIPTION	PART #	SOURCE
USB1	Syba USB stereo audio adapter	SD-CM-UAUD	**amazon.com** or **ebay.com**
R1	ASUS wireless router	WL-520GU	**amazon.com**, **newegg.com**, or **ebay.com**
PA1	Router power adapter supplied with router	N/A	N/A
A1	Sure 2x15W @ 4 ohm TA2024 Class D audio amplifier board*	#320-308	**parts-express.com**
PA2	Sure 12 VDC 3A power adapter	# 320-312	**parts-express.com**
LED	LED power indicator (used with a 1K resistor across the 12 VDC supply PA2 to limit brightness)	Color of your choosing; I used blue.	**superbrightleds.com**
SW1	110V power switch SPST, SPDT, or DPDT	N/A	RadioShack or **allelectronics.com**
Speakers	Any stereo speakers you want to use. I used the RadioShack Realistic Minimus 7 speakers I had on hand. Note: The better the quality of the speakers, the better your WIR will sound.		Many pairs of Minimus 7 speakers are available on eBay.

* The Class D stereo amplifier module is available in 2 , 8, 15, 25, and 100 watt sizes. I used the stereo 15 watt module in this build.

encouragement needed to build a WIR. The WIR Jeff presented was based on a repurposed ASUS WL-520gu router (with a USB interface) which can be purchased at Amazon, eBay, or NewEgg for around $30 after rebate, and sometimes even cheaper. A USB sound card/adapter is also required. In the finished configuration, the USB sound adapter plugs into the USB interface of the router and converts the streamed digital audio into analog for subsequent amplification.

With the Internet music production component (the repurposed ASUS router) defined, I went about designing the rest of the system to fit my personal requirements. Since I wanted the WIR in our living room, it had to look nice and fit in with the other living room furniture I built in the past. This meant the cabinet needed to be made of dark hardwood with black highlights. Next, I wanted a radio with a built-in stereo amplifier and speakers but without a display or knobs, and I also didn't want cords running from it for connection to my existing stereo system. In other words, I wanted a stand-alone unit requiring nothing more than a power connection as this would allow me to move the radio anywhere (inside or outside the house) where Wi-Fi and power are available.

I thought a lot about speakers and speaker enclosures during the design process. Fidelity was important to me but so was saving money. I had the option of buying individual speakers (a woofer and tweeter for each channel) and designing a cabinet to house them, but good quality speakers are expensive and designing speaker cabinets is an art I have little experience with. It was then I remembered I had a pair of RadioShack Realistic Minimus 7 speakers which I have had for years that have always sounded good for their size. Even after deciding to incorporate these speakers into my WIR, I still had another decision to make. I could either include these speaker enclosures in my WIR cabinet or I could cannibalize the components (the speakers, the crossovers, the acoustic batting) and reproduce the speaker cabinets out of wood in my cabinet. For simplicity, I decided on the former and designed cavities in my cabinet for the speakers to slide into. In the end, I epoxied the Minimus 7 speakers into the finished cabinet to prevent spurious vibrations from affecting the sound.

Amplification was the next design decision to make. The Minimus 7 speakers have a maximum rating of 40 watts, so I knew I didn't want to exceed that. In terms of amplifier technology, I had been reading about Class D digital amplifiers and was eager to try them out. A quick Internet search lead me to Sure Electronics Class D stereo amplifier modules, available from **parts-express.com** at a very reasonable price. After reading the positive reviews, I was sold on the idea and purchased the 2 x 15 watt amplifier module and its power supply. I thought 15 watts RMS per channel was probably enough power for my WIR and it has turned out to be so. Interestingly, the amplifier module doesn't have heatsinks because they are unnecessary due to the efficiency of the Class D design.

Figure 1 shows the block diagram/schematic of the WIR I had in mind and **Figure 2** shows the Parts List.

RESOURCES

Mighty Ohm Internet Radio Build
mightyohm.com/blog/2008/10/building-a-wifi-radio-part-1-introduction/

Instructables Internet Radio Build
www.instructables.com/id/Build-your-own-Wifi-radio/

Google SketchUp Information
sketchup.google.com/

Information about the InternetRadioMPC iPhone/iPod Touch/iPad app
clockwork.craigandheather.net/internetradio.html

Information about the OpenWrt Linux Distribution for Embedded Systems
openwrt.org

The Music Player Daemon Protocol
www.musicpd.org/doc/protocol/

■ **FIGURE 3.** Front view of the finished WIR cabinet.

With all of the components of the WIR selected, I went ahead and designed a cabinet to hold it all. **Figures 3** and **4** show the cabinet I built which scored a two thumbs up rating from my wife. The only control on the radio is a power switch on the rear of the unit, and the only indicator is a blue LED on the front to show that power is on.

MPD, MPC — The Big Picture

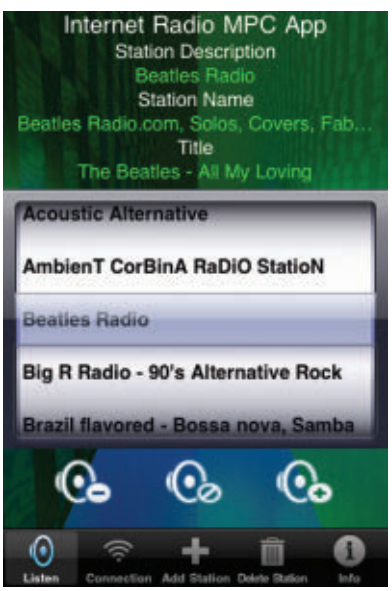
Having just described the hardware aspects of the WIR, we now turn our attention to the software that makes Internet radio streaming possible. In our WIR application, the router's firmware is replaced with OpenWrt — a Linux distribution for embedded devices with limited memory. OpenWrt provides a basic Linux operating system with built-in networking, a writable file system, and package management. Once OpenWrt is operational on the router's hardware, USB sound drivers and the MPD and MPC packages (to be discussed shortly) are installed. Then, after tweaks are made to various configuration files the router will be capable of streaming Internet radio. A step-by-step procedure for repurposing the router will be presented in the next section.

As you may have guessed, the MPD (music player daemon) and MPC (music player client) packages are key to Internet radio operation on the repurposed router. MPD is a Linux server application for playing music that accepts connections and commands from MPC applications running locally or remotely. Using plug-ins and libraries, MPD can play a variety of sound formats while being controlled by its network protocol. For those interested, a link to MPD information can be found in the **Resources**.

An MPC application directs the operation of the MPD server by connecting to it at a specific IP address and port number (typically at port 6600), and subsequently passing text based commands to it. MPD processes the commands, then returns information to the client. In some cases, only the success or failure of the command execution is returned. In other cases, text based data is

■ **FIGURE 4.** Rear view of the finished WIR cabinet.

■ **FIGURE 5.** Internet radio MPC iPhone/iPod Touch/iPad app.



returned (e.g., the content of the current play list) to the MPC from the MPD.

Strictly speaking, the MPC package doesn't need to remain on our repurposed router since it is used only for testing purposes and not used at all when the WIR is being controlled by a remote MPC. That being said, the presence of MPC does no harm either. It should also be mentioned that we are using just a small fraction of MPD's capabilities in our WIR application.

Any MPC program can be used with this WIR. However, most MPC programs are overkill as they are designed for MPD servers which — in addition to playing Internet radio stations — host complete digital music collections. This is not possible with our arrangement since there is little mass storage available on the router for the digital audio files of a music collection.

For this reason, I decided to develop an iPhone/iPod Touch/iPad MPC app specifically for this WIR. The app called "Internet Radio MPC" is available in the Apple App Store. Complete information about this app is available online. Again, see **Resources** for a link.

Figure 5 shows the main user interface of the Internet Radio MPC app. Other portions of the user interface (not shown) are used for adding and deleting radio stations.

Using a smartphone based MPC with this WIR is very convenient because you can control the radio from anywhere your Wi-Fi signal is available, and you don't have to point your mobile device at the radio like you do with IR type remote controls.

Repurposing the ASUS WL-520GU Router

I'm sure there are numerous ways to do this repurposing, but I will describe the process and tools I used because it worked for me. Please note:

1. A computer running Windows is required. I used my MacBook Pro configured with BootCamp to run Windows 7.
2. The router's warranty is null and void once you replace its firmware.
3. If you are not comfortable working in the Linux environment (e.g., logging in as root, running the vi editor, etc.), you may want to find someone who is and have them do the repurposing for you or at least assist you.
4. You need to have the SSID of your Wi-Fi network available and — if you are using encryption for security — you need to know which kind and the encryption key.

Carefully follow the steps outlined below to perform the repurposing. If things don't work as described, you can start over from step 3 as many times as necessary to get it right. There is very little possibility you will get the router into a state from which you cannot recover by starting over.

1. Download this article's zip file from the *Nuts & Volts* link and unzip it. It should contain (among other things) the router firmware restoration utility program (wl520.zip) which will allow us to load new firmware onto the router; the OpenWrt firmware image (openwrt-brcm-2.4-squashfs.trx) we will be loading; and Putty (putty.exe) which will allow us to telnet and SSH into the router once its firmware is replaced.
2. Unzip and install the router firmware restoration utility on your Windows computer.
3. Go to network connections on your PC, right click on the local area network connection, and selected Properties. Then, click on Internet protocol and click Properties again. Choose "Use the following IP address" and enter these values:
   IP address: 192.168.69.10
   Subnet mask: 255.255.255.0
   and click OK. If your computer has other network connections, disable them temporarily.
4. Plug an Ethernet cable into your computer and into the Lan 1 port on the router.
5. Put the router into firmware restoration mode by unplugging it and depressing the restore button on the rear panel while reconnecting its power. The power light will blink if all is well.
6. Execute the router restoration utility previously installed on your PC and browse to the location of the OpenWrt firmware. Select it and click Upload. You should see the progress bar advance as the firmware is uploaded to the router. If you have a problem uploading the firmware, you may have to disable your PC's firewall and try again.
7. Go back to your Network Properties and reset it so it obtains its IP address automatically.
8. Unplug the Ethernet cable from the router, wait a minute, and plug it back in so that it obtains a new IP address.
9. Start Putty, select Telnet, and type in 192.168.1.1 and click Open. If all is well, you should see the OpenWrt startup screen and the command prompt root@OpenWrt***:/#***.
10. Create a password for the root user by typing ***passwd***. I used ***internetradio*** as my password.
11. Restart Putty and specify an SSH connection to IP address 192.168.1.1.
12. Click yes to the dialog box that pops up and log in as root using the password you just created. You should again see the OpenWrt startup screen and command prompt.
13. To enable wireless operation, use vi to edit the file ***/etc/config/wireless***. Type ***vi /etc/config/wireless*** at the command prompt and modify your file to make it look like the following. The required changes are <u>underlined</u> and **bolded**.

```
config wifi-device   wl0
option type      broadcom
option channel   5

# REMOVE THIS LINE TO ENABLE WIFI:
```

```
#   option disabled 1

config wifi-iface
    option device   wl0
    option networklan
    option mode     sta
    option ssid     ssid of your network
    option encryption the type of encryption
    your wifi network uses
    option key      the encryption key for your
    network

    when you are finished editing type esc
    :wq to write out the changes and quit vi.
```

14. Next, edit ***/etc/config/network*** to make it look like the following. Again the changes are underlined and **bolded**.

```
    #### VLAN configuration
config switch eth0
    option vlan0  "1 2 3 4 5*"
    option vlan1  "0 5"

#### Loopback configuration
config interface loopback
    option ifname "lo"
    option proto  static
    option ipaddr 127.0.0.1
    option netmask255.0.0.0

#### LAN configuration
config interface lan
    option type   bridge
    option ifname "eth0.0"
    option proto  dhcp
#   option ipaddr 192.168.1.1
#   option netmask255.255.255.0

#### WAN configuration
config interface  wan
    option ifname "eth0.1"
    option proto  dhcp
```

15. After saving the file, restart the router networking by typing: ***/etc/init.d/network restart***. If all is well, in a few minutes you should see the air LED indicator on the router dimly light up.
16. Disconnect the Ethernet cable from the router and re-enable wireless networking on your PC. As a result of the changes made, your router will automatically acquire an IP address from your Wi-Fi network every time it powers up. We need to determine what IP address that is by logging into your Wi-Fi network and looking for connected devices. If you don't know how to do this, consult the manual for your Wi-Fi device.
17. Restart Putty and establish an SSH connection to the IP address found in the previous step. Log in as root.
18. Next, configure the package manager in preparation for loading packages across the network. Edit the file ***/etc/opkg.conf*** and make your file look like that shown below. With these changes, we will be pulling the packages we need from **mightyohm.com**.

```
src/gz snapshots http://mightyohm.com
/files/kamikaze-2.4/packages/mipsel
dest root /
dest ram /tmp
lists_dir ext /var/opkg-lists
```

19. Next, type ***opkg update*** to get a list of available packages.
20. Download the USB sound driver packages by executing the following from the command line: ***opkg install kmod-usb-audio kmod-usb-ohci***. With this done, plug in the USB adapter and cycle the power on the router.
21. Restart Putty, log in, and type ***opkg update*** once more.
22. Install the MPD and MPC packages with the command: ***opkg install mpd mpc***.
23. Next, create three directories on the router with the command: ***mkdir .mpd music .mpd/playlists***.
24. With vi, open the MPD configuration file ***/etc/mpd.conf***. Find the "An example of an OSS output" portion of the file and remove the # characters on each line to uncomment them; also change the device entry shown in **bold** below.

```
audio_output {
        type            "oss"
        name            "My OSS Device"
        device          "/dev/sound/dsp"
                        # optional
        format          "44100:16:2"
                        # optional
}
```

25. Create a link which will cause MPD to start every time the router does. Use the command: ***ln -s /etc/init.d/mpd /etc/rc.d/S93mpd***.
26. Start the daemon by typing ***mpd***. If you get an error message about not being able to open the database, you can ignore it.
27. Execute the music player client program by typing: ***mpc***. If you get the following response: **volume: 100% repeat: off random: off** you are good to go and the repurposing of the router is complete.
28. For the ultimate test, connect headphones or an amplifier and speakers to the output of the USB sound adapter and set a low volume level. Then, execute the following series of commands:
    1. mpc volume 25
    2. mpc add http://64.40.99.2:8088
    3. mpc play

If all is well, you should hear the Beatles.

Locating Internet Radio Stations

MPC programs requires a URL (Universal Resource Locator) to play a streaming radio station. Finding URLs of stations is easy in some cases and difficult in others. Some broadcast stations will publish a playlist file on their website in either .pls or .m3u formats; .pls playlists have a format similar to a Windows .ini file. A typical example is:

```
[playlist]
numberofentries=2
File1=http://88.191.111.120:8006
Title1=(#1 - 39/2000) Cool93
  Fahrenheit
Length1=-1
File2=http://203.150.224.142:8000
Title2=(#2 - 1950/5000) Cool93 Fahrenheit
Length1=-1
Version=2
```

Two different URLs are supplied for the same station in this file. The URLs are contained in the File entries and are of the form: **http://IPAddress:Port**. URLs in .m3u playlist files are specified in the same way.

Shoutcast.com is a great source of playlist files for hundreds (if not thousands) of Internet radio stations.

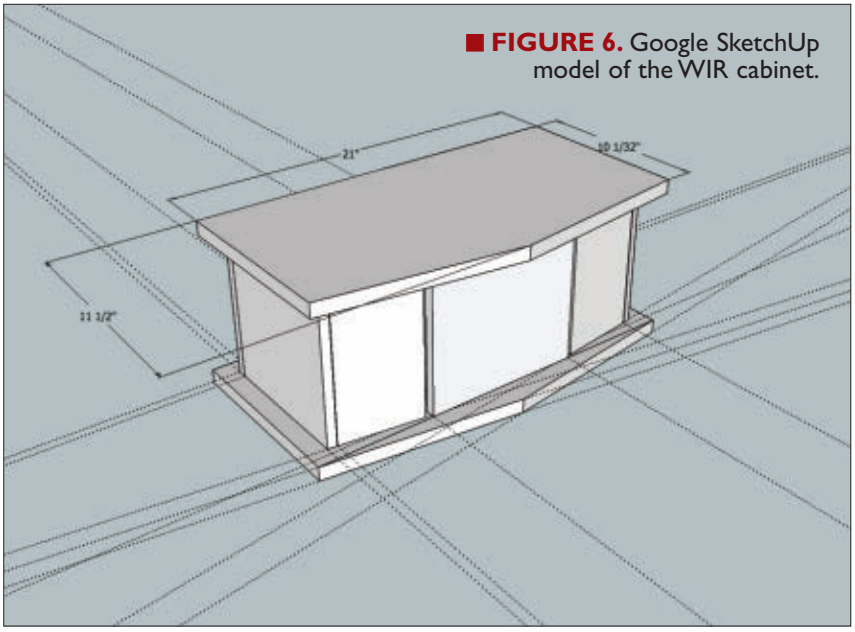
The nice things about **shoutcast.com** are the stations are arranged by genre and they also show the bit rates used for streaming. In general, the higher the bit rate the better the quality of audio. This is, of course, at the expense of using more bandwidth on your Internet connection.

While on the Shoutcast site, click on the name of the station you are interested in and you will get a playlist file downloaded to your computer. Open the playlist file in a text editor and extract the station name from the Titles line and the URL(s) from the Files line. Once you have the URL of an Internet radio station, you supply it to an MPC program and it, in turn, conveys it to the MPD for streaming.

Packaging the WIR

I had rather strict requirements for my WIR in terms of packaging but you have a lot of options for a WIR you might build, including:

1. No packaging at all. Here, the USB sound adapter is plugged into the router and the router's power adapter is plugged into the wall. Powered external speakers could be plugged into the USB adapter or the USB adapter could be connected to an existing stereo system via appropriate cables.
2. Packaging the router, USB adapter, and power amplifier in a small enclosure with connectors for external speakers.
3. If you have an old time radio or a juke box, you might consider building the WIR into that.
4. Build a cabinet for all the components which also functions as a stereo speaker cabinet. This would require one to know about speaker cabinet and electronic crossover design and would make the cabinet more complex to build.
5. You could do as I did and build a cabinet for all the components with cavities on each side large enough to accommodate pre-made speakers (in enclosures) to be installed.



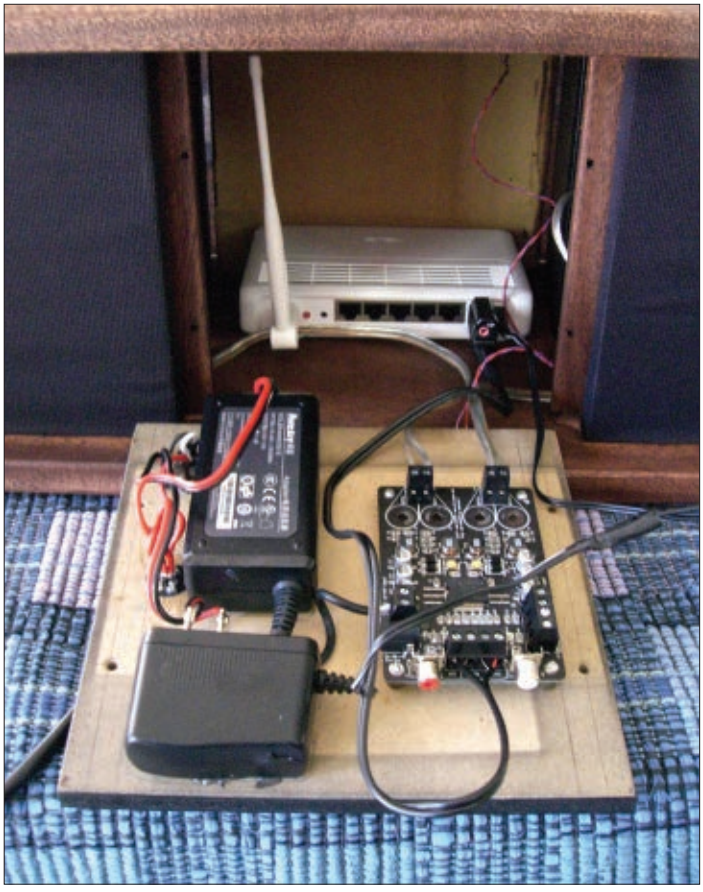
■ **FIGURE 6.** Google SketchUp model of the WIR cabinet.

I used Google SketchUp (a free 3D CAD program) to design the cabinet I ended up building. A rendering of the cabinet is shown in **Figure 6**. The cabinet design file is included in the article downloads for those people who would like to use my design as a starting point for theirs. The dimensions of each piece of the cabinet can be found using the dimensioning tool within SketchUp.

I stained the top and bottom hardwood pieces and then used paste wax to bring up the shine. The carcass of the cabinet was made from 1/2" MDF which — after being glued together with biscuits — was painted black so as not

SPEAKER CABINET PARTS LIST

DESCRIPTION	PART #	SOURCE
Hardwood for top and bottom	I used walnut but any nice wood can be used. The top and bottom pieces of the cabinet are identical and are 3/4" thick.	Woodcraft
1/2" MDF for cabinet carcass	N/A	Home Depot
Speaker grill cloth - black	260-335	parts-express.com



■ **FIGURE 7.** Electronics mounted on the removable rear panel.

to be visible through the grill cloth which wraps the cabinet. After cabinet construction was complete, I epoxied the speaker enclosures and router in place.

All electronic items (except the router) were mounted on the removable back panel for easy maintenance as shown in **Figure 7**. The power adapters were epoxied to the rear panel and the amplifier circuit board was mounted on short standoffs. Power and audio wire lengths were kept as short as practical to limit hum and noise pickup.

Conclusion

Building this WIR and the accompanying iPhone app was not only fun, but resulted in a device I will use for years to come. One enhancement I may make in the future is a mute circuit that prevents a pop when power is first applied to the radio. Other than that, this WIR matches my requirements for functionality and aesthetics, and I hope you get a chance to build one for yourself. **NV**

Craig is a retired hardware/software engineer and can be contacted at calhjh@gmail.com.

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

Custom Front Panels & Enclosures

Sample price $57.32 + S&H

Designed by you using our FREE software, **Front Panel Designer**

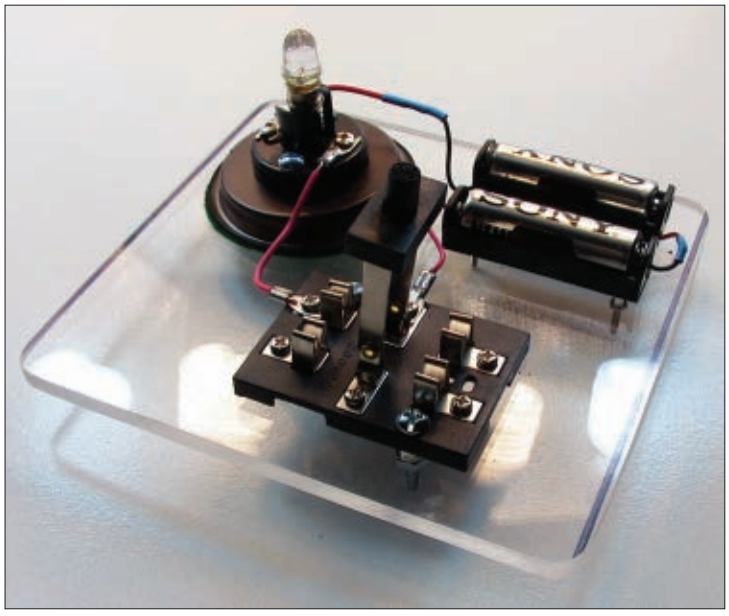
- Cost effective prototypes and production runs
- Powder-coated finish and panel thickness up to 10mm now available
- Choose from aluminum, acrylic or customer provided material
- 1, 3 and 5-day lead times available

FRONT PANEL EXPRESS

FrontPanelExpress.com
1(800)FPE-9060

BUILD A LITTLE ELECTRONIC MISCHIEF

BY WALTER NOON III



Free energy, aliens, psychic phenomenon ... Why is it that we just can't stop clicking on these things everytime we see them on the net?

I think that the answer is pretty simple because whether you love or hate them, they're almost always highly entertaining!

For this article, I am going to focus on real ESP! That is to say, this is an article in which we have "everything strictly phoney."

With April 1st just around the corner, it's my strong suggestion that we dust off the saw in the garage, warm up the soldering iron, and create a project designed to confound, confuse, and even possibly cause concern to all the engineering minds who encounter it! I'm talking about P.T. Barnum's great American pastime: the humbug.

In this article, we'll feature two devices. One is a classic source of circuitry illogic and confusion (and who hasn't been there in the real world) that will cause one of the simplest circuits possible to give "impossible" results.

The other is a simple – yet seemingly incontrovertible – demonstration of both free energy and perpetual motion.

The thinking behind the creation of these devices is addictive! I hope it will spur many thoughts and a little electronic mischief from *Nut & Volts* readers. I'm always ready to be humbugged myself, and hope to hear of some of your designs.

Perhaps we could create a running feature for every April Fool's Day!

The Perplexer

Our first candidate for confusion is the infamous Perplexer circuit. Oddly, I remember seeing one of these in an old electronics magazine from the early 1900s.

The basic gag is simple. A wooden block has a switch, a battery, and a light bulb. All the wires between the

components seem to be clearly visible. However, when the switch is closed on the circuit, the light goes off instead of on! Then, when the switch is opened (clearly leaving no electrical path to the bulb) the light comes back on!

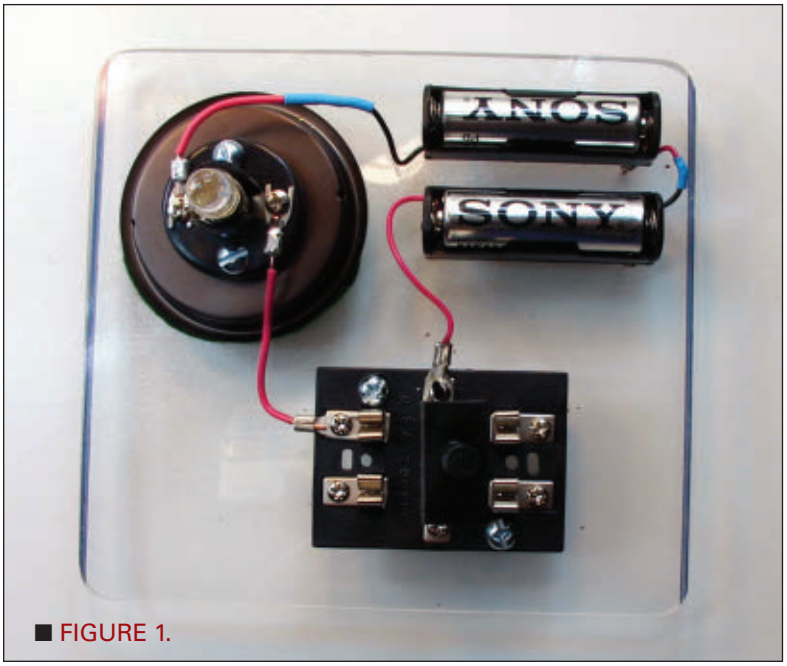
Everything is fully inspectable, and the very simplicity of the device is one of the strongest confounding factors in the illusion.

The method is simple, of course, and hidden inside what appears to be a solid wooden block are the real wires that connect to the lamp base. Closing the switch simply shorts the connection!

A wooden block may have been great for the 1900s, but with the amazing components we have today, we are going to take this great little illusion up a huge step! **Figure 1** shows my attempt to modernize and (hopefully) improve this classic illusion.

In place of a wooden block (where things could be hidden), we now have our circuit on a completely transparent piece of Plexiglas®, with all the wires and components isolated and completely visible from both sides of the board.

An old style "knife" switch is used (making it obvious contact has been made), and it's even possible for the skeptical to trace the circuit with a VOM — everything will read correctly right to the bulb! Yet, when the switch is thrown the light will extinguish; when the switch is opened, the light will stubbornly stay on. If that isn't enough to cause confusion, the light will return to normal function and operate properly at your command!



■ FIGURE 1.

The Workings

The secret of the new circuit is shown in **Schematic 1**. Inside the tiny base hidden under the light bulb is a small lithium cell and basic inverter circuit which actually power and control the light. The function of the circuit is as follows:

- B2 is the pair of AA batteries seen mounted to the Plexiglass, and B1 is the small lithium battery hidden in the lamp base.
- When S1 is closed, LED 1 lights, triggering phototransistor Q2.

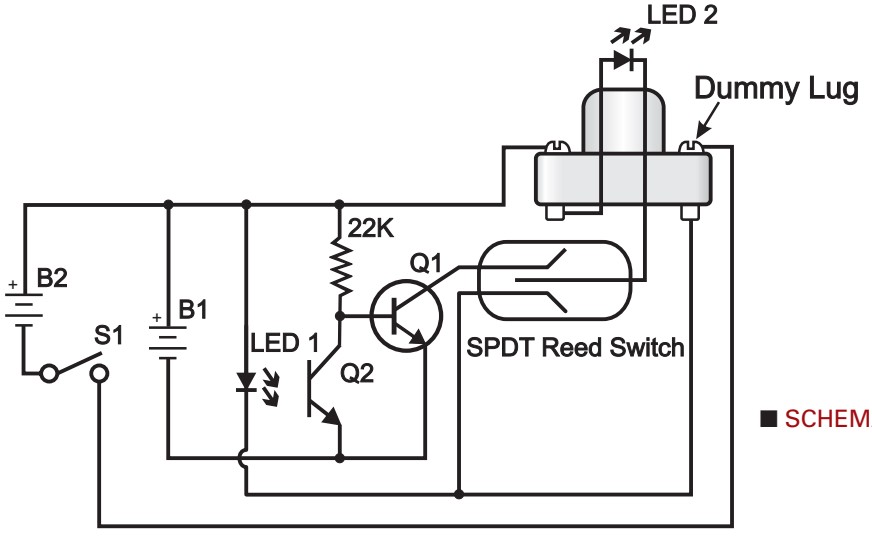
***Note**: You can use an optoisolator for this combo. I happened to use an LED (RadioShack #276-0019) and phototransistor (RadioShack #276-145) which I had on hand. I linked them nose to nose in a piece of heat shrink tubing. Don't forget the proper current-limiting resistor for the LED if you use an optoisolator.*

- Q2 pulls Q1 low, and the light goes out.
- When S1 is again opened, the light will — of course — go back on.

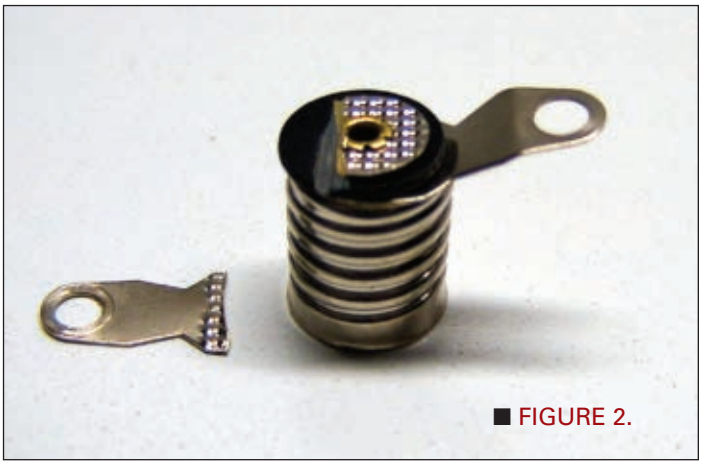
In addition to this, I added an SPDT magnetic reed switch. The reed switch determines whether the circuit will act normally, or in reverse. This is the gimmick that allows you to secretly control the circuit's forward or reverse operation.

Mechanical Modifications

In addition to the circuitry, a few mechanical

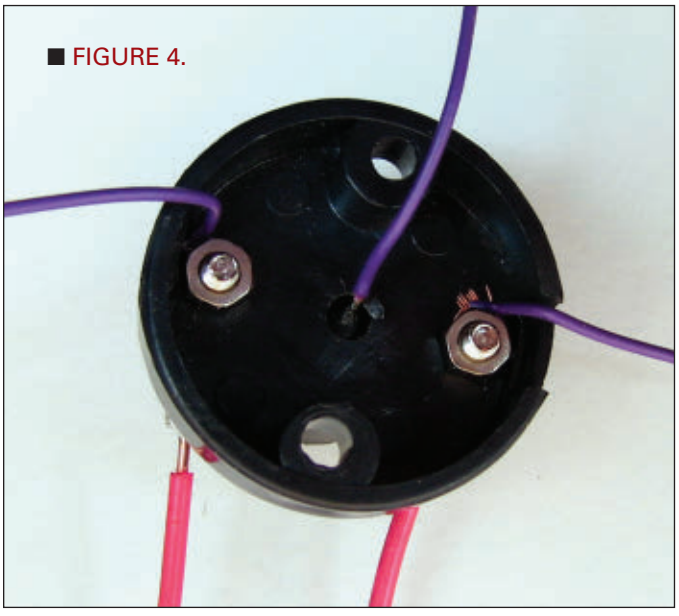


■ SCHEMATIC 1.



■ FIGURE 2.

■ FIGURE 3.

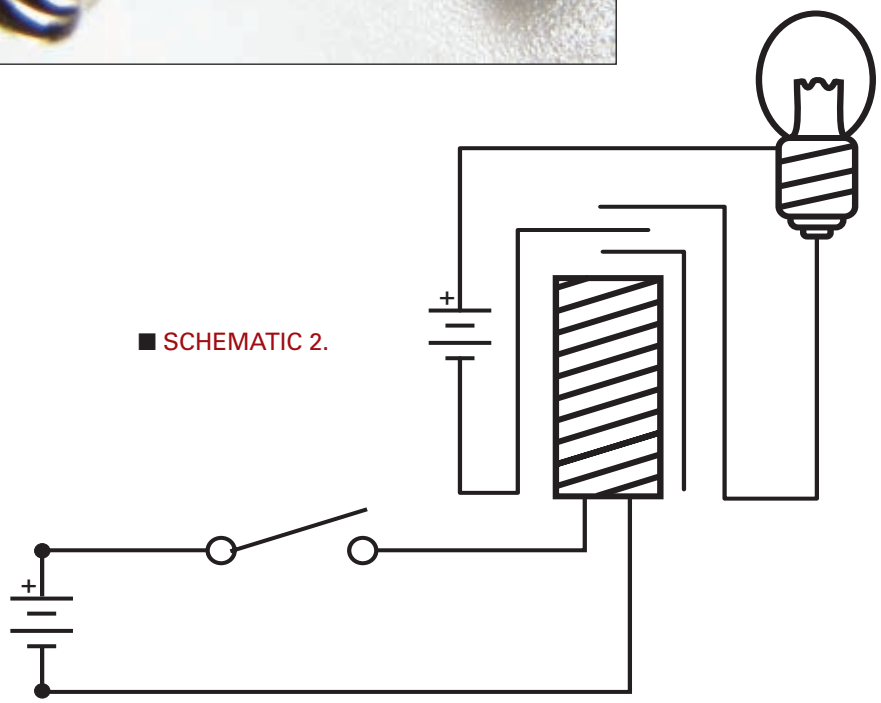


■ FIGURE 4.

modifications (the sneaky stuff) are necessary. **Figure 2** shows the lamp base disassembled, and the lug leading to the bulb's center terminal is cut (this lug will now be a "dummy" lug which *appears* to connect to the bulb, but actually does not).

Figure 3 shows the new wiring. The dummy lug is in place, and a wire is secretly run down from the light socket's center pin. **Figure 4** shows the bottom view of the base with all the wires connected. The red wires are the connections which will be visible on top. **Figure 5** shows the entire circuit wired to the bulb base.

In order to "scrunch" in all the components into a small and irregular area, I used simple point to point wiring. The last modification is to the light bulb itself. Though a light bulb could be used, the draw on the lithium cell would quickly deplete it. It's a simple matter to replace the bulb with a white LED. **Figure 6** shows a white LED soldered in place to the bulb base. I completed its assembly by filling the space below the bulb with clear epoxy.



■ SCHEMATIC 2.

Operation and Thoughts

The circuit works extremely well, and holds up even under close examination. Begin by placing a neodymium magnet under the table where you plan to display your Perplexer. Open S1 and then position the circuit above the magnet's position. The light will

come on. Your Perplexer will now function normally (that is to say in reverse) for any who come to try it.

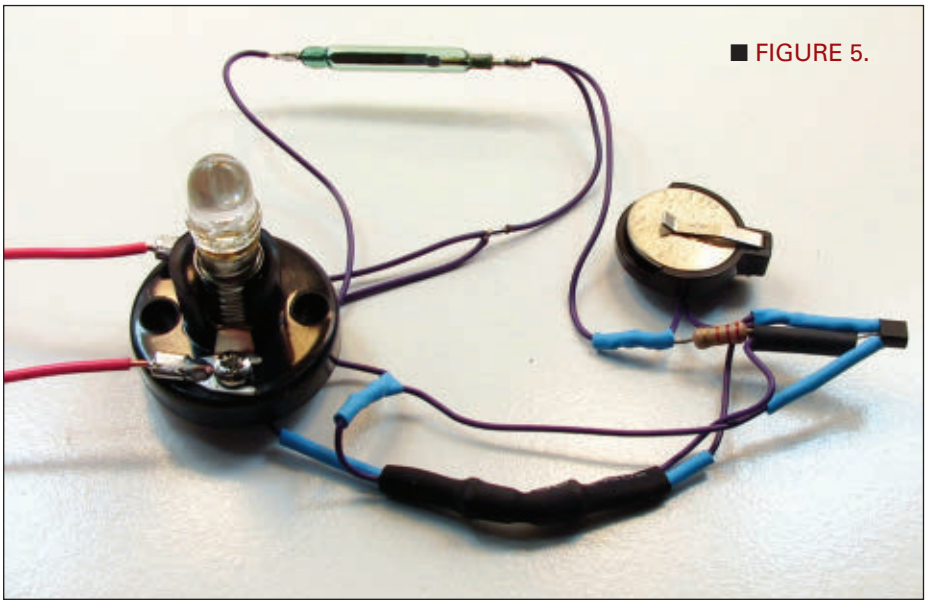
When you want to command it to behave itself (and return to normal switch on, switch off function), simply move the unit a few inches away from the hidden magnet.

Another possible spin on the trick is to remove the lithium battery from the base. In this case, the bulb will not light even if the switch is thrown. Then, at your command (and a subtle move away from the magnet) the light will function normally.

Many modifications are possible. You can forgo the reed switch and simply connect Q1's collector to LED 2's cathode if you'd like the circuit to just operate in reverse at all times. You can also reverse the wires on the reed switch so that the unit operates normally when near the magnet, and in reverse when removed from the magnet. (I think this might actually be a stronger performance set up.)

If you prefer a simplified design, a relay circuit such as that seen in **Schematic 2** can be used, keeping in mind the same mechanical modifications mentioned above.

Remember that there is a small consumption on the lithium battery at all times, so it should be removed when not in use for a period of time.



■ FIGURE 5.

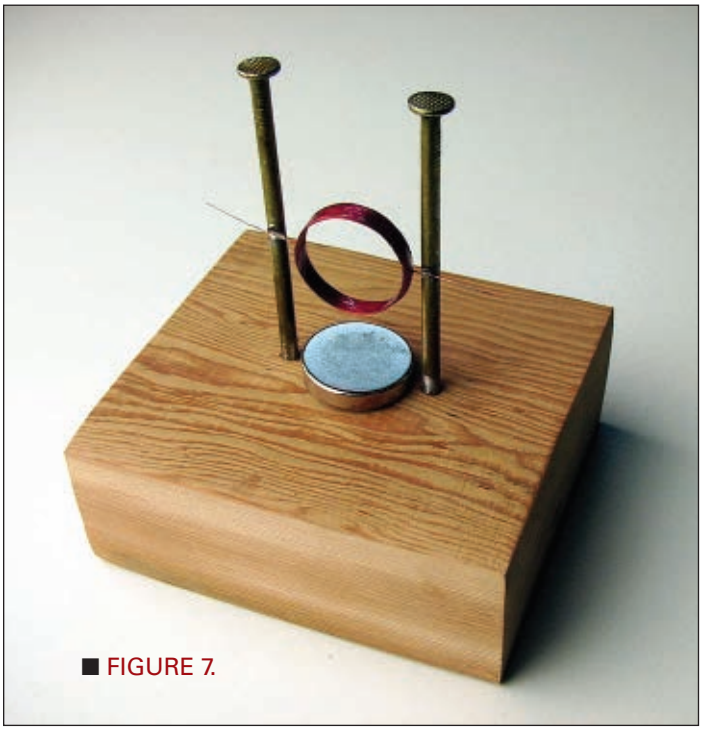
■ FIGURE 6.

A Perpetual Motion Machine

I've always said that the trickiest thing about building a perpetual motion machine is figuring out where to hide the batteries. **Figure 7** shows what I think is a very convincing "perpetual motion" demonstrator. In fact, I've already fooled some of the best with the prototype!

YouTube and the Internet have long been a buzz with free energy and perpetual motion machines. I've noticed that quite a number of these rely on monopole magnets. These are magnets with only a North or South pole which makes attraction without repulsion (and vice versa) possible, and therefore perpetual motion!

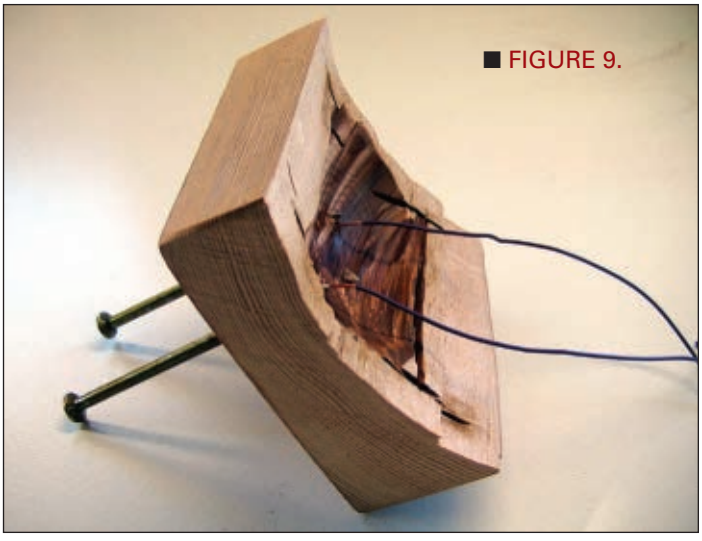
Many articles and even some claimed manufacturers have shown up from time to time. The perpetual motion machine here has been designed as a demonstrator of that magical monopole effect. (For those interested, though physics predicts a monopole particle is theoretically possible, it hasn't found one to my knowledge. These "one way" magnets

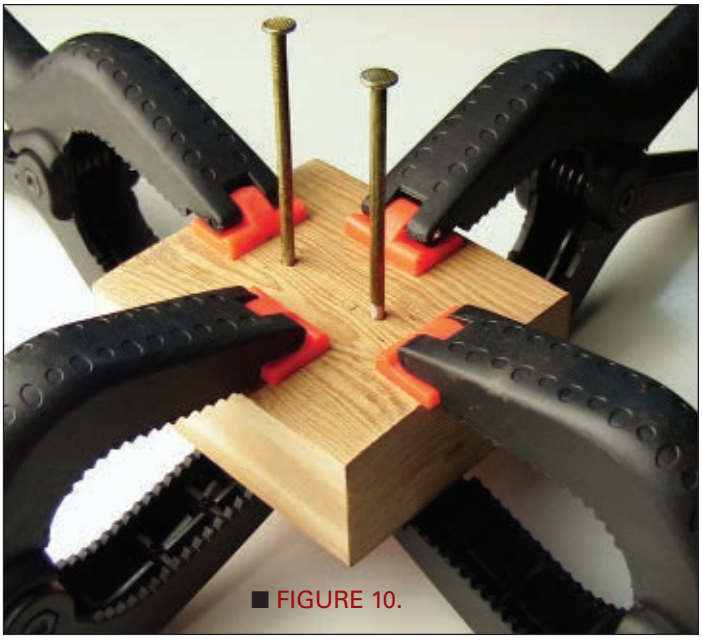


■ FIGURE 7.

■ FIGURE 8.

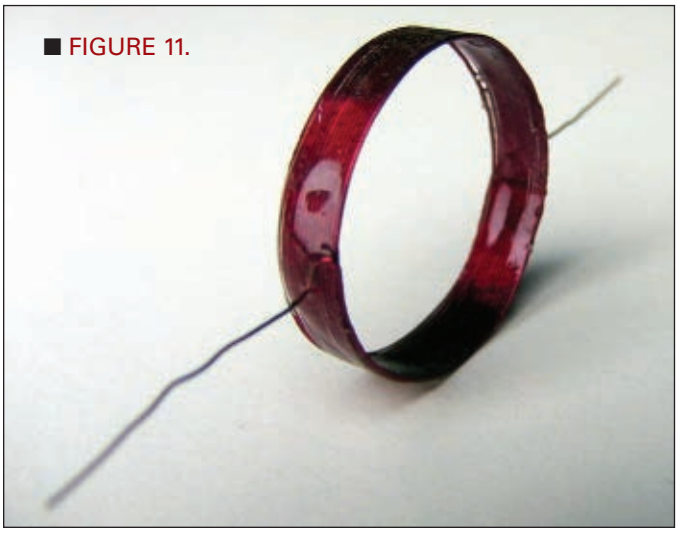
■ FIGURE 9.





■ FIGURE 10.

■ FIGURE 11.



are purely mythological.)

In operation, you tell everyone that you have a monopole magnet and that the currents it generates in a copper winding will create a free energy magnetic field. To demonsrate, place a small winding of copper wire between two nails (that have been pounded into a 2 x 4). Place the magic monopole magnet underneath, and with a woosh it will spin wildly in the cradle with absolutely no power source apparent — except for the magnet.

If you want to really push your luck, you can even claim the device generates a small amount of electricity by touching a VOM to the two nails and reading a generated voltage of 2.4 volts. I've had jaws absolutely drop when I did this, and it was all I could do to not encourage investors!

The Workings

The perpetual motion machine here is a very simple homopolar motor which is driven by the Lorentz force. The hidden secret is that two rechargeable batteries are hidden inside the "solid" 2 x 4 and connected to the nails to produce the power. The magnet is normal in every way.

Figure 8 shows a simple 2 x 4 which has been spilt, and a section hollowed out to receive the batteries. Split the 2 x 4 with a hammer and screwdriver. A messy, uneven split is actually best. Saw away the few inches of the 2 x 4 where the screwdriver left it marks, and you now have a piece ready to go together again with no visible seam!

To attach copper wires to the nails, predrill two holes to tightly fit the nails, insert the copper wires into the holes, and tap the nail into place. The nail will tightly wedge against the copper wires as shown in **Figure 9**. Ideally, use solder tab NiCads, or CAREFULLY solder the wires to any rechargeable AA batteries so they are connected in series; then connect the + and - leads to the nails, respectively. Clamp the 2 x 4 piece back together

tightly as seen in **Figure 10**. After the glue has dried, give the block a light sanding, and you will have a seamless masterpiece of deception!

Next, wind a few turns of magnetic wire around a form of any kind. Just about any number of turns above 20 will work. I wound my coil to be about an inch in diameter, and used #24 enameled wire. (Many other sizes will work; feel free to experiment.) I coated the magnetic wire with five minute epoxy so it would hold its shape. The resulting coil can be seen in **Figure 11**.

The last step is to create a cradle for the spinning coil to seat in. The easiest way is to attach alligator clips to the nails at an angle that creates a seat. In my case, I simply filed a couple of diagonal slots into the nails as seen in the main photo. Viola! You're ready to demonstrate homopolar magnetics and perpetual motion!

Operation

To demonstrate your device, simply place a neodymium magnet at the base of the nails as shown. The little coil should be well balanced to spin, and the insulation should be stripped off the ends of the wire which touch the nails. As soon as the coil is seated between the nails, it will wobble mysteriously, and then begin spinning at high speed. (It might need a little push to get started.) It really is a little wonder to behold.

I used a 2 x 4 scrap to further the illusion that nothing was being hidden. However, these little motors are so much fun to make and run, that a much nicer piece of wood (such as a trophy base) could be used for permanent displays.

I was also considering nickel-plating my nails to prevent rust, especially in the slots which need to be conductive long term. When perpetual motion no longer occurs on command, simply recharge your batteries through the nails.

Wrap-Up

I'll try to put together a video for *Nuts & Volts* readers for those who would enjoy seeing both circuits in operation at the article link and at **www.noonco.com/perpetual**.

Now, the question is should I tip the secret in the video? Or, let those who haven't read this article wonder?

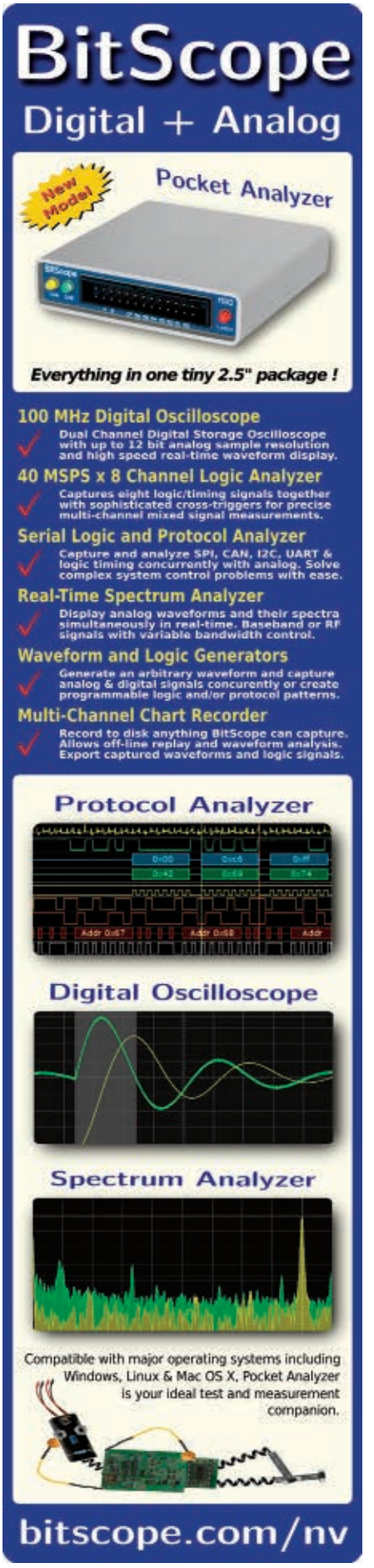
Happy 1st of April! **NV**

PERPLEXER PARTS LIST

ITEM	PART #
R1 22K	
Q1	PN3566
Q2 & LED 1	See Text
S1 Knife Switch	RadioShack #275-1537
SPDT Magnetic Reed Switch	
LED 2 10 mm White LED	RadioShack #276-0005
B1 3V Lithium Cell 2032	
B2 (2) AA batteries.	
S1 Knife Switch	RadioShack #275-1537
Misc.	
CR2032 Battery Holder	RadioShack #270-009
Miniature Lamp	RadioShack #272-1132
Lamp Base	RadioShack #272-0357
(2) AA Battery Holder	RadioShack #270-401
Neodymium Magnet 2 x 2 x 1/2 (or larger)	
Plexiglas Scrap	

PERPETUAL MOTION PARTS

Neodymium Magnet Circle 1" x 5/16
#24 Magnetic Wire
(Many other sizes work for either of these parts.)



How To Succeed At Circuit Design

By Learning From These Mistakes

By Bob Colwell

www.nutsvolts.com/index.php?/magazine/article/march2012_Colwell
Discuss this article in the Nuts & Volts forums at http://forum.nutsvolts.com.

The only way to avoid ever making a mistake is to do nothing — but that would be a mistake! Just try not to make the same mistakes twice; better yet, learn from someone else's.

This article is intended to pass along some of the things I learned while designing and developing the Wi-Fi sprinkler project that appeared back in the February '11 issue of *Nuts & Volts*. Some of my errors were outright blunders; some were fairly subtle; and some were tool related. A few might suggest to my alma maters that they reconsider whether granting me my EE degrees was a good idea. Please don't tell them.

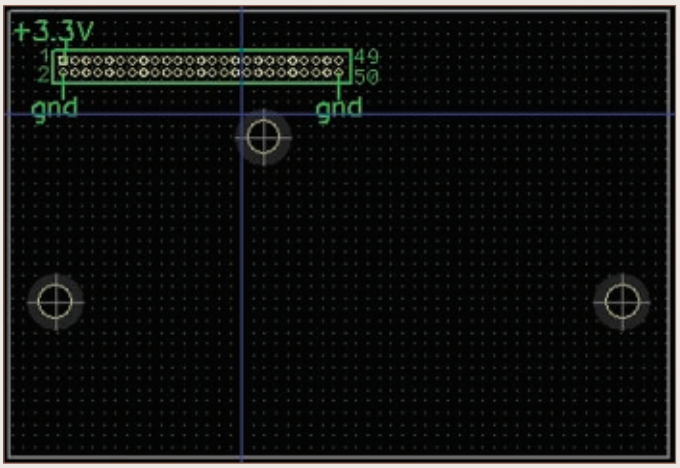


Figure 1. RCM5450W module PCB footprint.

Get the Physical Dimensions Right

If you intend to deploy something that you have designed — like a water sprinkler controller — into a functional role in your household, then to maintain marital harmony your design had better work reliably. That means that some lashed-together prototype board festooned with wires is out; you need a printed circuit board (PCB). If you have not designed one of these before, I encourage you to consider it. They're really fun, and they don't cost very much. Using very inexpensive (or free) downloadable software, you "capture" your schematic, map that schematic into a library of parts for their board footprint, place and route the board, then upload that new database to a board fabrication house. For around $100, you can get three boards with your own silkscreening — looking every bit as professional as the commercial boards inside your computer or television.

Despite many verification steps along the way, there are ways to goof up the PCB. One way that I did more than once was to not pay enough attention to the sizes of the holes associated with various components. The DipTrace software that I used for schematic capture and board layout did not have preexisting library entries for the Rabbit Semiconductor RCM5450W wireless module I wanted to use, so I had to create my own. Physically, this module has three bolt holes for the standoffs, and one 50-pin connector on a 0.05" pitch. I wanted to use a through-hole connector (for ease of soldering), so I found such a connector at Mouser and bought a few. Using their datasheets, I drew up the physical component and entered it into my private DipTrace component library. My RCM5450W module footprint looked like **Figure 1**.

On my first board revision, I got the bolt holes exactly in the right places by carefully reading the Rabbit documentation, and also by carefully measuring the actual module with a digital caliper — a procedure I highly recommend. (These calipers are inexpensive and extremely accurate.) However, I generally just eyeballed the hole sizes for the leads on the 50-pin connector, and

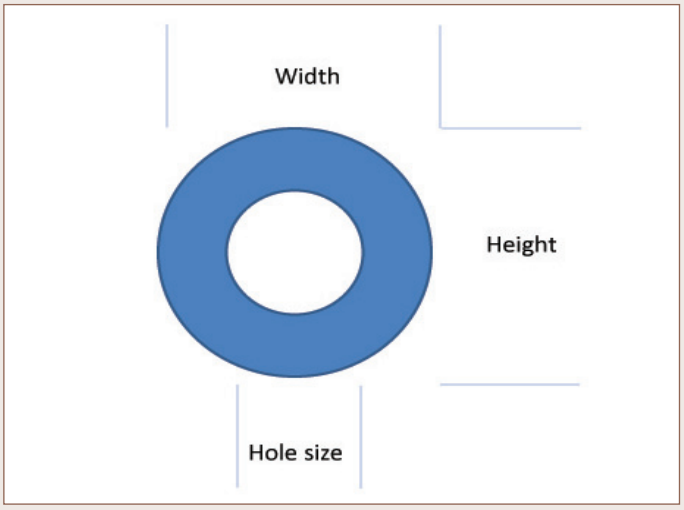


Figure 2. PCB through-hole dimensions.

that was dumb. I did that because when I used this new component in the PCB layout program, I got verification check errors about not enough clearance between the pins. Fixing that issue by shrinking the hole diameters was not my best idea ever. The real connector pins were then exactly the same size as the real holes in the real board, and all 50 pins did not want to go into their respective holes. Respin the PCB: $100.

Get the Pins in the Right Places

Then, things got worse. While fixing the hole sizes of the 50-pin connector, I managed to get the two rows of pins interchanged. I think this happened because the default pin numbering facility on my schematic capture software likes to start at pin 1 and number sequentially around the perimeter in a counterclockwise direction, looking down on the component from above. Since Rabbit wants all of the even-numbered pins on one side and odds on the other, I had to manually renumber all the pins, and along the way I accidentally swapped the rows.

Swapping the rows reverses the power and ground connections to the Rabbit module — something Rabbit explicitly warns you not to do. Chips don't like to be powered up backwards. I once was working next to a technician who had inadvertently reverse-powered all 25 CMOS chips on a board. When he hit the power supply switch for the first time, it was like July 4th fireworks. Chip lids were blasting off and hitting the lab ceiling all over the place, with smoke, flashes, and loud bangs. Fortunately, my Rabbit module took the error in stride while I roundly cursed the dummy (me) who botched the design of this batch of boards. Another $100 mistake.

With the subminiature relays I was using, I not only made the same hole size error, I also didn't pay enough attention to the fact that these relays were 0.3″ wide — pin to pin — not the 0.2″ wide that the relay template I was using had assumed. If the holes are too big, that's generally not a problem, but if they're too small, it generally is. So, if the spec for a component says its leads have a 0.045″ diameter, don't make the hole 0.045″! Make it slightly bigger. For instance, the 50-pin connector spec says the connector pins are 0.020″ in diameter, so I made the PCB holes 0.024″ and everything fits great.

Also note that if you set the hole size to be bigger than the width or height, you will have violated the laws of physics, and that never works in your favor.

Board Placement and Routing Dos and Don'ts

I always do board placement manually. There are some provisions in the board layout software for doing auto-place, but I generally have constraints that the program knows nothing about, e.g., where should the wireless module go on the board, if I want its antenna to stick out the top of the chassis in a certain spot. Besides, placement is easy: You just put things where they make logical sense to you. (It's kinda like when you buy something small and want to know where to keep it. Put it where you would look for it first, in case it goes missing.)

If you possibly can, do a one- or two-layer board because these are significantly cheaper than boards with more layers. Modern boards have a feature called copper fill which lets you fill otherwise unused portions of the PCB with fields of copper that can largely mimic the electrical characteristics of having a true ground plane. If you have a high speed board, you will probably need ground and power planes in it.

The trouble with two-layer boards is that routing all the wires where they need to go can be a challenge, particularly around components with dense pinouts. The RCM5450W, for example, packs 50 pins into a connector with 0.05″ pitch which means you cannot route wires between the pins the way you can when the pitch is a more forgiving 0.1″.

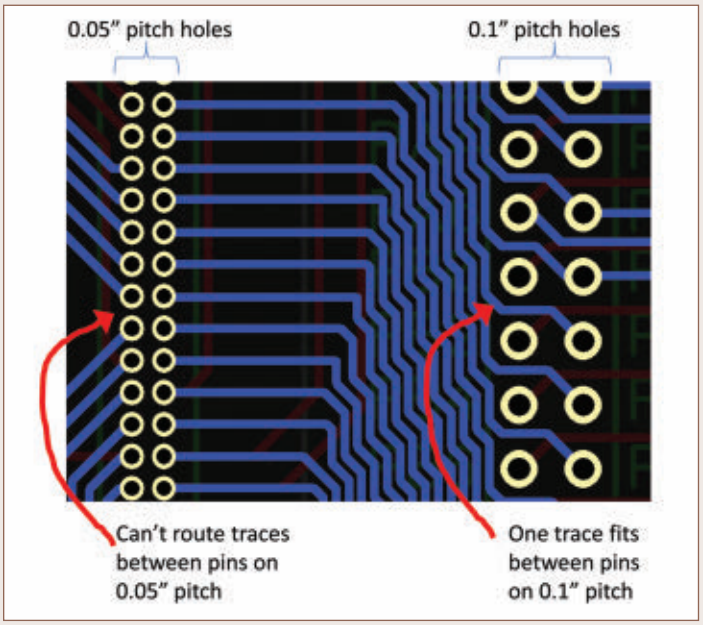


Figure 3. Routing between pins.

Figure 4. Rabbit pins brought to labeled stakes.

I also do routing manually. This is related to the two-layer board having no ground plane — there are traces that must be wider than normal signal traces, in order to minimize IR voltage drops for higher currents. I discovered something obvious by doing it the hard way on one board: I auto-routed it, and then hand-edited the result to make sure the fat traces were okay. They weren't, and it was extremely hard to snake them through the dense underbrush of signals that had been routed hither and yon by the auto-router.

Using the auto-router in that way does not save you any time or effort. It only means you won't enjoy the experience. Instead, hand-route the power and grounds, and then do any critical signals. Save the resulting file as a checkpoint, then save it again to a new file name. That way, if you don't like what happens on ensuing steps, it's easy to get back to the point where power and ground are still the way you wanted them.

I think hand-routing a board is fun. It's a logical puzzle but with a point: When you're finished, the result actually does something useful. You can always put jumper wires into your design to "jump over" problem areas, and if you're going for a one-layer board jumpers will be unavoidable. For two-layer designs, show some pride and design them out.

One of my board revisions came back without the extensive silkscreening I had expected (and paid for). My name wasn't on the board, nor was the date, board revision, and various labels of switches and other components. It wasn't the board layout software's fault. When I entered all that text, I had forgotten to switch that text from the default non-printing layer to the top silkscreen. I did not realize yet one should always check the Gerber output files to make absolutely sure that what you are sending to the PCB fabrication house is what was intended. I do now. The Gerbers are the files that the board fabrication house will actually be using to make your board. Your schematic capture and board layout software probably has a Gerber previewer built in. Use it. If they don't, there are free Gerber viewers online.

Feature Creep Will Cost You

I had already done several board revisions and debugged them before it dawned on me that without a display on the Wi-Fi Sprinkler (WFS) chassis, there would be no way of telling what state the machine was in by looking at it. If the power was off to the WFS, or its program was malfunctioning, or the wireless wasn't working, or the home network was down, or the iPod had depleted its batteries, the WFS would not be fulfilling its mission of timed or manual sprinkling, and the user would not know why. LCD modules are cheap and easy to interface to, but I had to again respin the PCB to accommodate this new feature that I should have anticipated from day one.

When I first designed the LCD module in, I figured the software would either be updating the LCD module or sprinkling. I didn't think I would want to do both at the same time. Later on, I realized I would have to come up with a way to have the WFS do automatic time/date sprinkling, and to do that it would have to know the actual time and date. Using Rabbit example code, I figured out how to use the LCD as a real time clock. But that meant I needed to update the LCD module periodically. If the WFS happened to have a zone sprinkling, it might well sprinkle for 10 or 20 minutes straight. All during that time, port A would not be available to talk to the LCD module. On my last revision of the board, I changed the 4:16 decoder chip to a similar chip with an internal four-bit latch (CD4515). Now, port A could write that latch, and talk to the LCD while the sprinkling continued. I should have worked this all out at the beginning.

I also did not anticipate the need for a 50-pin field of stakes on the board, so that test equipment could readily be attached to known signals on the board. I added this facility after spending many hours with previous revisions of the board, with the usual time wastage associated with connecting a logic analyzer probe to one signal while thinking it was a different one, then wondering why the resulting measurement looked so weird. Thinking ahead to how you'll debug problems is always a good idea, and will often turn up problems in the design that you can then avoid in the first place. Routing those 50 close pins from the RCM module over to their counterparts on this pin field was a challenge, but I ultimately found a routing pattern that would fit. Silkscreening the name of every pin is a great idea and really cuts down on scope probe placement errors.

Rats, Didn't See That One Coming

On one revision of the PCB, I had partially populated the board with a few relays and their drivers, and I was wrestling with a peculiar problem: a couple of the relays worked as expected, and a few didn't. Occasionally, one of the ones that didn't would chatter and buzz instead of locking in. I wondered if I had miscalculated the base drive resistor values, or if there was a software error, a grounding problem, or the transistors didn't have the gain I expected. After multiple days of headscratching debug, I finally paid careful attention to what my scope was telling me: Logic lows were as expected, but logic highs into the

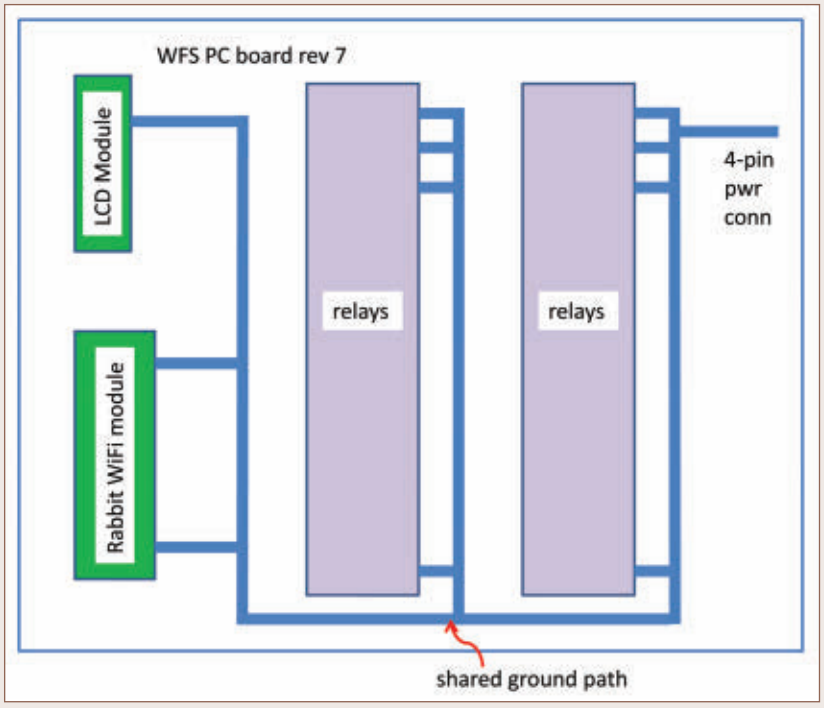


Figure 5. Early design with shared grounds.

relay drivers were only 3.3V — not the 5V I had assumed in sizing the resistors. Well, duh ... that's because my schematic was calling for the CD4515 4:16 decoder chip to run off +3.3V, while the relay driver transistors were connected to +5V. I cut the trace to the 4515 power connection, wired it to +5V, recalculated the base resistor values, and Voila! It was hard for me to see this error because I had assumed one thing while designing the base drive circuit and another thing while drawing up the schematics.

I've learned that particular lesson repeatedly in my career: When you're stuck, it's always because you're blinded by some wrong assumption you are making. Question the right assumption, and enlightenment will surely follow.

I remember an incident at Intel when my team was simulating what would eventually become known as the Pentium Pro microprocessor. The man who had written the simulator offhandedly mentioned to me that it was possible to make the simulator initialize flip-flop values pseudo randomly. I said I had been under the assumption we had been testing that way all along. He shrugged and walked away, but the next morning he came back and said he checked; we had not been testing with random initial states, but instead had been simulating our design as though every flip-flop was coming up reset on powerup (which in hardware they most certainly do not). He changed the simulator's startup configuration to the random initial setting, and re-ran some of the validation regression tests. Many failed. This simple check exposed dozens of design shortcomings that were easy to fix but would potentially have been fatal had they survived into silicon. Assumptions are necessary to make, but some of them will bite you.

Don't Share Grounds With Noisy Circuits

As Arthur Delagrange said in *The Art and Science of Analog Circuit Design*, "WARNING: The [board] layout is part of the circuit." Grounding paths included.

When a relay coil is deasserted, the magnetic field around the coil collapses and induces a current in the coil. That induced current attempts to establish a substantial voltage potential on the transistor's collector, and a "snubber" diode is connected so as to discharge that current.

However, diodes aren't perfect. When conducting, silicon diodes drop approximately 0.7 volts across their junctions. That means that the coils can still drive enough current onto their ground connections to make it seem to any logic nearby that ground has dropped by a few tenths of a volt. The Rabbit module itself seemed immune to this, but the LCD module didn't like it at all and would act as though it had been written with some new value that caused its screen to go blank.

Figure 5 shows the original ground routing of my rev WFS 7 board. This layout mostly worked. Only when the relay that was electrically farthest from the four-pin power connector at the top right was deactivated, would a large enough current spike occur to cause an LCD module malfunction. The first remedy I tried was to strap a lot of

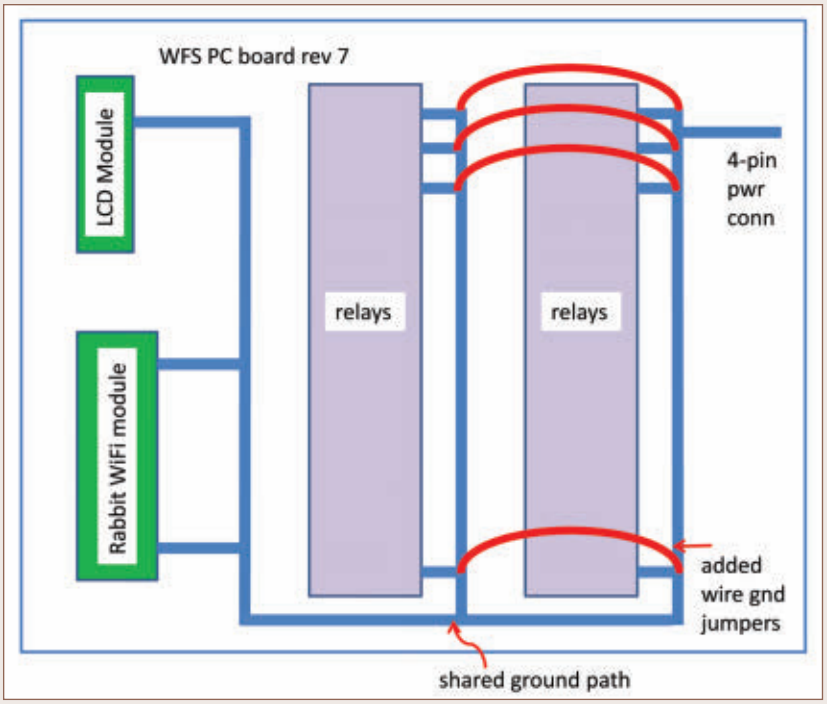


Figure 6. Experiment with extra ground straps.

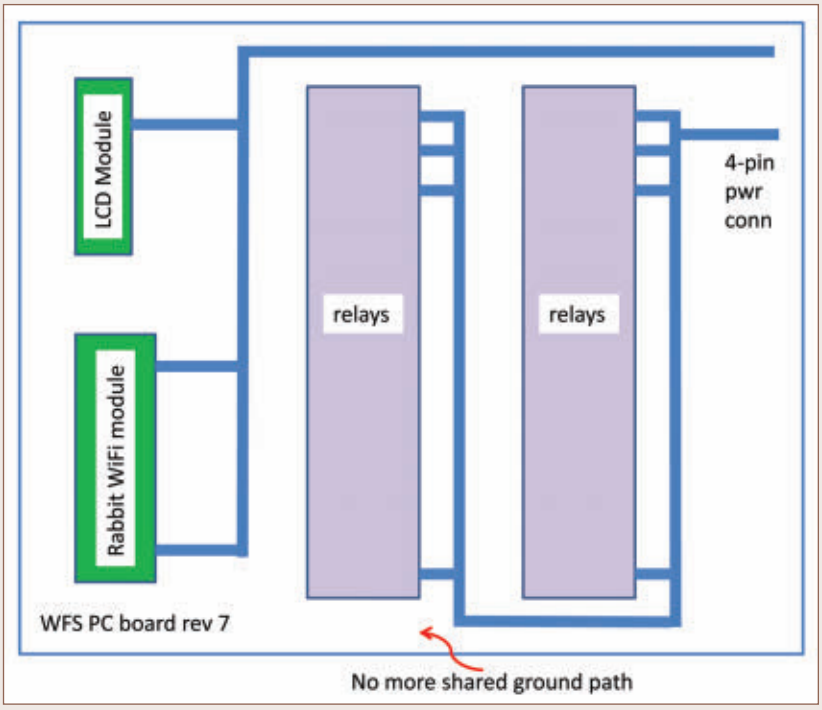


Figure 7. Final solution: separate ground paths.

extra ground wires across the top of the board, hoping to drive the aggregate ground impedance down. (This was to gather information only; I would not consider this a permanent fix to a production board, even if it eliminated the problem.)

That helped, but the LCD module would still blank out occasionally. So then I got serious, and cut the LCD and Rabbit grounds away from the relays entirely — even at the four-pin power connector. This allowed the relays and the logic to have their own ground current paths all the way back to the power supply itself. With no shared paths, the relays were no longer able to interfere with the logic of the LCD module. Problem solved.

Measure Twice, Cut Once

In woodworking, they have a saying: Measure twice, cut once. The idea is to double-check what you're about to do because once you've cut a board, you can't uncut it. Don't take that idea too far though, or you'll be paralyzed by the fear that you're overlooking something. Often, you have to simply do your best, fix what didn't come out right, and keep repeating that loop until you're finished. If you never make a mistake, you're not trying hard enough.

Getting better at your craft requires that you learn from mistakes. If you really want to accelerate your learning, learn from other people's mistakes too! **NV**

Proto Buddy Book & Kit Combo

Only $59.95

For complete details visit our webstore @ www.nutsvolts.com

NIGHTFIRE ELECTRONICS KITS

http://vakits.com

352-390-6195

Hours:
9AM to 6PM EST

Component Kits	Electronic Kits
Resistor Kits	PIC Kits
Capacitor Kits	LED Kits
Diode Kits	Timer Kits
Transistor Kits	Power Supply Kits
Hardware	Relay Kits
Thru-Hole & SMT	Audio Kits

Free Shipping for orders over $39.99 (USA & Canada)

Celebrating 10 Years! Family Owned!

Sabertooth 2x60

DimensionEngineering

Dual 60A Continuous Brushed Motor Controller

Specifications:

- 60A Continuous, 120A peak current
- 6V - 33.8V input voltage range (8s lipo max)
- Analog, RC (PWM), and Serial Interface
- Overcurrent, overvoltage, undervoltage, and overheat protection built in
- Fan cooling keeps the controller cool
- Heavy duty terminals take up to 2 gauge wire
- 1 year warranty on every Sabertooth
- DEScribe Software Suite Compatable

ONLY $189.99

www.dimensionengineering.com/Sabertooth2x60.htm · 899 Moe Dr. #21 Akron, OH 44310 · 330-634-1430

THE NEW PICOSCOPE
2205 MSO
MIXED SIGNAL OSCILLOSCOPE

GREAT VALUE, PORTABLE, HIGH END FEATURES AS STANDARD AND EASY TO USE

Think Logically...

pico Technology

Channels	2 Analog, 16 Digital
Resolution	8 bit
Bandwidth Digital frequency	Analog 25 MHz, Digital 100MHz combined
Sampling rate	200MS/s
Trigger modes	Edge, Window, Pulse width, Window pulse width, Dropout, Window dropout, Interval, Runt pulse, Digital, Logic
Price	$575

www.picotech.com/pco469
1-800-591-2796

Continued from page 29

GPIB TO LAN **PRINTER INTERFACE**

ICS Electronics now has a new GPIB to LAN printer interface for

connecting older analyzers and instruments with GPIB outputs to a printer with an Ethernet interface. ICS's Model 4872 lets older analyzers and instruments that were designed to operate with a GPIB plotter find new life with a modern printer.

The need for this interface has come about as the older GPIB based printers and plotters are failing and replacement parts and supplies are becoming obsolete. Printers have also evolved from having GPIB interfaces to parallel 'Centronics' to USB and now to Ethernet interfaces.

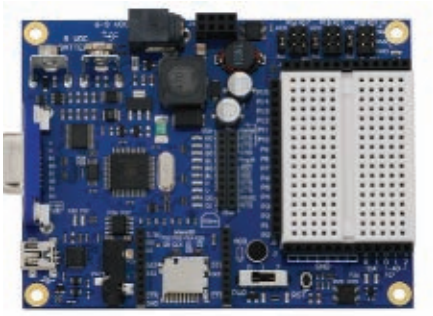
The Model 4872 is a follow-on product to ICS's older 4892B GPIB to parallel printer interface and incorporates several features that make it easy to use in today's networked world. The 4872 is easily configured with any browser and includes a test page to verify that the printer is PCL5 and HP-GL compatible. The 4872 uses the SNMP protocol to monitor the printer's status and can be configured to handle many instrument-printer compatibility problems. The 4872 also has the ability to output the instrument's data to a PC for archival purposes while printing.

Pricing for the Model 4872 is $485 each in quantities of one to four units. Each 4872 includes a full manual, Ethernet cable, and a support CD with an example data archival program.

For more information, contact:
ICS ELECTRONICS
Web: **www.icselect.com**

PROPELLER BOARD OF EDUCATION

The form of the original Board of Education (BOE) from Parallax now meets the powerful function of the multicore Propeller microcontroller. A built-in set of



peripherals makes it ready to support an amazing array of projects, prototypes, hands-on activities, and kits. The Propeller BOE is ideal for learning the basics of electronics, programming, and robotics. It also simplifies advanced applications that require RF-linked communication, audio/visual peripherals, and gigs of SD memory.

Features include:

- Built-in Propeller microcontroller, 64 KB EEPROM, and 5 MHz crystal oscillator.
- Breadboard, sockets for power, and I/O access, and six servo ports with power-select jumpers for easy prototyping.
- Automatically selects between USB and external power sources and provides USB over-current protection.
- 9V battery and center-positive 2.1 mm power connectors offer two external power options.
- Convenient reset button and three-position power switch.
- Onboard mini stereo-audio jack, electret microphone, and VGA port for audio/visual projects.
- Built-in MicroSD card and XBee wireless module sockets simplify advanced applications.
- Dedicated analog header sockets provide three 10-bit inputs and two buffered variable-resolution outputs.
- 2x20 header for connecting I/O pins to VGA, XBee, Propeller clock and reset, USB serial flow control, and up to 10 LEDs.
- Indicator lights for system power, servo power, eight color-coded VGA channels, two analog output level, XBee TX/RX, and USB TX/RX.
- SEPIC 5 V switching regulator can deliver up to 3 A across the commercial temperature range.
- Linear 3.3 V regulator can deliver up to 460 mA at room temperature.

Price is $129.

For more information, contact:
PARALLAX, INC.
Web: **www.Parallax.com**

EASYPIC PRO V7 **RELEASED**

mikroElektronika now offers the EasyPIC™ PRO v7 board. They have combined all the features of the BIGPIC6 and LV18F v6 boards which support high pin count PICs into their unique PRO v7.

Supporting microcontrollers in both 5V and 3.3V power supply technology, this board is a handy tool for development. mikroElektronika has grouped PORT headers, LEDs, and buttons into input-output groups on the Pro v7. They've equipped the boards with tri-state DIP switches, so that placing pull-up or pull-down jumpers to desired pins will be just a matter of pushing the switch.

Connectivity is the focus of this board with its dual power supply. Another feature of the board is a

powerful onboard mikroProg™ programmer and In-Circuit debugger capable of programming almost 100 high pin count PIC18 microcontrollers. Debugging is supported with all of mikroElektronika PIC compilers with mikroC, mikroBasic, and mikroPascal.

STELLARIS M3 V1.101 RELEASED

mikroElektronika also presents their first ARM® Cortex™-M3 multimedia board: the Stellaris® M3. Users can develop multimedia-rich applications on the high performance LM3S9B9 Stellaris ARM Cortex-M3

device with this new board. The Stellaris M3 has rich multimedia peripherals: 320x240px TFT display with touch screen and stereo MP3 codec – VS1053 – which is capable of decoding MP3/WMA/AAC /eAAC+/Ogg Vorbis/WAV files from MMC cards. A microSD card slot is also available; a three-axis serial accelerometer, USB connector, and eight-bit serial Flash memory are on the board, as well. The board features a frontal reset button, battery charger circuit for Li-Polymer batteries, crystal oscillator, and connection pads for all other available pins. The board is compatible with all mikromedia shields, including gaming shields, battery boost shields, proto, and connect shields.

ANALOG SYSTEM LAB KIT PRO

Finally, mikroElektronika presents their first analog development

board: the Texas Instruments® Analog System Lab Kit PRO.

The Analog System Lab Kit PRO is specially designed to provide students and engineers a platform for creating analog systems using modules such as op-amps, analog multipliers, digital-to-analog converters, Low dropout voltage regulators, transistors, diodes, and more. The board comes with a user-friendly manual which guides you through 14 laboratory exercises which help users to understand onboard modules.

The user manual is easy to read, with good explanations and lots of photos. There are also full-color board schematics and a 100-page graph paper book with linear and logarithmic grids for easier drawings of graphs required by the experiments.

For more information, contact:
mikroElectronika
Web: **www.mikroelectronika.com**

SINGLE-CELL, DUAL-INPUT LI-ION BATTERY CHARGERS

Texas Instruments has introduced a battery charger integrated circuit to support higher cell capacity batteries and the increasing battery charge currents of tablets, e-readers, and smartphones. The highly integrated single-cell Li-Ion battery charger has dual inputs which allow operation from either a USB port or higher power input supply (AC adapter or wireless power input). The two inputs are fully independent from each other and are easily configurable using the I²C interface or stand-alone interface.

Integrated FETs support charge

Continued on page 81

Need a small and cost-effective device?
Look no further.

PoScope Mega1+

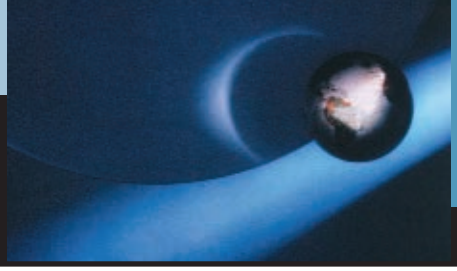
Smallest USB 2.0 portable 1MS/s oscilloscope
Data acquisition of analog and digital signals
Data recording
Export to CSV, XLS, PDF and HTML
Simple usage of advanced features
Examples for C++, VB, Delphi and LabView
Free software and updates

PoKeys 56

Smallest USB HID or ETHERNET I/O interface
Keyboard and joystick simulator (USB)
55 digital I/O (configurable)
LCD and LED matrixes driver
6 PWM outputs, 26 encoder inputs
Supports up to 10 I2C, 1-Wire sensors, up to 7 analog sensors
Expandable with PoNet
Free software and web interface (Ethernet)

Visit www.poscope.com

PoLabs



■ BY L. PAUL VERHAGE

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

FLIGHT 100: A REPORT AND A REFLECTION

It's hard to believe, but I've flown 100 near space missions. It all began in 1994 when amateur radio operator Pete Sias (N0OY) presented on near space to the Manhattan Area Amateur Radio Society (MAARS). That presentation committed me to flying experiments into near space. It took me two years to get started. However, since my first flight in November 1996 I've launched near space missions with a nearly religious zeal.

I suppose what initially hooked me was Pete's image of the earth taken from near space. The earth's horizon was curved and the sky was black. You would swear that only an astronaut could record such an image. In fact, on two occasions photo lab technicians processing my near space images have asked if I was an astronaut. I was also attracted to near space because Pete showed how it incorporated three of my current interests: GPS receivers, digital radio, and microcontrollers. Pete's presentation united these three into a single project that allowed me to indulge my spaceflight interest.

In 100 missions, my near spacecraft have reached peak altitudes from eight feet to over 114,600 feet. The winds have carried them to landing sites ranging from nine miles away to over 160 miles. Ninety-five of them were recovered shortly after landing (with one caught as it landed) and only one remains lost today.

My near space missions have measured cosmic rays, sound transmission, air pressure, air temperature, relative humidity, and sky brightness and color. Images have been recorded on color film, infrared film, VHS tape, and now digitally. Bacteria, yeast, and cockroaches have taken their turn riding my near spacecraft and my missions have released gliders, parachutes, and potato chips. I'm now involved with a dissertation to study the effect of BalloonSats on attitude toward science. It's been a pretty amazing 15 years.

■ **FIGURE 1.** A reusable lunch sack is soft-sided and insulated. So as an airframe, it holds up quite well to landing and remains warmer inside than outside. In this photo, the antenna is the two red wires attached to the aluminum and fiberglass boom protruding from the left side of the airframe.

FLIGHT 100

Hays, KS has a university — Fort Hays State University — and one of the school's physics professors is Dr. Adams. I had the opportunity to meet Dr. Adams last year over email while he was president of KATS: the Kansas Association of Teachers of Science. He recently mentioned to me that he was interested in developing a near space program for Fort Hays. As usual, I was only too happy to offer my help. Therefore, I found myself visiting the campus last November to discuss near space to science students. I went back in December to help launch their first mission from the fairgrounds outside of town and not far from the campus.

Fort Hays packed their GPS tracker inside of an insulated lunch sack. The empty volume inside is packed with foam rubber sheets. I believe this method was first developed by the Treasure Valley Near Space Project (TVNSP) in 2000. I've since recommended changes to the design that permits the tracking module to use a wire dipole antenna. You can see this modification in **Figure 1**.

Because the surface wind was light that morning, the

■ **FIGURE 2.** Dr. Adams is filling the Fort Hays weather balloon with helium. The bed sheet below him protects the balloon from debris on the ground. The filler he is using is a green oxygen hose attached to the least expensive regulator I could find at a welding supply store. The valve on the helium tank (and not the regulator) is controlling the flow of helium into the balloon.

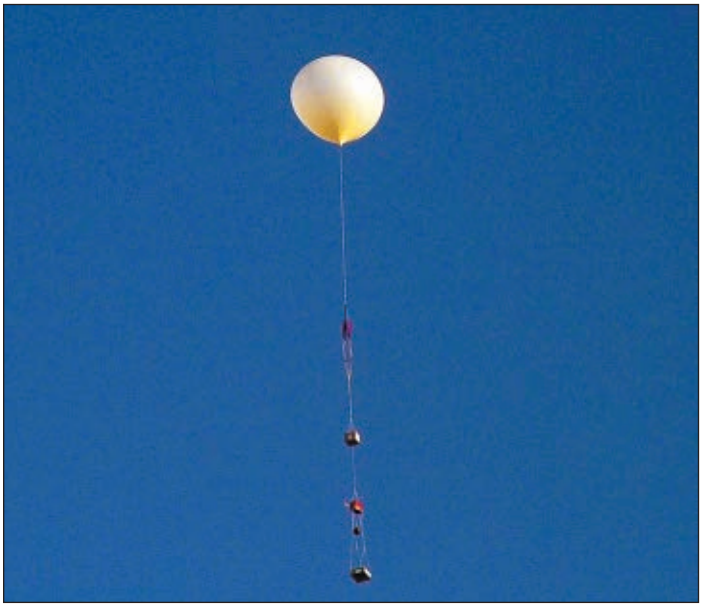
■ **FIGURE 3.** A filled weather balloon is a big beastie. The payload for this flight is visible at the bottom of the picture.

Fort Hays team filled the balloon outside the building. Filling a balloon indoors is fine if the doorway is large enough for a seven foot tall balloon to pass through. Even if the balloon bursts, it remains safe inside because helium is an inert gas. However, with the rising cost of helium, more near space groups are using hydrogen as their lifting gas. Hydrogen by itself is perfectly safe; it's just that the gas exhibits a nasty reaction around oxygen. Therefore, if you feel obligated to use hydrogen, then only fill the balloon outdoors.

Since hydrogen burns hot and colorless, you might want someone continuously scanning the balloon and filling operation with an infrared thermometer. That way, if a hot jet of hydrogen is escaping the balloon, it can be detected before someone walks into it.

Since the payload for this flight weighed a combined 12 pounds, the launch crew filled the balloon until it lifted with 15 pounds of force. It was our desire for the balloon to lift with three pounds more force than the payload pulled down. With three pounds of positive lift (PPL), the near space stack (balloon, parachute, and payload) would rise with an ascent rate of at least 1,000 feet per minute. That would keep the ascent to no more than 90 minutes long. While extra helium does lower the maximum altitude slightly, its effect is not significant compared to the shorter flight and chase that it creates.

To see why the maximum altitude is not strongly effective by an additional pound of positive lift, it's important to know that the air pressure drops by a factor of two for every 18,000 foot increase in altitude. This



■ **FIGURE 4.** What a pretty sight! The balloon, recovery parachute, and four payload modules are visible in this image. The cord between the balloon and parachute is the load line and is around 15 feet long. That way, what's left of the balloon falls over the parachute rather than on top of it.

■ **FIGURE 5**. From my BalloonSat's perspective, this is what lift-off looks like. The near spacecraft has just climbed above the fairground buildings and is on its way to 87,606 feet.

Not all science comes from the near spacecraft. I made these two discoveries by being observant.

Before filling operations began, I noticed the earth's shadow in the west. Many people have observed this dark band in the sky while the sun is a little below the horizon. However, most don't realize what they are looking at. To see the earth's shadow, look opposite to the sun either for the 15 minutes after sunset or starting 15 minutes before sunrise.

Keep your eyes open during recoveries because you never know what you'll find. As best as I can tell, these are Inoceramid clam fossils from the Upper Cretaceous. I found them in a layer of the Lincoln limestone near a recovery site.

■ **FIGURE 6**. The recovery site was a bit off the road, but nothing that a bunch of college students couldn't handle. Be sure to talk to land owners before walking onto their land to recover your payload, and be sure to leave everything alone.

means that the balloon's volume must double for the balloon to climb an additional 18,000 feet. The balloon used for the Fort Hays launch weighed 1,200 grams empty, or about 2.5 pounds. Therefore, when the balloon was lifting with a force of 15 pounds, it really had enough helium to displace 17.5 pounds of atmosphere. To lower the maximum altitude of the balloon from the expected 90,000 feet to 72,000 feet, we would have to fill it with enough helium to displace 35 pounds of atmosphere.

Filling a balloon with just enough helium to go from two pounds positive lift to three pounds only changes its volume by 1/16.5, or six percent. That's tiny compared to the 100 percent increase in volume required to lower the maximum altitude by 18,000 feet. However, by going from two pounds positive lift to three pounds, the balloon's ascent rate nearly doubled. That faster ascent rate resulted in the balloon reaching burst altitude in about half the time and it cut the chase time short by around 50 percent.

The flight path for the balloon was about what we expected, but the ascent rate was a little lower. Therefore, it drifted a little further downwind than predicted, but not excessively so. If you ever drive I-80 through Kansas, be on the look-out for the new crop that farmers are planting. In Lincoln County (west of Salina), there is a farm of these new sunflowers. As you can see in **Figure 6**, our near spacecraft landed near one of them.

SCIENCE RETURN

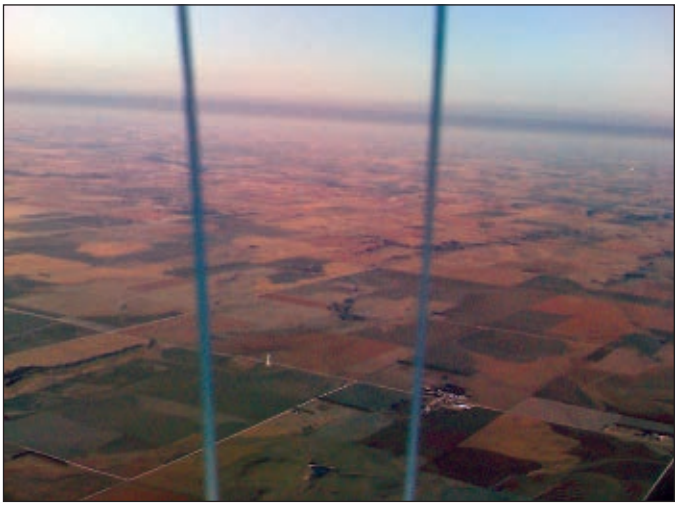
The BalloonSat attached to the Fort Hays launch carried a mini weather station and camera. The PICAXE-08M-based flight computer recorded the air temperature and relative humidity every minute, and images every 15 seconds. The graphs in **Figures 7-9** were generated by the BalloonSat's weather data.

FLIGHT 100 IS JUST A BEGINNING

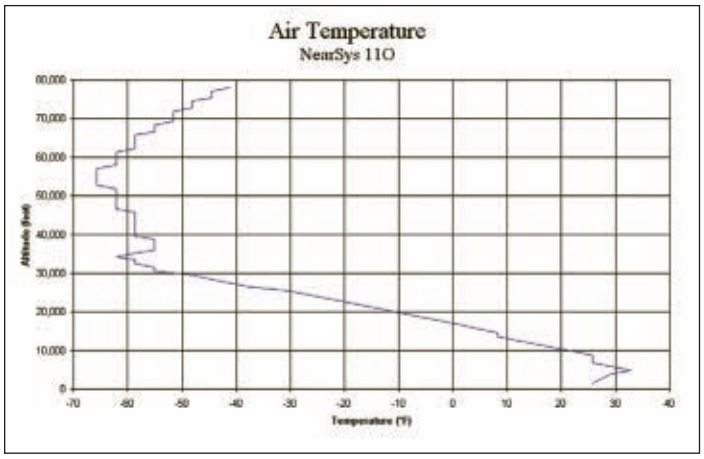
Flight 100 wasn't exactly planned, but I did have a BalloonSat ready to launch. So, it's an example of how random chance favors those who are prepared. However, I am not relying on chance for my dissertation. It involves 32 classrooms and over 400 junior and senior high school students. As I write this column, the kits are out and the students are learning how to build and program a BalloonSat. I'm investigating whether BalloonSats can increase student interest in science. If successful, future studies will investigate the BalloonSat's effectiveness in math and engineering. Further down the road, I want to know how effective BalloonSats are at teaching math, science, and engineering concepts.

To make these deeper studies possible, I'll design a national BalloonSat program modeled after national robotics challenges like FIRST and BEST. I envision calling it, "Onward and Upward" and having students design BalloonSats from kits under strict limits, like construction time and weight. It will be a big program for me, so I'll start small and make the program a part of my job. There's one other thing I'll be looking for: strong involvement by the amateur ballooning community. Their help is critical for the launch, chase, and recovery of all these K-12 BalloonSats. Perhaps some *Nuts & Volts* readers will be ready to help out.

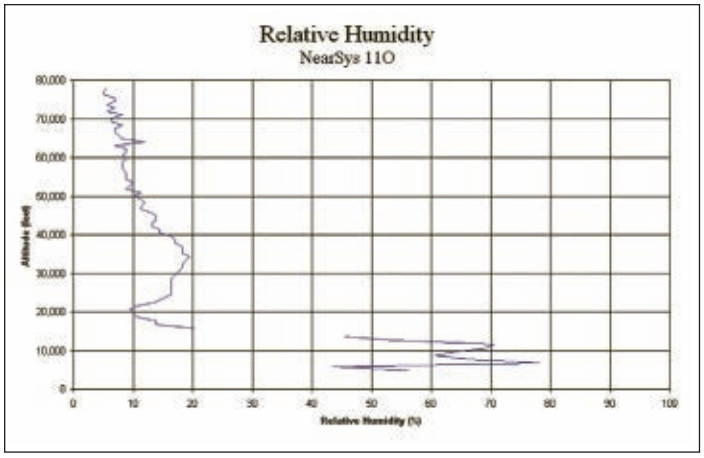
Onwards and Upwards,
Your near space guide **NV**



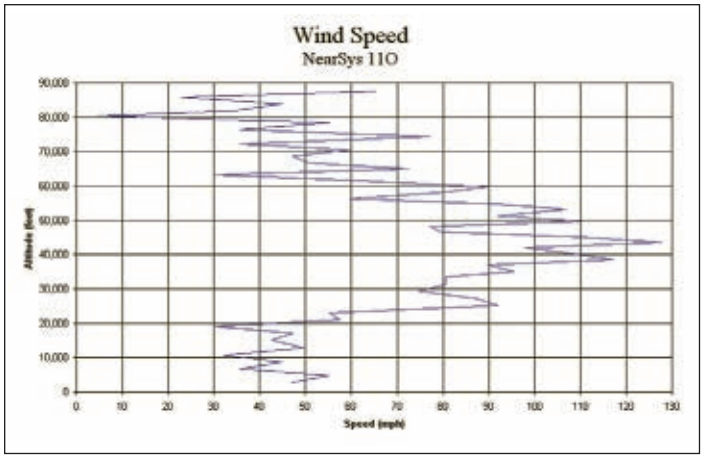
■ **FIGURE 10.** The Near Space String Theory. If there's a string hanging down from the module above, it will position itself right in front of the camera. Notice the balloon is passing through a layer of haze. I suspect this haze is trapped by the temperature inversion. Way below, you can see a water tower.



■ **FIGURE 7.** As expected, the air temperature decreased with altitude until the BalloonSat reached the stratosphere. Note, however, there was a temperature inversion below 5,000 feet (mean sea level). Because Hays is at about 2,000 feet, the air was eight degrees warmer 3,000 feet above the ground. The tropopause is visible in the data between 35,000 and 55,000 feet. Above 55,000 feet, the stratosphere gets warmer with altitude because of ultraviolet radiation blocked by the ozone layer.



■ **FIGURE 8.** There were a few bad relative humidity readings on this flight, but otherwise, the tendency for the atmosphere to get drier with altitude is evident in this chart.



■ **FIGURE 9.** Would you look at that jet stream! These are some of the fastest winds I've ever observed during a near space mission. The data came from the GPS receiver's speed and heading reports.

TCF™-2012

The College of New Jersey Hosts
The 37th Anniversary of
THE ORIGINAL PERSONAL COMPUTER SHOW

37th Annual

Trenton Computer Festival™

KEYNOTE SPEAKER:
Jeff Gomez,
President & CEO,
Starlight Runner
Entertainment
on
"From the Inner City to Pandora: The Power of Story in a Tech-Driven World"

DOOR PRIZES

INNOVATION POWERED BY COMPUTING

Admission:
Advance Tickets - $10.00
(Door Prize for Advance Ticketholders)
www.tcf-nj.org ***(deadline March 4)***

One-Day Ticket (at gate) - $10.00
Rain or Shine - Free Parking

@ The College of New Jersey, Ewing, NJ
Saturday, March 10, 2012
10 am - 5 pm

- **Apple/Mac/iOS Day**
  Full Day with Apple's Dave Marra, N3ODX
- **Windows 8 Presentation**
  by David Soll, KC2YJI

65+ Talks, Workshops, Tutorials, Demos and Special Events!
TALKS ON WINDOWS, MAC and LINUX.

- *Special low winter prices for vendor and hobbyist tables in the indoor Flea Market. (See web site.)*
- *Also, special room rates at the Element Hotel in Ewing Twp., $109/night plus tax. Reserve a room in the ITPC/ISEC/TCF block by Feb. 14 by calling (609) 671-0050 or (877) 353-6368.*

MULTIMEDIA, 3D VIDEO, PHOTOGRAPHY
HOME CONTROL, SECURITY and WIFI
Get an Amateur Radio License at TCF!
Ham Cram Session & Exam
Arduino Developer/User Tutorial/Workshop

IMPORTANT CHANGES TO THIS YEAR'S FESTIVAL

- The Festival will be in March this year.
- The Festival will be only **ONE DAY** this year, on Saturday, March 10.
- Outdoor Flea Market vendors will be INDOORS this year, because of the early date of the Festival.
- The IT Pro and ISEC conferences will be on Friday, March 9.

Integrated STEM Education Conference (ISEC)
Friday, March 9 – **Theme: Integrate by Design.**
Discussion and exploration of best practices in K-16 STEM education (extra cost registration).
Continuing education credits available!
Info: http://ewh.ieee.org/conf/stem/

TCF IT PROFESSIONAL CONFERENCE
Friday March 9, 2012, 9am —5pm
For Conference Info and Fees See
http://www.tcf-nj.org/pc

The optional TCF IT Pro and ISEC Conferences require add'l fees.

For additional TCF'12 info, directions and advance tickets:
www.tcf-nj.org

SPONSORS
The College of New Jersey (TCNJ)
New York Amateur Computer Club (NYACC)
IEEE Region 1
IEEE Princeton Central Jersey Section, and
the Joint Princeton Chapters of the ACM and
the IEEE Computer Society

The 2012 Trenton Computer Festival™ is produced by TCF, Inc., a not-for-profit 501(c)(3) educational organization.

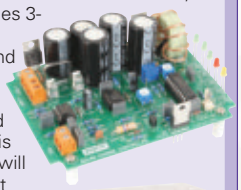
2012P-rev-04a

Power & Solar Kits for Electronic Enthusiasts

KIT OF THE MONTH

Solar Charge Controller Kit
KC-5500 $93.00 plus postage & packing

Charge controllers are essential for solar setups, although commercial units can run into several hundred dollars. Designed for use with 40W to 120W 12V solar panels and lead acid batteries, this solar charger provides 3-stage charging with the option of equalisation and with MPPT (Maximum Power Point Tracking). Operation is for 12V and the kit configured for this voltage, a 24V upgrade will be available in future. Kit includes PCB, all components and case.



Features
- Suitable for 40W to 120W 12V solar panels
- 3-step charging
- MPPT (maximum power point tracking) charging
- Charge indicator LEDs
- Temperature compensation for charge voltage
- Optional equalisation cycle
- Optional 24V 80W to 240W operation upgrade
- PCB: 111(L) x 85(W)mm

Voltage Regulators

Improved Low Voltage Regulator
KC-5463 $13.00 plus postage & packing

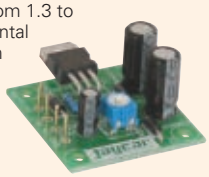
This handy regulator will let you run a variety of devices such as CD, DVD or MP3 players from your car cigarette lighter sockets or even a digital camera or powered speakers from the power supply inside your PC. This unit can will supply either 3V, 5V, 6V, 9V, 12V or 15V from a higher input voltage at up to four amps (with suitable heatsink). Kit includes screen printed PCB and all specified components. Heatsink not included.

- PCB: 108(L) x 37(W)mm

Note: that to ensure trouble free 4 amp output, a heatsink with a thermal resistance of 1.4 degrees C per watt, and an input voltage 3VDC above the output voltage is required.

Voltage Regulator Kit
KC-5446 $12.25 plus postage & packing

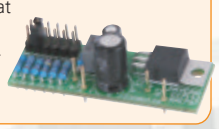
This handy voltage regulator can provide up to 1,000mA at any voltage from 1.3 to 22VDC. Ideal for experimental projects or as a mini bench power supply etc. Kit supplied with PCB and all electronic components.



- PCB: 38(L) x 35(W)mm

Voltage Regulator
KA-1797 $6.00 plus postage & packing

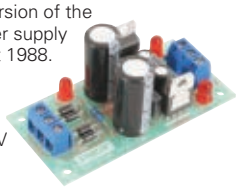
A low-powered DC converter suited for many applications such as a peripheral computer power supply, powered speakers, modems, music/MIDI keyboards, etc. Just plug it's input into your PC's internal power supply cable and have selectable regulated voltage out from 3 to 15VDC. Output current capability is around 1.5 amps depending on the size of heatsink used (heat sink sold separately). PCB plus electronic components included.



- PCB: 52(L) x 19(W)mm

Universal Power Supply Regulator
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).



Don't just sit there BUILD SOMETHING!

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

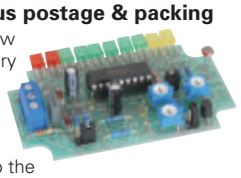
DC Relay Switch Kit
KC-5434 $12.25 plus postage & packing

An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400µA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options. The kit includes PCB with overlay and all electronic components with clear instructions.

- PCB: 61(L) x 41(W)mm

Voltage Monitor Kit
KC-5424 $16.75 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.



- 12VDC
- PCB: 74(L) x 47(W)mm

Battery Checker
KC-5482 $57.75 plus postage & packing

The first versions of the battery zapper included a checker circuit. The Mk III battery zapper (KC-5479) has a separate checker circuit - and this is it. It checks the health of SLA batteries prior to charging or zapping with a simple LED condition indication of fair, poor, good etc.

- Overlay PCB and electronic components
- Case with machined and silk-screened front panel
- PCB: 185(L) x 101(W)mm

LED Battery Voltage Indicator
KA-1778 $7.25 plus postage & packing

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED, and can be used in just about any piece of battery operated equipment. Current consumption is only 3mA at 6V and 8mA at 10V and the circuit is suitable for equipment powered from about 6-30VDC.
With a simple circuit change, the bi-colour LED will produce a red glow to indicate that the voltage has exceeded a preset value.

- PCB: 25(L) x 25(W)mm
- PCB, bi-colour LED and all specified electronic components supplied

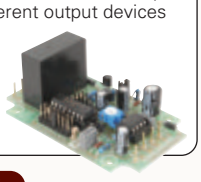
3V to 9V DC to DC Converter Kit
KC-5391 $11.50 plus postage & packing

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.

- PCB: 59(L) x 29(W)mm
- Kit supplied with PCB, and all electronic components

The Flexitimer
KA-1732 $14.50 plus postage & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains plugpack.



- Kit includes PCB and all components
- Requires 12 - 15VDC power

ATTENTION KIT BUILDERS

Kit Back Catalogue
If you can't find the kit you are looking for, try the Jaycar Kit Back Catalogue. Our central warehouse keeps a quantity of older and slow-moving kits that can no longer be held in stores. A list of kits can be found on our website. Just search for "kit back catalogue".

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 550lb (250kg). Heavier parcels POA. Minimum order $25.

- √ We ship via DHL
- √ Expect 5-10 days for air parcel delivery
- √ Track & Trace parcel

Note: Products are despatched from Australia, so local customs duty & taxes may apply.

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

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

All prices in US dollars. Prices valid until 31/03/2012

Jaycar Electronics

■ BY FRED EADY

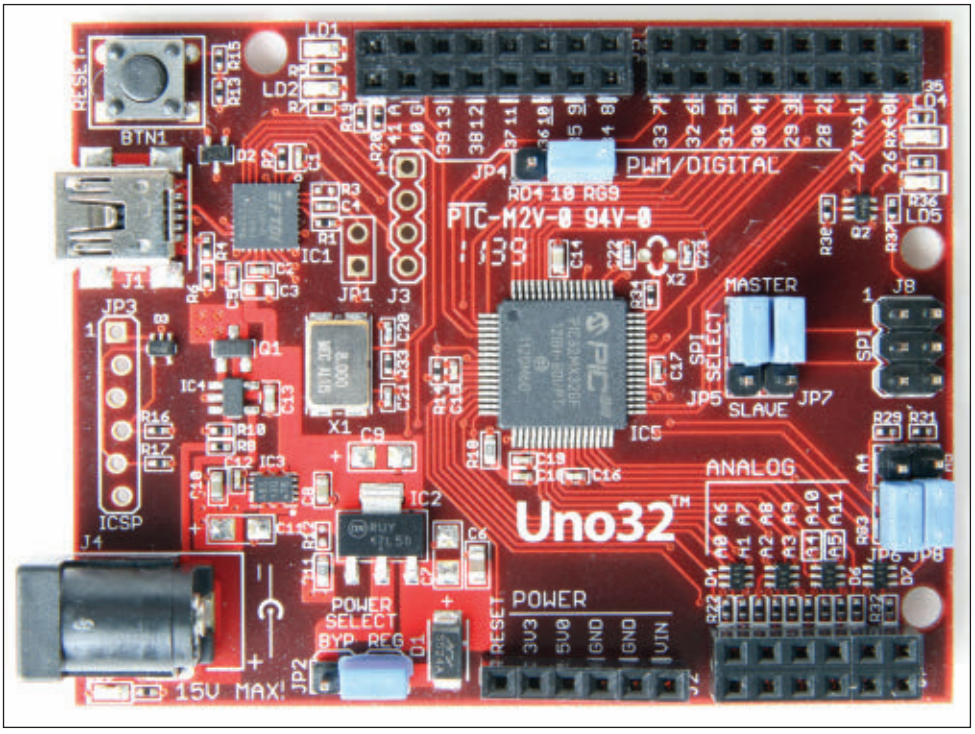
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

IT'S ALL ABOUT THE Uno32 HARDWARE

It used to be all about the hardware. Remember your first personal computer? Yep, you and I were enthralled and bedazzled by the canned software applications and the command line OS. In reality, our immediate intention was to understand enough about the PC's hardware design to interface with the microprocessor and the I/O subsystem.

I was talking to a friend last night and the discussion fell back into the good old days of the Intel 1702 EPROM and 8085 microprocessor. The 1702 required multiple supply voltages and a unique negative 48 volt programming pulse sequence to store data in its 256 x 8 memory matrix. If your program was big enough, it took a full 30 seconds to program all 256 bytes of the 1702's nonvolatile memory. The 1702 was eventually replaced by the single voltage 1K x 8 2708 and the 2K x 8 2716. I can remember having multiple 2716s that I rotated through the UV eraser with every new spin of code. The EPROMs and companion microprocessor were all we had to work with, and work with them we did. I couldn't afford the expensive EPROM programmers of the time. So, I (and everybody else) designed and built my own. Compilers and printed circuit boards were food for the gods. We used assembler and wire-wrapped breadboards. In the end, it was all about the hardware.

Despite the advent of the instant technology found in our smart phones and electronic notepads, it is still all about the hardware. If it weren't for the 1702, the 8085, and the men and women that plied them, we would still be plunking quarters into public telephones and replacing the needles on our phonographs.

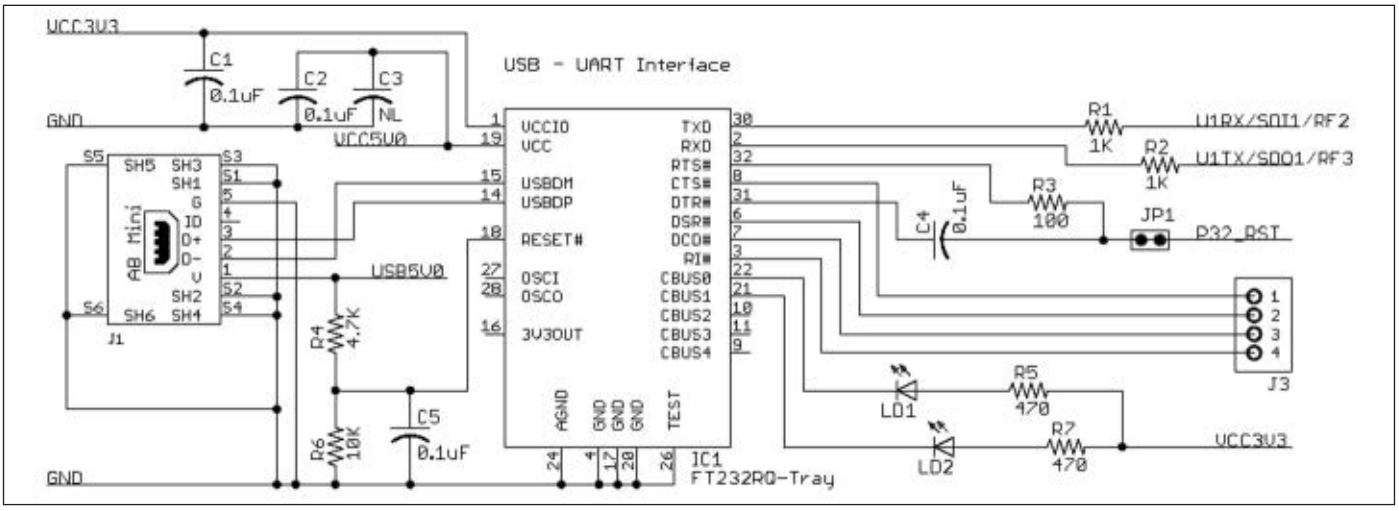


■ PHOTO 1. The Uno32 is a very simple electronic design with very powerful possibilities.

A NEW HARDWARE MODEL

The modern microcontroller has replaced the breadboard mounted rows and columns of combinatorial logic ICs that I used to design around. Gone also are the heavily heatsinked high current power supplies that were required to support the garden of TTL logic ICs.

The discrete hardware components that we can buy from electronic parts distributors are getting smaller and smaller. Some are too small for even the most experienced electronics experimenter to mount



■ SCHEMATIC 1. A MAX232 just wouldn't fit very well in this role. The FT232RQ has it beat in terms of speed and versatility.

by hand. Thus, instead of revolving around a set of passive discrete components, we find ourselves plotting designs that are centered on a cluster of "smart" electronic components.

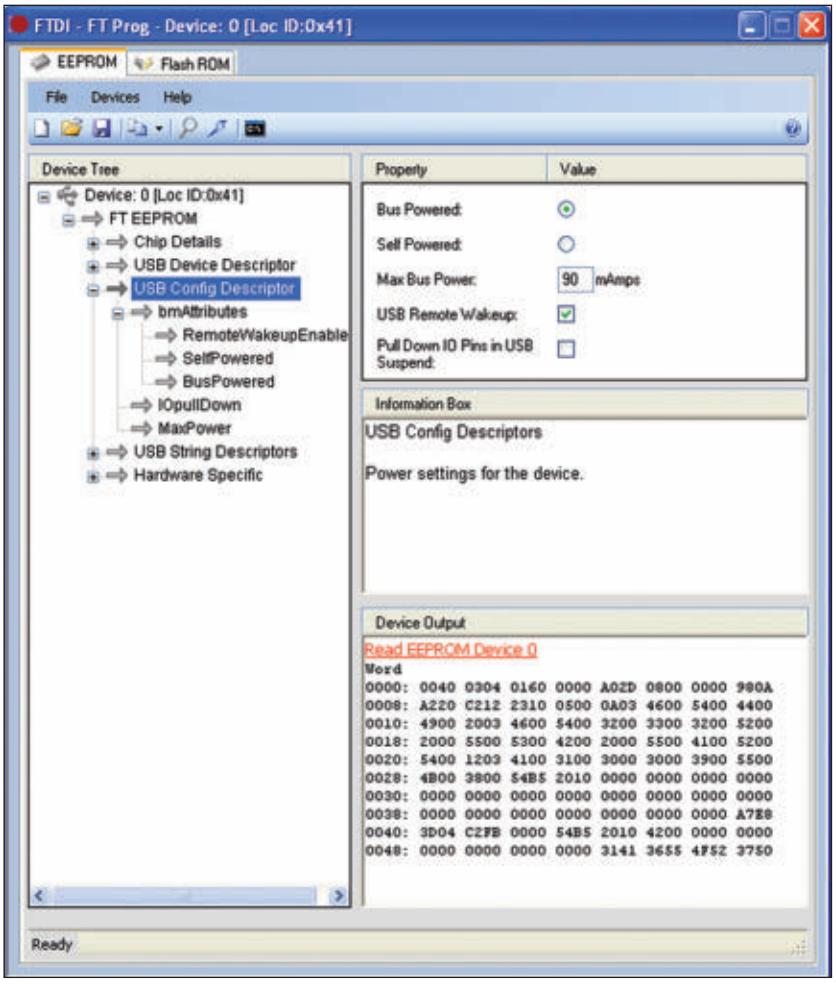
In one-off designs, the passives and logic that made up your electronic cluster would be customized for the application. However, universal electronic cluster designs tend to be cheaper in the long run since the universal cluster can be adapted to multiple missions. More often than not, a universal electronic cluster is built around a microcontroller. The Arduino hardware concept is a perfect example of a universal electronic cluster design.

The Arduino environment provides a way to write applications without the Arduino programmer having to know anything about the hardware. From a pure programmer's point of view, that's a good thing. From a hardware head's point of view, that could be a bad thing. I like to know everything I can about the hardware. Since you're reading Design Cycle, I'm sure you do too.

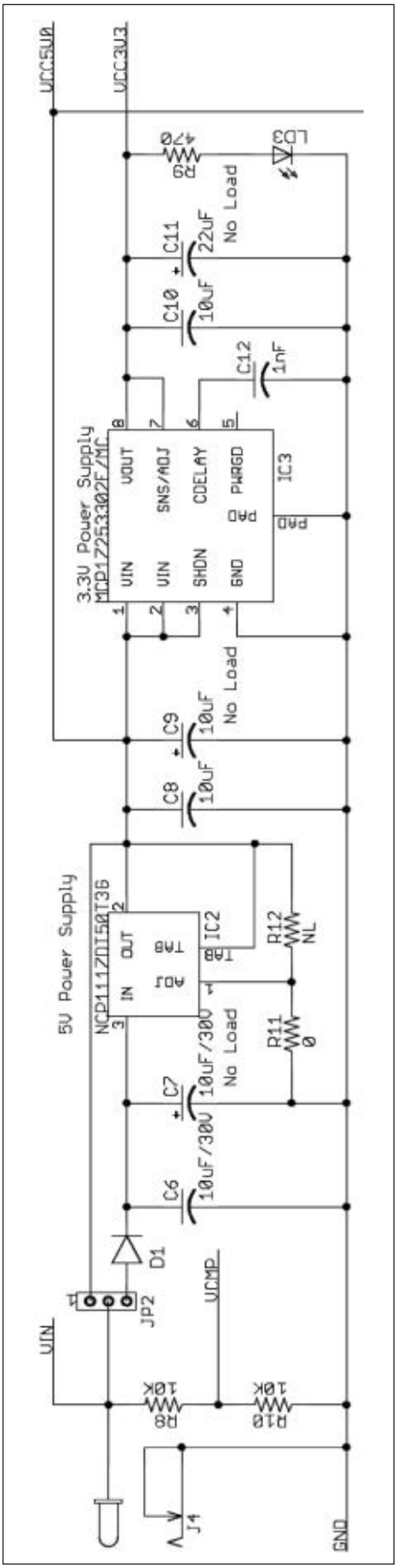
IT'S ALL ABOUT THE HARDWARE

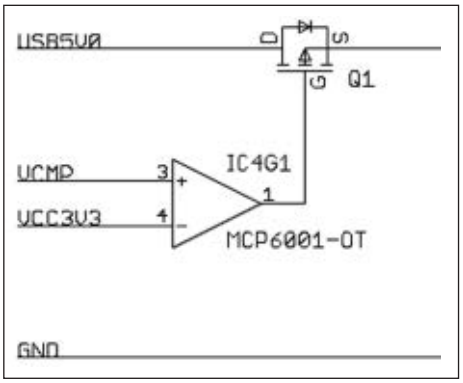
The Digilent Uno32 captured in **Photo 1** qualifies as a universal electronics cluster that can interoperate in an Arduino or native programming environment. I'm sure that there are new Arduino sketches being written for the Uno32 as we speak. While the Arduino programmers are hammering out libraries and applications, we'll turn our attention to the Uno32's 32-bit electronics cluster.

The Uno32's serial port design is graphically depicted in **Schematic 1**. The Uno32 embedded platform uses an FTDI USB device instead of an RS-232 interface IC as its serial port interface hardware. The advantages of implementing a USB interface solution in this situation are



■ SCREENSHOT 1. FTProg is a free utility that can be downloaded from the FTDI site. Here, we see that the Uno32's USB portal is bus powered, asking for a maximum of 90 mA of that power.





■ SCHEMATIC 2. When the MCP6001 op-amp's VCMP input is less than +3.3 volts, MOSFET Q1 allows the Uno32 to be powered by the USB host.

many. For instance, it is not likely that you'll find a nine-pin RS-232 portal on any desktop or laptop computer that is marketed today. However, odds are that you will find at least one USB portal on any PC you can buy new right now. In terms of speed, the FT232RQ easily outruns any MAX232 variant. The FT232RQ is also more versatile than a single RS-232 interface IC.

A single FT232RQ can process transmit and receive data traffic while simultaneously supervising all of the common modem control signals. Transmit/receive visual signaling duty is also handled by the FT232RQ via its programmable five-bit I/O control subsystem. A single FT232RQ literally replaces a herd of RS-232 ICs.

The Uno32's FT232RQ data transfer functions are supported on the PC side by a set of FTDI drivers that are used to construct a Virtual Comm Port, or VCP. On the Uno32 side, the FT232RQ needs no special programming and can be configured using FTDI's FT Prog Utility.

I've connected my laptop to our Uno32's FT232RQ-based USB portal and fired up an instance of the FTDI FT Prog Utility. **Screenshot 1** contains the USB Config Descriptor information. The **Screenshot 1** FT232RQ scoop tells us that the Uno32's USB portal is bus powered and will require a maximum of 90 mA from the USB host. The fact that

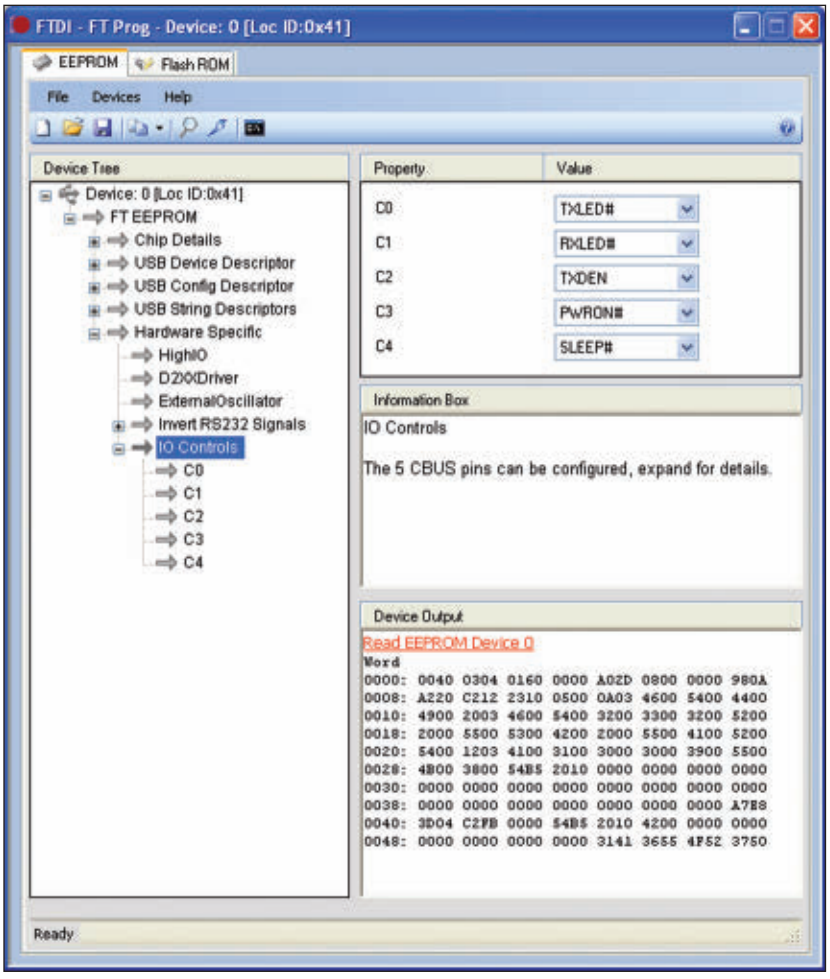
■ SCHEMATIC 3. No rocket science here. If you've ever worked with a linear voltage regulator, everything should be obvious to even the most casual observer.

the Uno32's FT232RQ is bus powered is not obvious in the realm of **Schematic 1**. So, let's follow the FT232RQ's power train beginning with **Schematic 2**.

The MCP6001 operational amplifier you see in **Schematic 2** is used as a comparator. When the MCP6001's VCMP input is presented with less than +3.3 volts, MOSFET Q1 is biased ON and allows the USB host to power the Uno32 via the USB host portal. MOSFET Q1's source pin feeds the VCC5V0 power signal you see in **Schematic 3**. While your eyes are on **Schematic 3**, note that the Uno32 can also be powered by an external power source other than a host USB portal. The VCMP power signal is derived from the external power source that does not originate from the USB host. Thus, the use of a USB host power source and an external non-USB power source is mutually exclusive. The host USB power source will always be overridden by an external power source greater than 7.0 VDC.

Now that we know how the Uno32's FT232RQ is powered, we can look back at **Schematic 1** and see that the FT232RQ's I/O subsystem is set up for 3.3 volt logic levels via the voltage applied to its VCCIO pin. Also, note that the FT232RQ's active-low RESET pin is controlled by the host USB portal. The voltage divider made up of resistors R4 and R6 provide a pullup voltage source for the internal 1.5KΩ pullup resistor that is electrically attached to the FT232RQ's USBDP pin. When power is applied to the internal pullup 1.5KΩ resistor, the USB host is informed by the presence of the pullup voltage that the Uno32's FT232RQ is a full speed USB device.

Moving to the modem control / I/O side of the FT232RQ, we find transmit and receive data signals, a modem control instantiated CPU reset signal, and visual indicators in



■ SCREENSHOT 2. We have no direct control of LEDs LD1 and LD2 unless we reconfigure the FT232RQ's I/O controls.

the guise of a couple of LEDs. The FT232RQ's TXD and RXD pins are operating at 3.3 volt logic levels and are electrically attached to the Uno32's PIC32MX320F128H UART1 interface.

Driving the FT232RQ's DTR signal logically low presents a reset condition to the PIC32MX320F128H. As you've probably already ascertained, the modem control signals (DTR, RTS, etc.) are under the control of the PC program that's in charge of the data flow on the USB portal.

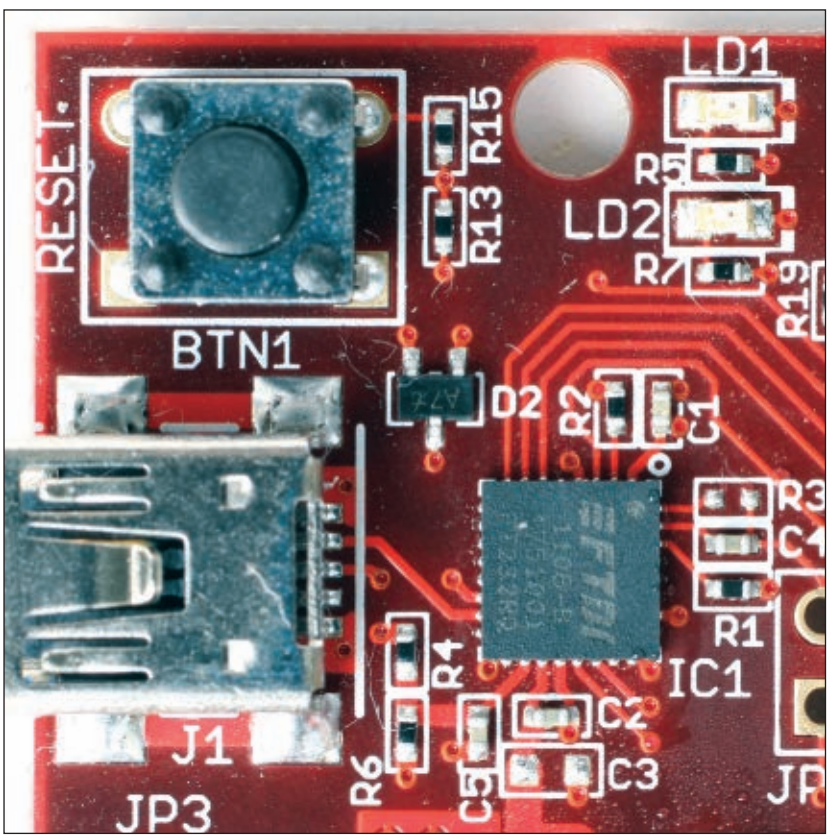
The operation of the LED indicators, LD1 and LD2, is preconfigured using the FTDI FT_Prog Utility. **Screenshot 2** is representative of how the Uno32's FT232RQ I/O controls are set up. LD1 flashes on transmit events while LD2 blinks when data is received.

Photo 2 is a spy satellite view of the Uno32's FT232RQ resident area on the Uno32's PCB. The entire FT232RQ design fits within the space of a quarter. The FT232RQ USB-to-TTL services could also be performed by the PIC32MX320F128H's internal USB engine. The FT232RQ is a better choice here as it conserves PIC32MX320F128H I/O pins by providing the CPU reset and visual indicator control via its software-controlled modem control signals and five-bit I/O control subsystem. Plus, we didn't have to write a byte of code to partake of the FT232RQ's control and signaling services.

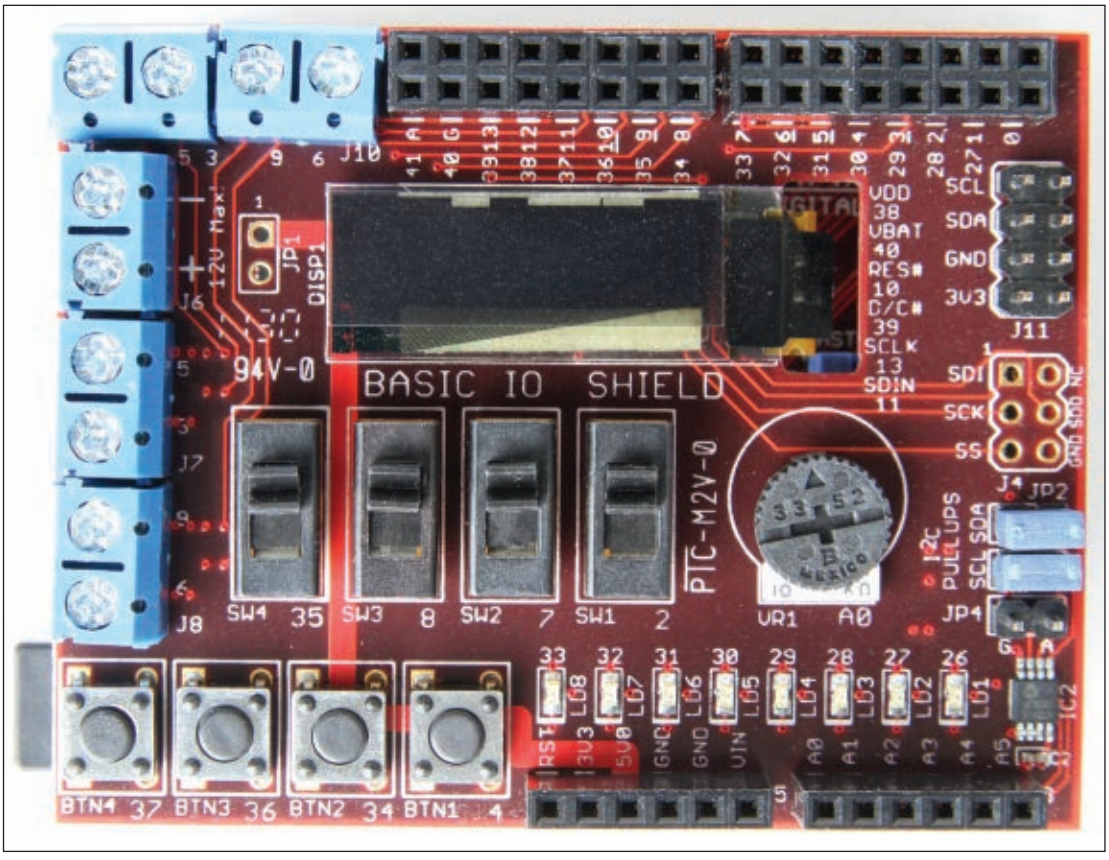
Take another close look at **Photo 1**. The only other programmable electronic component in the universal electronic cluster called Uno32 is the PIC32MX320F128H. All of the Uno32's base peripherals are stationed in the PIC32MX320F128H silicon. I won't quote the PIC32MX320F128H datasheet here since you can download your own copy. All of that peripheral potential energy cooped up in the PIC32MX320F128H silicon is useless if we can't access it. It's all about the hardware. So, let's provide the PIC32MX320F128H's internal peripherals with a playmate.

HUMAN INTERFACE HARDWARE

The Uno32 can be enhanced with yet another electronic cluster in the form of a Digilent Basic I/O Shield. In the Arduino sense,



■ PHOTO 2. Small size and minimal board space requirements are two advantages to the FTDI USB serial interface solution.



■ PHOTO 3. The combination of the Basic I/O Shield and Uno32 is simple enough for the beginner to understand and complex enough to aid in professional embedded development.

the Basic I/O Shield is a universal electronic cluster as it is designed to be interoperable with the stock Arduino hardware. The Basic I/O Shield is made up of familiar electromechanical and electronic components. You can identify most of the Shield's features just by observing them in **Photo 3**.

The Basic I/O Shield is intended for use by both neophyte and professional. Resident Shield hardware includes pushbuttons, slide switches, a byte-wide group of LEDs, and a potentiometer. The potentiometer is designed in as an analog input device and is electrically connected to one of the PIC32MX320F128H's analog inputs.

The Shield also offers advanced I/O devices. You'll find a 24LC256 EEPROM and a TCN75 digital temperature sensor on its I²C bus. The Shield's SPI portal directly supports a 128 x 32 pixel OLED display. For those of you that wish to control high current loads such as motors or solenoids, the I/O Shield is equipped with a quad of N-channel MOSFETs in an open drain configuration.

The idea behind the Basic I/O Shield is to allow the application designer to use standard Arduino calls to manipulate the Shield's I/O devices. To that end, you'll find documentation detailing its pinout in Arduinoese. If you prefer not to go with Arduino as a development tool, you can use the Shield schematic to map the I/O devices to the PIC32MX320F128H. The folks at Digilent do a very good job at documentation, and you can get the information and specifications you need for the price of a free download.

TACOS

There are beef tacos, pork tacos, and fish tacos just to name a few. No matter what's inside the taco shell, it's still a taco. High level languages are like tacos. For instance, the C programming language basically uses the same statements and rules to create assembly code for an 8085 microprocessor as it does for a PIC. In the case of the Uno32, Arduino takes the taco concept one shell further. An Uno32 Arduino language statement begins as a PIC C function. The PIC C function is then wrapped up as a C++ object that eventually becomes an Arduino statement. So, one could say that even with high level languages it's still all about the hardware. To emphasize the point, let's see what's behind the Uno32 Arduino statement that initializes the OLED display that is integral to the Basic I/O Shield.

Here's the Arduino way to wake up the Shield's OLED display:

```
void setup()
{
  IOShieldOled.begin();
}
```

Right away, we know that an object called *IOShieldOled* has been instantiated. We also know that the *begin()* function is a member of the object *IOShieldOled*. The class declaration from which the object *IOShieldOled* is spawned looks like this:

```
class IOShieldOledClass
{
  private:

  public:
    /* Class Constants*/
       static const int colMax = 128;
//number of columns in the display
       static const int rowMax = 32;
//number of rows in the display
       static const int pageMax = 4;
```

```
        //number of display pages
        static const int modeSet = 0;
        //set pixel drawing mode
        static const int modeOr  = 1;
        //or pixels drawing mode
        static const int modeAnd = 2;
        //and pixels drawing mode
        static const int modeXor = 3;
        //xor pixels drawing mode

    IOShieldOledClass();

        /* Basic device control functions.*/
        void begin(void);
        void end(void);
        void displayOn(void);
        void displayOff(void);
        void clear(void);
        void clearBuffer(void);
        void updateDisplay(void);

        /* Character output functions.*/
        void  setCursor(int xch, int ych);
        void  getCursor(int *pxcy, int *pych);
        int   defineUserChar(char ch, BYTE
        *pbDef);
        void  setCharUpdate(int f);
        int   getCharUpdate(void);
        void  putChar(char ch);
        void  putString(char *sz);

        /* Graphic output functions.       */
        void  setDrawColor(BYTE clr);
        void  setDrawMode(int mod);
        int   getDrawMode();
        BYTE* getStdPattern(int ipat);
        void  setFillPattern(BYTE *pbPat);

        void moveTo(int xco, int yco);
        void getPos(int *pxco, int *pyco);
        void drawPixel(void);
        BYTE getPixel(void);
        void drawLine
        (int xco, int yco);
        void drawRect
        (int xco, int yco);
        void drawFillRect
        (int xco, int yco);
        void getBmp
        (int dxco, int dyco,
        BYTE *pbBmp);
        void putBmp
        (int dxcp, int dyco,
        BYTE *pbBmp);
        void drawChar(char ch);
        void drawString(char *sz);
};
```

Everything — I mean everything — that has to do with controlling the Shield's OLED display is defined within the *IOShieldOledClass* class declaration. Note that our *begin()* control function is contained within the *IOShieldOledClass* class declaration's braces. The class declaration can be found in the *IOShieldOled.h* file.

An instance of the class *IOShieldOledClass* called *IOShieldOled* is created in the *IOShieldOled.cpp* C++ source file. We also place C++ code to flesh out the function members of the class *IOShieldOledClass* in the *IOShieldOled.cpp* C++ source file. All of the functions are addressed. However, we're only interested in the *begin()* control function:

```
void IOShieldOledClass::begin(void)
{
        OledInit();
}
```

As it turns out, the *OledInit()* function is part of the Oled driver code which is found in the file *Oleddriver.c*:

```
void OledInit()
        {

        /* Init the PIC32 peripherals used to
        ** talk to the display. */
        OledHostInit();

        /* Init the memory variables used to
        ** control access to the display. */
        OledDvrInit();

        /* Init the OLED display hardware. */
        OledDevInit();

        /* Clear the display. */
        OledClear();

}
```

Since it's all about the hardware, let's look at the meat of the *OledHostInit()* function:

```
void OledHostInit()
        {
        #if defined (_BOARD_UNO_)
                /* Initialize SPI port 2.*/
                SPI2CON = 0;
                SPI2BRG = 4;
                //8Mhz, with 80Mhz PB clock
                SPI2STATbits.SPIROV = 0;
                SPI2CONbits.CKP = 1;
                SPI2CONbits.MSTEN = 1;
                SPI2CONbits.ON = 1;
        #elif defined (_BOARD_MEGA_)
                /* Initialize pins for bit bang
                **SPI. The Arduino Mega boards,
                ** and therefore the Max32 don't
                **have the SPI port on the same
                ** connector pins as the Uno. The
                **Basic I/O Shield doesn't even
                ** connecto to the pins where the
                **SPI port is located. So, for
                ** the Max32 board we need to do
                **bit-banged SPI.
                */
                PORTSetBits(prtSck, bitSck);
                PORTSetBits(prtMosi, bitMosi);
                PORTSetPinsDigitalOut(prtSck,
                bitSck);
                PORTSetPinsDigitalOut(prtMosi,
                bitMosi);
        #else
                #error "No Supported Board
                Defined"
        #endif
        PORTSetBits(prtDataCmd, bitDataCmd);
        PORTSetBits(prtVddCtrl, bitVddCtrl);
        PORTSetBits(prtVbatCtrl, bitVbatCtrl);

        PORTSetPinsDigitalOut(prtDataCmd,
        bitDataCmd);  //Data/Command# select
        PORTSetPinsDigitalOut(prtVddCtrl,
        bitVddCtrl);  //VDD power control (1=off)
        PORTSetPinsDigitalOut(prtVbatCtrl,
        bitVbatCtrl); //VBAT power control
        (1=off)
```

```
        /* Make the RG9 pin be an output. On the
        ** Basic I/O Shield, this pin is tied to
        ** reset.*/
        PORTSetBits(prtReset, bitReset);
        PORTSetPinsDigitalOut(prtReset, bitReset);

}
```

We're finally down to the C code that speaks directly to the PIC32MX320F128H. Every function within the *OledInit()* function will execute initializing the PIC32MX320F128H, the Oled hardware, and the Oled driver. All of the definitions for the arguments of the functions contained within the functions found in *OledInit()* are contained within the *OledDriver.h* file. The *PORTSet* functions are PIC32MX peripheral library calls that are part of the PIC32MX Peripheral Library, which is part of the Microchip.PIC32MX C compiler.

IT'S STILL ALL ABOUT THE HARDWARE

Now you know what happens behind that *IOShieldOled.begin()* Arduino statement. I guess you could classify the Arduino statement we examined with one of those tacos with two shells separated by cheese. The C and C++ code we discussed ends up being compiled to form an Arduino OLED library. Naturally, the *IOShieldOled.xxx* calls are used in your Arduino sketches.

If we equate eating with coding, Arduinoese is easy to swallow. The C behind the Arduinoese is a bit chewy, but easily consumed. If you're interested in moving from being an Arduino user to an Arduino developer, the Uno32 can help you get there. The Uno32 comes with a factory installed bootloader that is designed to be used with Digilent's MPIDE Arduino-compatible development tool. For those of you that aren't grazing on the Arduino farm, the Uno32 is PICkit3-ready too.

You can use assembler, C, C++, and Arduinoese to prod the Uno32's PIC32MX320F128H into programmable action. The bottom line is that the Uno32's hardware is a common denominator no matter what programming language you choose to use. The Uno32 puts 32-bit Arduino computing into your Design Cycle. **NV**

SOURCES

Digilent
Uno32
Basic I/O Shield
MPIDE
www.digilentinc.com

ELECTRONET

www.canakit.com
• Over 200 Kits & Modules to choose from!
• Easy Worldwide Online Ordering
• Fast Delivery & Same Day Shipping
FM Transmitters • Timers • Audio Amplifiers • Motor Controllers

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

PowerBotix Robotic Power System
Powerful components providing hot-swappable battery connections and USB data connections. Isolated regulated 12v and 5v for electronics and raw 12v for motors. Separate powerful noise filter.
www.powerbotix.com

THE ORIGINAL SINCE 1994
PCB-POOL®
Beta LAYOUT
• Low Cost PCB prototypes
• Free laser SMT stencil with all Proto orders
WWW.PCB-POOL.COM

Chip Adapters
Device Package Changed? Need to go from QSOP to DIP, TSOP to SOIC, or other? 0603, 0805, 1206, DIP, MSOP, PLCC, QFN, QSOP, SOIC, SOJ, SOT, SSOP, TSOP
www.EZPrototypes.com

Simple Chaser Lights Board
Parts Kit for this Month's Smiley's Workshop
Simple Chaser Lights parts kit, with pre-programmed LED patterns.
$24.95
Breadboardable LCD Navigator
Breadboard friendly LCD and five-button keypad parts kit. Details on Smiley's Blog at: www.smileymicros.com\blog.
$34.95
From Smiley's Workshop
Call to order at 1-800-783-4624 or go to www.nutsvolts.com

INVEST in your BOT!
INVEST in HiTEC
12115 Paine Street • Poway, CA 92064 • 858-748-6948 • www.hitecrcd.com

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

ALL ELECTRONICS CORPORATION
Electronic Parts & Supplies Since 1967

For complete product details, visit our webstore!!

The Nuts & Volts WEBSTORE

GREAT FOR DIYers!

Steampunk Gear, Gadgets, and Gizmos
by Thomas Willeford

NEW!

A Maker's Guide to Creating Modern Artifacts

Welcome to the wondrous world of Thomas Willeford (a.k.a., Lord Archibald "Feathers" Featherstone) in which he shares his closely guarded secrets of Steampunkery. Filled with do-it-yourself projects, *Steampunk Gear, Gadgets, and Gizmos: A Maker's Guide to Creating Modern Artifacts* shows you how to build exquisite, ingenious contraptions on a budget.

$24.95

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

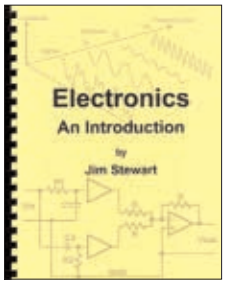
Programming Arduino Getting Started with Sketches
by Simon Monk

Program Arduino with ease!

Using clear, easy-to-follow examples, *Programming Arduino: Getting Started with Sketches* reveals the software side of Arduino and explains how to write well-crafted sketches using the modified C language of Arduino. No prior programming experience is required! The downloadable sample programs featured in the book can be used as-is or modified to suit your purposes.

$14.95

Electronics An Introduction
by Jim Stewart

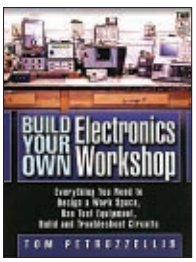


This book is designed as an in-depth introduction to important concepts in electronics. While electronics can be highly mathematical, this text is not about calculations. It is about how electronic equipment is able to extract, process, and present information held in electrical signals. If you are in — 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 $26.95

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.

$39.95

HTML: A Beginner's Guide
by Wendy Willard

Create highly functional, impressive websites in no time. Fully updated and revised, *HTML: A Beginner's Guide*, Fourth Edition explains how to structure a page, place images, format text, create links, add color, work with multimedia, and use forms. You'll also go beyond the basics and learn how to save your own web graphics, use Cascading Style Sheets (CSS), create dynamic web content with basic JavaScript, and upload your site to the web. By the end of the book, you'll be able to build custom websites using the latest HTML techniques.

$29.95

Programming PICs in Basic
by Chuck Hellebuyck

If you wanted to learn how to program microcontrollers, then you've found the right book! Microchip PIC microcontrollers are being designed into electronics throughout the world and none is more popular than the eight-pin version. Now the home hobbyist can create projects with these little microcontrollers using a low cost development tool called the CHIPAXE system and the Basic software language. Chuck Hellebuyck introduces how to use this development setup to build useful projects with an eight-pin PIC12F683 microcontroller. **$14.95**

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 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

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

BOOK & KIT COMBOS

Proto Buddy Book & Kit Combo

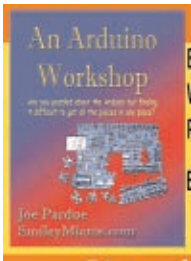
Only $59.95

For complete details visit our webstore @ www.nutsvolts.com

Beginner's Guide Vol 3 Combo

Combo Price $139.95

For complete details, visit our webstore @ www.servomagazine.com.



Book: An Arduino Workshop $44.95
Projects Kit $84.95

Book and Kit Combo $124.95

Book: C Programming for Microcontrollers $44.95
Projects Kit $58.49

Book and Kit Combo $99.95

Simple Chaser Lights Board

Parts Kit for this Month's Smiley's Workshop
Simple Chaser Lights parts kit, with pre-programmed LED patterns.

$24.95

Breadboardable LCD Navigator

Breadboard friendly LCD and five-button keypad parts kit. Details on Smiley's Blog at: www.smileymicros.com\blog.

$34.95

From Smiley's Workshop

CD-ROM SPECIAL

Nuts & Volts 8 CD-ROMs & Hat Special!

That's 96 issues. Complete with supporting code and media files.

Free Shipping!

Only $169.95
or $24.95 each.

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. AND it still fits in your shirt pocket!

Only $12.95

Visit http://store.nutsvolts.com or call (800) 783-4624

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

PROJECTS

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.

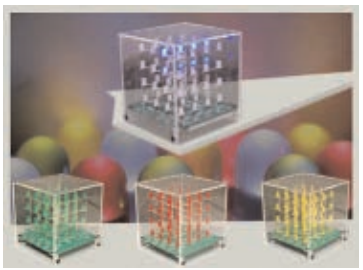
Battery Marvel Kit

As seen in the November 2011 issue. Battery Marvel helps protect cars, trucks, motorcycles, boats, and any other 12V vehicles from sudden battery failure. This easy-to-build kit features a single LED that glows green, yellow, or red, indicating battery health at a glance. An extra-loud piezo driver alerts you to any problems.

For more info, please visit our website.

Subscriber's Price **$18.95**
Non-Subscriber's Price **$19.95**

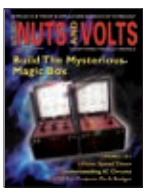
3D LED Cube Kit



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**

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**

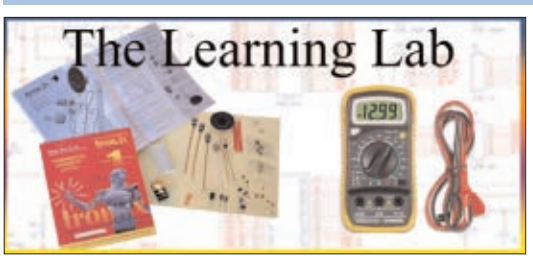
32-Bit Micro Experimenter Board

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**

FOR BEGINNER GEEKS!



Reg Price $99.95 **Subscriber's Price $95.95**

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

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!

$26.95

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

#44 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

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

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

Simple Chaser Lights Kit

Recap

Last month, we finished with the LCD Navigator Project Kit (available through the *Nuts & Volts* webstore) by learning how to use the navigator buttons with our hard-won knowledge of C bitwise operators. This month, we will start to learn about C pointers, arrays, and structures. This is going to take a while — maybe three Workshops — and since it will be about the densest thing you'll come across, we will lighten things up a bit by using some blinking LEDs for examples of how to use what we are learning. We will apply the hard stuff to storing data to be displayed on the Simple Chaser Lights Board (also available from *Nuts & Volts*). This board will let us build various sorts of chaser lights such as in a theater marquee like in **Figure 1**, or for Battlestar Glactica Cylons or Knight Rider Kitts as shown in **Figures 4** and **5**.

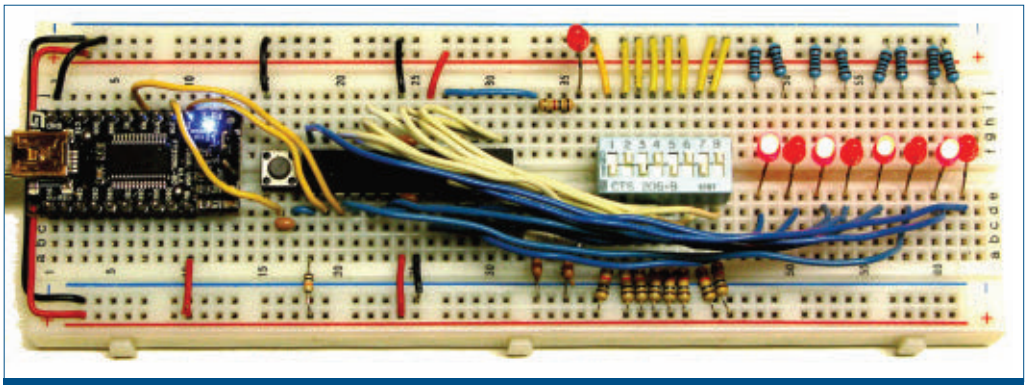
Introducing the Simple Chaser Lights Kit

In the December Smiley's Workshop, we learned about C bitwise operations and we used that knowledge to make a simple chaser lights project using the BreadboArduino (available from *Nuts & Volts*) as shown in **Figure 2**. This is a great project for learning bitwise digital input and output operations since it reads the bit states from an eight-bit DIP switch and outputs eight-bit patterns on eight LEDs, thus providing tangible physical representations of bits and bytes used for input and output.

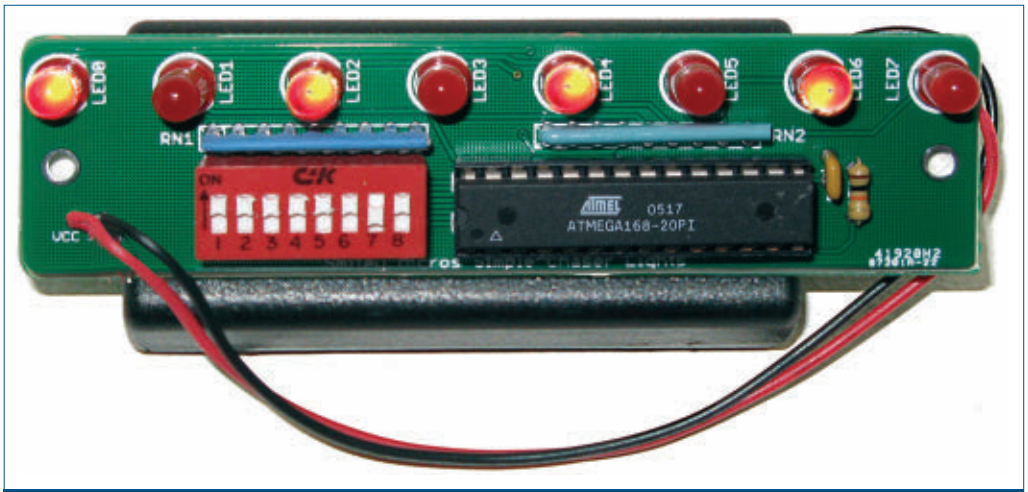
If you built the breadboard project shown in **Figure 2**, you probably had some problems getting it wired correctly — I sure did and it was my project! So, I decided to put the design (minus the USB board) on a printed circuit board so we can build it easily and have something we can knock around a bit and not worry about parts and wires falling off. **Figure 3** shows the results. This kit is very easy to assemble. You can find details on my blog at **www.smileymicros.com\blog** and it is available from *Nuts & Volts*. As usual, this is a fully open source project so the source code and the Eagle schematics and layout are located at **http://code.google.com/p/avrtoolbox/**.

The main difference between this board and the circuit discussed in December's Workshop is that this one does not have a communication channel for reprogramming. It comes with a bunch of chaser patterns built in, but if you want to reprogram it, you will have to remove the IC and reprogram it on an STK500 or Dragon, or some other socketed programmer with an ISP connection (this is also covered in the blog). You will find

■ FIGURE 1. ATTACK OF THE KILLER CHASER LIGHTS.



■ FIGURE 2. Chaser lights on BreadboArduino.



■ FIGURE 3. Chaser lights board.

the simple_chaser_lights software in avrtoolbox under the avr_applications directory so you can get a head start on this visually arresting project before we look at the details in next month's Workshop.

Theory

Before the dessert, eat your broccoli!

Let's do some theory first. We will look at C variables and data types as a lead into introducing pointers. Next month, we will dig into the gory details of pointers and look at how the theory of variables, data types, and pointers applies to the code used for the Simple Chaser Lights kit.

What is a variable?

Back in elementary school, you probably learned that a variable is just a way to name some unknown number before knowing what it is. Like, if X is my variable name, it can represent any number. If we find that it has a value of 12, then X = 12. In computers, a variable is a name used to refer to a location in memory. That location in memory holds any number that can fit at that memory location. If the memory is eight-bit, then it can hold up to 256 unique values; if 16-bit, up to 65535 values; and so on.

According to the dictionary, a variable used as an adjective is something that is subject to variation or change. When used as a noun, it means a quantity that can assume any one of a set of values; it also means a symbol representing a variable. If X is an eight-bit variable, it is restricted to the set of all integers from 0 to 255. Now, notice that we have three features that characterize a variable:

1. The name.
2. The set of valid values.
3. The value.

In C, a variable is a name used to refer to a location in memory that holds a value that is 'subject to variation or change' within a set of values. The name aspect of the variable in C is simply an alias for an address in memory. The 'set of valid values' aspect is defined by the data type (more on data types in a moment). In C, data types are related to the way data is stored in memory. For instance, on the AVR a char data type is stored in an eight-bit memory location and an int data type is stored in a 16-bit memory location. There are many other data types, and we will discuss them elsewhere so as not to dilute the discussion of pointers. If you write the following C program:

```
int main()
{
  unsigned char x = 10;
  unsigned char y = 20;
  unsigned char z = 0;

  z = x + y;

  printf("For z = x + y\n");
  printf("z = %d\n",z);
}
```

The result shown in a terminal program will be:

```
For z = x + y
z = 30.
```

You have created three variables, each restricted to the data type unsigned char which is the set of integers that can be encoded in eight-bits — 0 to 255. When you

perform the operation z = x + y, the value of x and y are added together, and z is set to the value of that sum. You can do this sort of thing all day long with pencil and paper, but computers do things their own way. The C compiler will allocate three SRAM memory locations for storing eight-bit data — one each for x, y, and z. Then, it will generate assembly code that will cause the computer to take the data at the memory location named x and add it to the data at the memory location named y, then put the results in the memory location named z.

The hardware involved in this operation varies among various computer families, but that isn't important here. What is important is that we understand the dual nature of a variable. It has an address of a memory location and it has the data stored at that location. We see the data, but we don't see the address. Instead of the actual address, we see a name for that address. C does this as a convenience for the programmer who sees x, y, and z and not 0x0342, 0x0145, and 0x0215 (which might be the addresses of those values). By now, you may be thinking that I'm way overdoing this explanation, but it is critical that you understand this before proceeding. So, get out a pencil and some paper, and answer the following questions:

Variables Quiz

- What are the three aspects of a variable?
- What is the name of a variable?
- What is the value of a variable?
- What is the data type of a variable?
- Where does C keep a copy of the value of a variable?
- How does C know where to find the value of a variable?

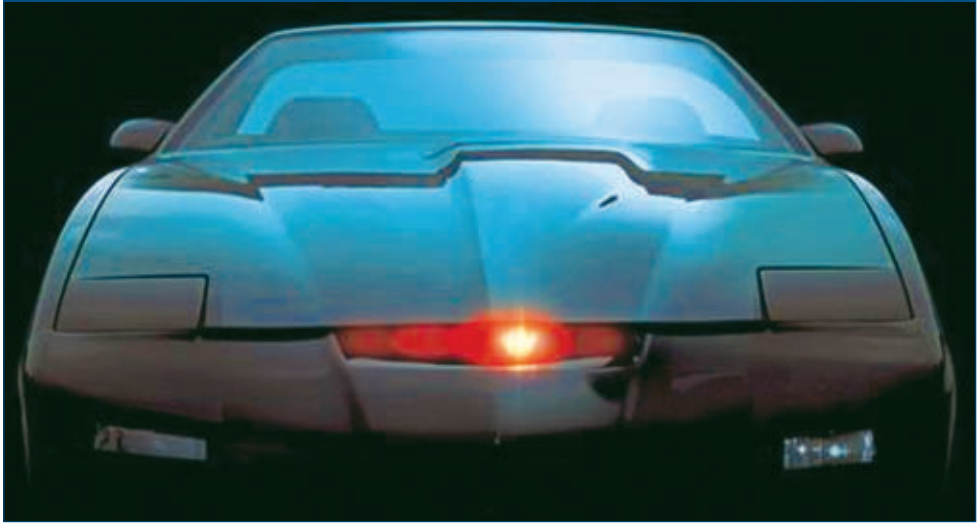
The answers are at the end of the Workshop.

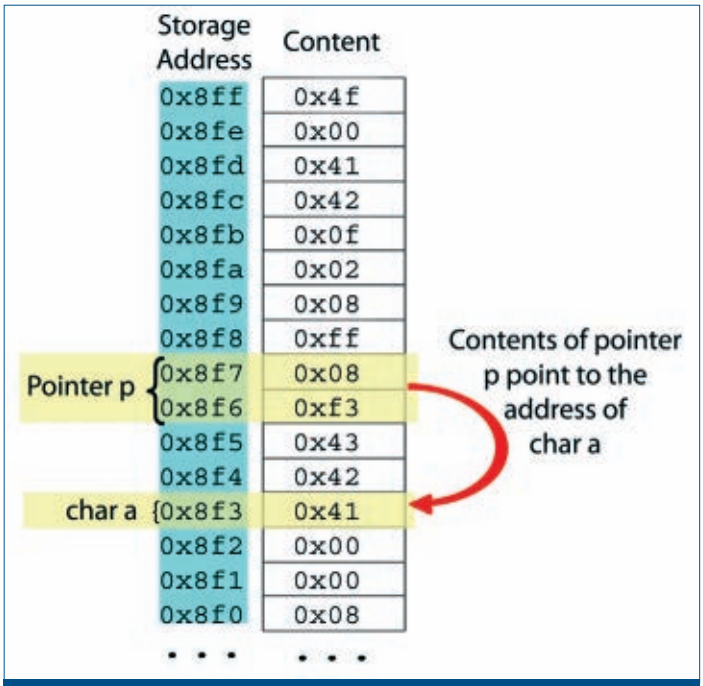
What are data types?

Data types are a system that C uses to declare variables of different kinds. Basic data types and methods are provided for building array and compound types. The original C types included things like char, int, unsigned char, unsigned int, float, etc. When you declare a variable with a type, the compiler knows how much memory to allocate for that type. For instance, in AVRs the char data type is stored in a single eight-bit memory location, while the int is stored in a 16-bit memory location. If we want to store eight bits of data, we can use char data type on an AVR, but if we port the code to some other device we can't be certain that the char will be eight bits. However, other systems might use different sizes for storing these, and for this reason the header inttypes.h was added so that we can specify the

■ FIGURE 4. Cylon eyes.

■ FIGURE 5. Kitt from Knight Rider.





■ FIGURE 6. Memory for pointer and pointee.

bits used to store a particular data type. This is where we get things like uint8_t (unsigned eight-bit integer) that you'll often see in the avrtoolbox code.

Unsigned? We can have unsigned char and unsigned int that are equivalent to uint8_t and uint16_t. Without 'unsigned,' the compiler considers the number to be signed which means it can have negative values. A char can hold numbers from -128 to 127, while an unsigned char holds numbers from 0 to 255. Either way, the data is stored in eight bits and its signed-ness is only used for computations using the data.

The important thing to remember about data types for this discussion is that they define how much memory storage will be needed for a particular type. Again, this is all system-dependent. However, for the AVR — since the unit of memory is an eight-bit byte — a char can be stored at a single memory location while an int requires two memory locations.

Typecasting. C has a cast operator that lets us change the type of a variable for a specific use. For instance, we may have defined a variable as an int but want to use it in an operation, as in char. For example, we might want to print all the ASCII characters and the number of each character:

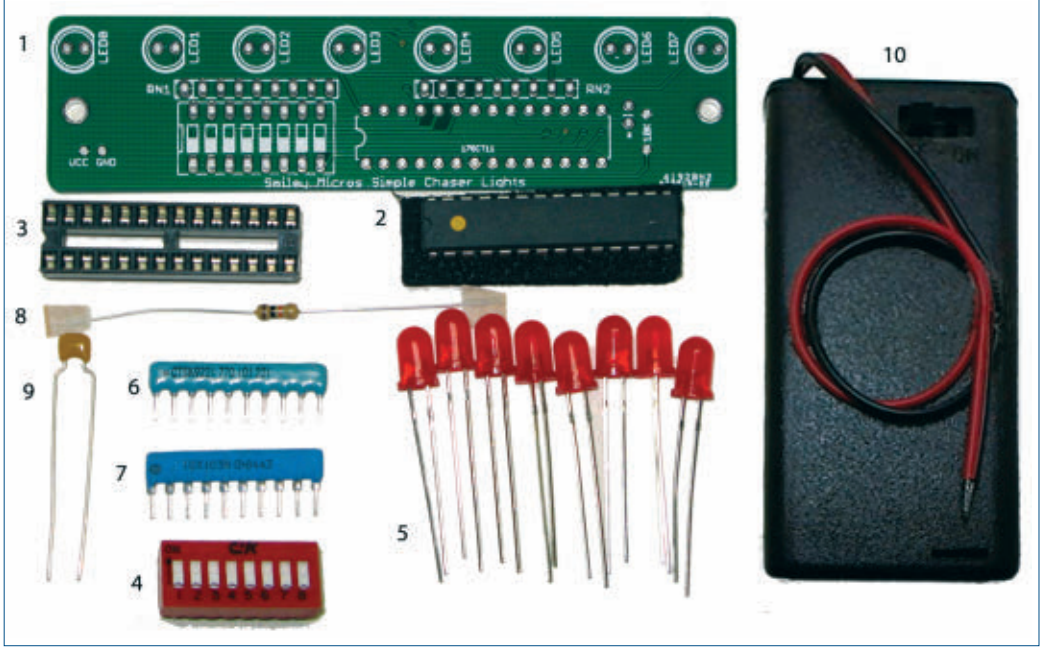
```
for(int i = 0; i < 256; i++)
{
        printf("%d = %c\n",i,(char)i);
}
```

Here we cast the int x used for the count to a char that we can print by using (char)x;

Data Types Quiz:

- How many bits are used to store an int?
- What is the largest number that can be stored in an uint8_t variable?
- What is the smallest number that can be stored in a uint8_t variable?
- What is the largest number that can be stored in an int8_t variable?
- What is the smallest number that can be stored in an int8_t variable?
- How would I use a char as an unsigned int?

■ FIGURE 7. Simple Chaser Lights Kit parts.



As before, the answers are at the end of the article.

Introducing Pointers

In C, we have a pointer data type with a value that refers directly to (points to) another value stored elsewhere in memory. A pointer is said to reference that value, and using a pointer to get that value is called dereferencing. A pointer is like any other variable in that it has an address and that there is data stored at that address. However, it is different from other variables in that C knows that it is to be used to store the address of another variable. This means

that at the memory address of a pointer, the memory address of another variable is stored. By dereferencing a pointer, C gets the address stored at the pointer's address and uses that stored address to access the data stored at the address indicated. So, a variable has an address and data is stored at that address. A pointer has an address and the address of another variable is stored at that address.

You might ask why on earth would you want to do this? One answer is that it provides a very efficient mechanism to access large blocks of data. Think for a moment about how a function works. When you call a function, you provide parameters that the function can work on, but what if you wanted to send the function all the byte data you logged in one-minute intervals over the past 24 hours? That is 60*24=1440 bytes. As you may recall, the parameters for a function are pushed on to the stack, so to send this data you would have to push 1,440 bytes and likely blow your stack. However, if you had those 1,440 bytes stored sequentially in memory, you would only need to send the function the address of the first byte and the number of bytes logged. For the AVR, an address is two bytes long and the number '1440' requires two bytes, so only four bytes are pushed on the stack. The function can then take the pointer address and increment it 1,440 times to access each byte stored. If you are thinking, 'Blocks of data ... is he talking about arrays?' you are ahead of the game and later you'll see how pointers are intimately related to arrays.

At this point, I hope you have at least some concept of what a pointer might be. Next month, we are going to really wring these out and see some program examples to help understand these concepts. And — lucky you — there is no pointer quiz at this point, but next month ...

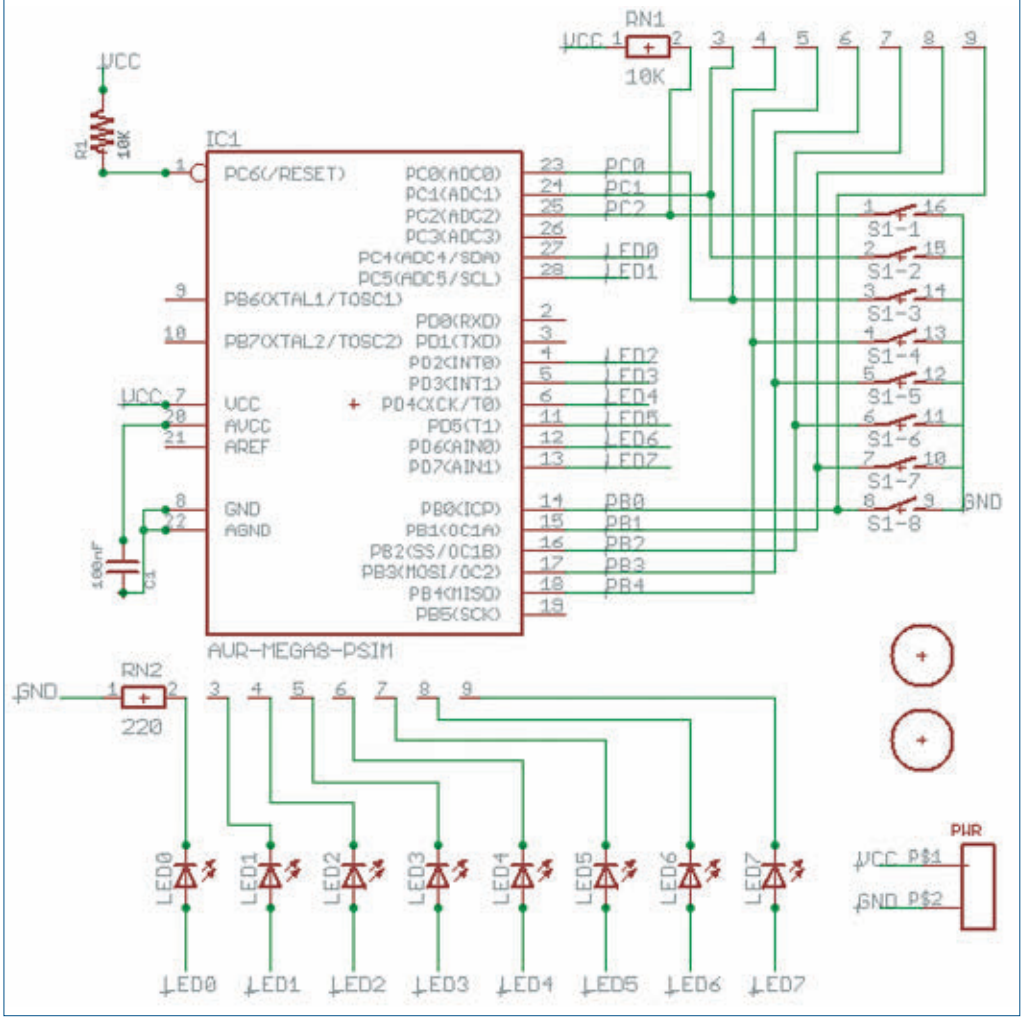
Lab

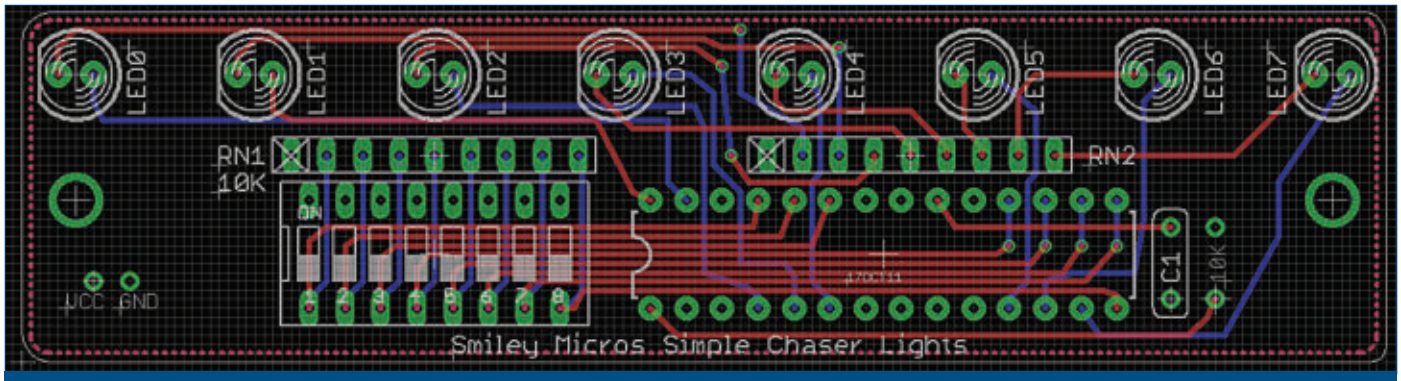
Figure 7 and **Table 1** show the Simple Chaser Lights Kit parts and Bill of Materials available from *Nuts & Volts*. **Figures 8** and **9** show the schematic and layout. Most folks will be able to figure out how to build this thing from the picture and parts list. Since I just noticed that it is the 21st century and that for very little money I could start doing videos for some of these concepts I am trying to get across, I decided to do a video demonstration on how to construct the Simple Chaser

#	Quantity	Description
1	1	PCB
2	1	ATMEGA328p
3	1	28-pin socket
4	1	Eight-bit DIP switch
5	8	5 mm Red LED
6	1	220 resistor network
7	1	10K resistor network
8	1	10K resistor
9	1	.01 µF capacitor
10	1	Battery box 2-AA

Table 1. Simple Chaser Lights Bill of Materials.

FIGURE 8. Simple Chaser Lights schematic.





■ FIGURE 9. Simple Chaser Lights layout.

Lights Board Kit. You can find this by Googling 'Simple Chaser Light Assembly' or checking my blog at **www.smileymicros.com\blog**.

When you build this, one thing to remember is that the LED images on the PCB (and the LEDs themselves) have a flat side that faces the LED short leg that is the one you connect to ground. Don't get them backwards since LEDs are diodes and current will flow in one direction. Another thing to note is that the VCC and GND pads do not have any sort of connection hardware. You solder the connections to the battery box's red and black connections (VCC and GND, respectively).

Unfortunately, this economy comes at the cost of fragility. As you wiggle these wires around, they quickly fatigue and will break off. So, to prevent this add a glob of high temperature hot glue to the connection to seal the wires and their insulation to the PCB. This will serve for strain relief and help lessen the likelihood that you'll bread the power connection. Yeah, it's ugly — but cheap — so like many a date I've had, I just go with it.

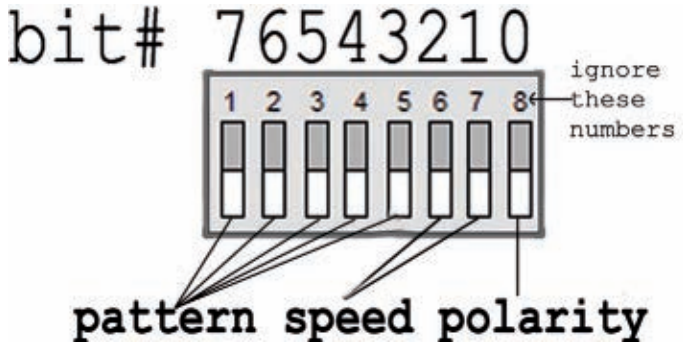
How to Use the Simple Chaser Lights

Out of the box, the microcontroller is programmed to show 32 patterns (encoded on the leftmost five bits of the DIP) at four speeds (encoded on the next two bits), and you can invert all the patterns (encoded on the rightmost bit) as shown in **Figure 10**.

The following list shows the results of various bit patterns set on the DIP switch:

DIP Switch Bit Positions for Patterns:
00000xxx (0): right_sweep1
00001xxx (1): right_sweep2
00010xxx (2): right_sweep3
00011xxx (3): right_sweep4
00100xxx (4): left_sweep1
00101xxx (5): left_sweep2
00110xxx (6): left_sweep3
00111xxx (7): left_sweep4
01000xxx (8): right_stack
01001xxx (9): left_stack
01010xxx (10): right_ant
01011xxx (11): left_ant
01100xxx (12): inout
01101xxx (13): blinkin
01110xxx (14): brownian
01111xxx (15): random
10000xxx (16): cylon1
10001xxx (17): cylon2
10010xxx (18): cylon3
10011xxx (19): cylon4
10100xxx (20): cylon_all
10101xxx (21): tick_tock_half
10110xxx (22): tick_tock_all
10111xxx (23): pov_smiley_micros
11000xxx (24): pov_nutsvolts
11001xxx (25): pov_help
11010xxx (26): pov_stop
11011xxx (27): pov_ I_love_you
11100xxx (28): pov_ taxi

■ FIGURE 10. DIP switch.



Theory is all well and good, but to really learn this stuff you have to get your hands on some tangible items that blink, whirr, and sometimes detonate. As a service for the readers of the Smiley's Workshop articles, we have simple and inexpensive projects kits available that can help you make it real. You can find these kits (and some darn good books) at the *Nuts & Volts* Webstore.

Variables Quiz Answers:

- What are the three aspects of a variable?
  It has a name, a value, and a data type.
- What is the name of a variable?
  It is an alias of the address in memory where the value of the variable is stored.
- What is the value of a variable?
  It is the data stored at the address in memory specified by the name.
- What is the data type of a variable?
  It is the range of values that are valid for the variable data.
- Where does C keep a copy of the value of a variable?
  It stores the value in SRAM memory on the AVR.
- How does C know where to find the value of a variable?
  The variable name is an alias for the address in memory for the value.

Data Types Quiz:

- How many bits are used to store an int? *That is entirely device-dependent, so we can't be sure.*
- What is the largest number that can be stored in an uint8_t variable? *127*
- What is the smallest number that can be stored in a uint8_t variable? *-128*
- What is the largest number that can be stored in an int8_t variable? 255
- What is the smallest number that can be stored in an int8_t variable? *0*
- How would I use a char as an unsigned int?

```
char myChar = 'A';
unsigned int myInt = 0;

myInt = (unsigned int)myChar;
```

11101xxx (29): pov_right_arrows
11110xxx (30): pov_left_arrows
11111xxx (31): show_all_chasers

DIP Switch Bit Positions for Speeds:
xxxxx00x (0) lowest speed
xxxxx01x (0) lower speed
xxxxx10x (0) higher speed
xxxxx11x (0) highest speed

DIP Switch Bit Positions for Polarity:
xxxxxxx0 (0) Normal
xxxxxxx1 (1) Inverted

You may notice that patterns 23 through 30 start with 'pov_' which stands for persistence of vision. When you set one of those patterns, the output will look pretty strange, unless you wave the board about — then they will look even stranger. We'll reserve the details of that for another Workshop. Next month, we are going to see how to extend the eight LEDs into a full-fledged chaser marquee style frame.

Questions? *Nuts & Volts* is hosting forums for its writers and you can find mine at **http://forum.servomagazine.com**/. If you want a quick response — especially to a question not directly related to an article — you can put on your biohazard suit and start a thread on **www.avrfreaks.net**. If you haven't done so yet, read my blog entry that will tell you why you need the biohazard suit: **http://smileymicros.com/blog/2011/01/24/using-an-internet-forum**.

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 (while helping support your favorite magazine and technical writer), then buy my *C Programming* book and Butterfly projects kit, and the *Virtual Serial Port Cookbook* using the *Nuts & Volts* web shop. **NV**

USB-LOGIC
USB Logic Analyzer

CanaKit™
www.canakit.com

DSO-NANO-V2
Pocket-Sized Digital Oscilloscope

ARDUINO-STK
Arduino Uno Starter Kit

UK1104
4-Port USB Relay Controller with 6-Channel Analog/Digital Interface

FM Transmitters • Timers • Audio Amplifiers • Motor Controllers • Custom Designs

www.canakit.com 1•888•540-KITS (5487)

FUNDAMENTALS FOR THE BEGINNER

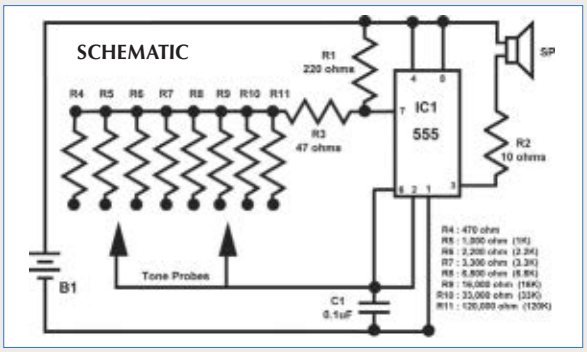
Build an IC Electronic Organ

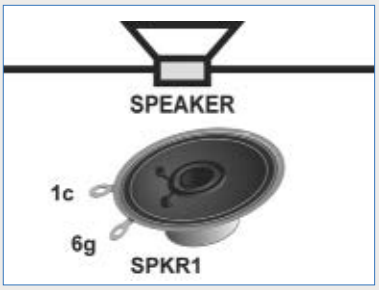
A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at www.nutsvolts.com or call us at 800-783-4624.

Play your favorite tunes with this month's experiment.

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

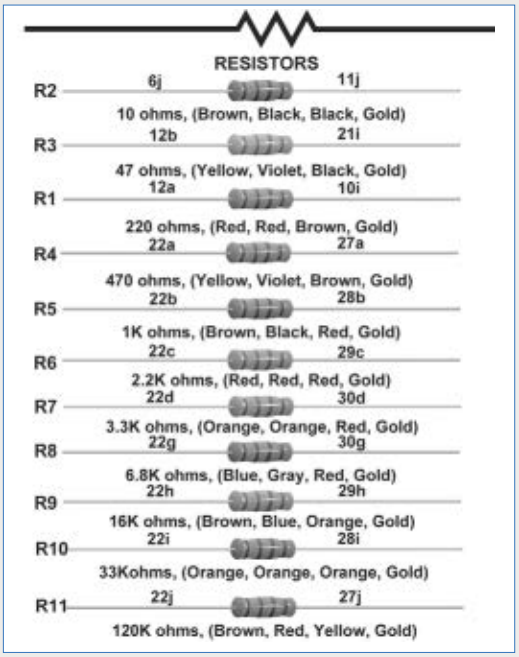
Do the Experiment. Theory: We are using the 555 timer IC as an astable multivibrator. As we change the voltage across pins 6 and 7, we change the frequency of the output pulses at pin 3. These tones can be made louder by feeding them to a transistor and amplifying them. **Procedure:** Connect a nine volt battery to the battery snap and touch one of the tone probe wires to a resistor lead, from R4 to R11. As you touch each one, you will hear a different tone. Place a tone probe in each hand and you can play your favorite tune. (Note: The 10 ohm resistor will get hot while doing this experiment.) The pitch or frequency of each tone is different, depending on the value of the resistor.

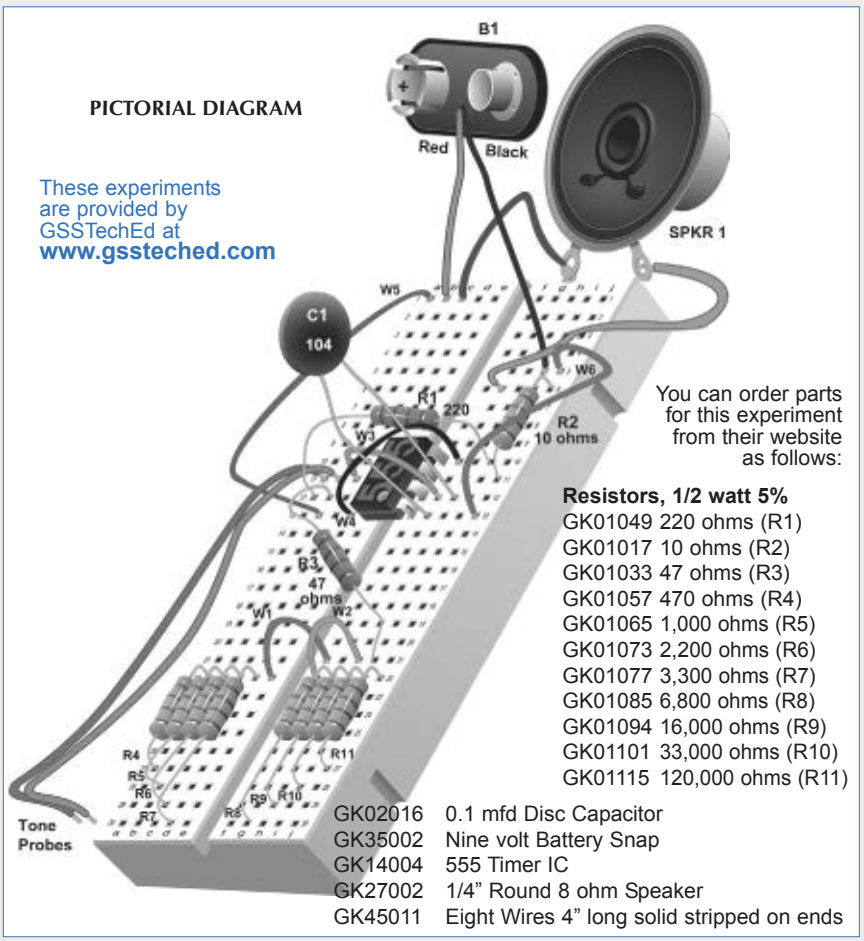




WIRES
W1 = 21f and 22e
W2 = 21h and 22f
W3 = 12g and 11c
W4 = 13d and 10g
W5 = 1a and 13b
W6 = 5j and 13j

TONE PROBES
11a, 11b



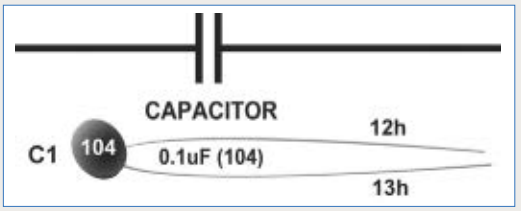


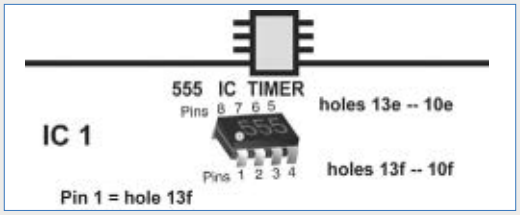
These experiments are provided by GSSTechEd at **www.gssteched.com**

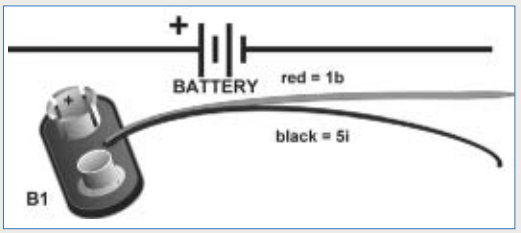
You can order parts for this experiment from their website as follows:

Resistors, 1/2 watt 5%
GK01049 220 ohms (R1)
GK01017 10 ohms (R2)
GK01033 47 ohms (R3)
GK01057 470 ohms (R4)
GK01065 1,000 ohms (R5)
GK01073 2,200 ohms (R6)
GK01077 3,300 ohms (R7)
GK01085 6,800 ohms (R8)
GK01094 16,000 ohms (R9)
GK01101 33,000 ohms (R10)
GK01115 120,000 ohms (R11)

GK02016 0.1 mfd Disc Capacitor
GK35002 Nine volt Battery Snap
GK14004 555 Timer IC
GK27002 1/4" Round 8 ohm Speaker
GK45011 Eight Wires 4" long solid stripped on ends







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

DIP-28, SOIC-28,TQFP-44

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

www.micromegacorp.com

KITS/PLANS

QKITS.COM

50 AMP PWM
1-888-GO 4 KITS

Electronic Kits

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

www.bakatronics.com

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

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

www.nutsvolts.com

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

LIGHTING

HARDWARE WANTED

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

ENERGY SOLUTIONS

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)

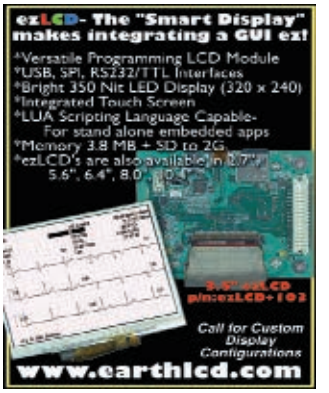
INDICATORS

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.

INTERNET

LCDS



READER-TO-READER TECHFORUM

>>> QUESTIONS

Heart Rate Monitor

I need a circuit that will read a person's heart rate by gripping two electrodes.

I have an "older" treadmill and find the clip-on ear heart rate monitor too unreliable. The newer treadmills use hand grips to measure pulse rate.

The circuit should use readily available components such as a digital voltmeter as a readout device. Also, the cost should be low (there are commercial devices costing over a $100).

#3121 **F. Muratore**
Long Island, NY

Monitoring Thermostat

A programmable thermostat switches a 24 VDC relay to control 240 VAC electric heaters. I would like to know when and for how long the heaters are on and off in a 24 hour time span, although 12 hours would be okay. Is there such a thing as the electronic equivalent of a chart recorder that can display via Windows XP, and be built for less than a small fortune in time and money?

#3122 **Vincent Knoll**
Seattle, WA

Sensor Cable

I'm looking for a cable that sends an input to the PLC when touched. Any suggestions?

#3123 **Brenda**
Denver, CO

Musical Effects Adjustments

I am a musician who uses several stomp boxes to change the sounds of my string musical instruments. Some of these effect units have as many as 80 different modifications available, of which I use only a few. I need an electronic device which will give an output of several different sound wave forms i.e., sine wave, triangle wave, sawtooth, etc., which will give me a constant level to use as I set up the various effects. There should be a meter or other read-out to adjust the level of the input and output so each effect is at the same amplitude. There also needs to be a switch which can select a burst of sound in addition to a constant signal to test the attack and decay of a sound.

#3124 **Ned Kartchner**
via email

>>> ANSWERS

[#1121 - January 2012] Autorangeing DVM Using 7101

I want a small circuit using a microcontroller to convert an analog DVM to an autoranging DVM using a 7107 IC. Or, just explain how to convert the input of a 7107 DVM to an auto-ranging input.

Although it doesn't use a microcontroller, Intersil described a circuit for making an auto-ranging DVM in their Application Note AN046. The URL for the PDF file of this article is **www.intersil.com/data/an/an046.pdf**.

Their basic circuit (Figure 1 in the app note) is for a 7106 DVM chip which is meant to drive an LCD display and run off batteries. A modification of that circuit is required to use a 7107 chip which uses a dual supply instead of a single supply, and has a higher power drain due to the LED display needs. That modification is given at the end of the Intersil article, in the text and in Figure 8. This circuit design utilizes the over-range/under-range states of the DVM chip to trigger the auto-ranging function, so depending on your application it might be of benefit to use an improved DVM chip that incorporates a zero-integrate phase feature to improve the recovery from over-range. Some manufacturers have added zero-integrate phase to their modern versions of the 7107 (e.g., Maxim), but DVM chip versions that explicitly include this improvement include the 7136 chip (sub for the 7106) and the 7137 chip (sub for the 7107). I noticed a couple of minor typos in the Figure 1 circuit of this article. The CD4028 logic chip is mislabeled as CD402T, and both output lines are labeled as over-range ("OR") instead of one line being labeled over-range ("OR") and one being labeled under-range ("UR").

William Braell
via email

[#1123 - January 2012] Multi Output Power Supply

I want to know the simplest solution for this power supply need. My input is 36-75 DC.

I need these outputs:
+-65V @ 70 ma
+5V @ 200 ma
+-15V @ 150 ma

First, you won't find (as far as I can tell) any negative regulators that will take more than -40V input. Indeed, you will have trouble finding ANY regulator (positive or negative) that will take 36 to 75 VDC input.

So, since it appears that you have only +35 to +75 VDC available, I recommend something like the MIC28500 switching regulator (Digi-Key has them; **http://search.digikey.com/us/en/products/MIC28500YJL%20TR/576-3969-2-ND/2764089**

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

Always use common sense and good judgment!

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

— *note that these are surface-mount deals ... sorry!*) to provide something in a voltage range that is easier for other regulators to handle (or you could just use two of those for the five and 6.5 volt outputs, and one for supplying the other regulators — note that one of these things can supply up to four amps!). So, I'd say:

- One MIC28500 for the +5V
- One MIC28500 for the +6.5V
- One MIC28500 supplying +12V (its max output) to the following:

Some sort of switching inverting regulators (like the LT3483 or similar) to convert the +12V to -6.5V, and -15V outputs.

Another switching regulator to boost the 12V to 15V, for example, something like the LM2574N.

If the MIC28500 chips are too expensive, you could just use one to supply +12V and choose other regulators from there (for example, an old run of the mill 7805 or 78L05 for the 5V).

I found all the above regulators by going to **digikey.com** and searching for 'voltage regulator IC.'

On the other hand, you could drop the voltage down to something easier for 'normal' voltage regulator ICs to handle using a resistor and a zener diode. So, you'd have a resistor of proper wattage and resistance in series with a 20V (for example) zener. Allowing for 2A of current (assuming we end up using inefficient linear regulators here, since the load is only 640 mA max) with an input voltage of 80V and an output of 20V, we need to drop 60V in that resistor at 2A, or 120 watts. *Ouch!* That's nuts! So, let's go back to the MIC28500 or similar.

Is there some way of getting a 'nicer' voltage input range beyond regulating it inside this power supply? That is, if you can manage to get the input voltage to a max of 30V, you greatly open up the possibilities for off-the-shelf voltage regulator ICs.

On the other hand, if you don't want to build it, I found that Acopian makes DC-DC supplies that could work — even if you just use one to convert that 36-75 range to something more friendly. The 48C5FT1000 supplies 5V and the 48C15FT400 supplies 15V, but they are pricy; about $188 each. TRC Electronics also makes such things, with various output voltages (**trcelectronics.com**).

Summary:

The options seem to me to be:

1 - Buy an off-the-shelf regulator(s), e.g., Acopian (expensive).

2 - Use some sort of down-regulator (Acopian, TRC, MIC28500, zener(!), etc.) to supply a lower voltage to the various end-user regulators, then have some number (probably five; one for each voltage output) of regulators supplying each output voltage from the step-down intermediate supply. Use inverting switches for the negative; use whatever you feel comfortable with (LM7805, etc) for the + voltages (still somewhat expensive, and now you have to make it work).

Rusty Carruth
Tempe, AZ

[#1129 - January 2012]
Extra Bright Picture/Exit Bulb

I'm looking for help locating or building a super bright exit/picture/display style bulb with an E26 base for my mom.

My 95 year old mother has macular degeneration in both eyes. She still enjoys reading but finds it harder by the day. Her main complaint is that she can't get enough light on the printed page.

I'm asking for help to locate and/or build a bulb with what I know as ultra-bright LEDs. It will throw the equivalent of 200 [fairly cold] incandescent watts of light down onto her page. I'm no engineer, but am handy with a soldering iron and multimeter. Can anyone help me?

I'm reading between the lines here, so I apologize up front if I'm in the wrong universe with my answer.

I see two main approaches (off the top of my head): build an LED illumination thingy from scratch, or buy LED spotlight bulbs off-the-shelf and fabricate whatever you need to get enough light.

Get It Off-The-Shelf

A fairly long search on Google found all sorts of possibilities, if you only want to get some E26 base bulbs and create an array of <n> LED spotlight bulbs to supply the desired light level. If you assume your 200W incandescent bulb puts out something in the neighborhood of 3,000 lumens, then you need about seven or eight 420 lumen spots like the Grainger 3CRA2 (Optiled model 1503050217) which Grainger sells for $45 each. Or, just three 6XWKDs (GE Lighting LED20P38S830/25) which put out 1,050 lumens (at $60 each) would also supply the desired light output.

If you want to go this way, Google is probably your best friend (along with eBay). Use "LED spotlight" or "LED high power" or "LED 20W" (or even "LED e26" which is what I started with).

Build It Yourself

Googling for 20W LEDs, I found **www.hero-ledstore.com/heroled-20w-led-c-2_184.html** with all the parts you'd need to make a 20W LED lamp (but that's gonna run you about $74 and you still need two of them (apparently they are 1,600 lumens each). Interestingly, the parts to make a 50W (4,000 lumen) 'system' are only about $175 — and you'd only need one of those.

There are other options out there, I'm sure, as a Google for "high power LED" returned about 78 million hits. The thing is that you need a constant-current source to feed the LEDs with, not a constant voltage (but with voltage limits, IIRC).

Rusty Carruth
Tempe, AZ

[#2124 - February 2012]
Two AC Switches, One Fan

I have two different bathroom vents going into the same exhaust fan. I want to sense either or both switches to access the main relay to run the fan (kind of like an OR gate which I can make from logic gates for DC).

However, my situation calls for AC switches and fans, and I cannot think of a way without converting to DC to be able to switch the AC (long way around).

Is there a simple solution using two 110 VAC switches to turn on the exhaust fan, and then off when both switches are off?

All that is necessary to make two switches control a single relay for your bathroom fans are two single pole double throw switches. They're very often sold as three-way switches for controlling a lamp with two switches and are readily available at Lowes or Home Depot.

Feed the hot line (the black mains wire) to the common terminal of one of the switches; the two legs of the switches connect to one another — these are called 'traveler' lines. The relay connects between the common of the second switch and the neutral line (white mains wire).

Using the circuit in **Figure 1**, if the relay is energized, then flipping either switch will turn it off. Then with the relay off, flipping either switch will turn it on. It is shown in the on position.

Stan Strom
via email

[#2127 - February 2012]
What's Up With 10- or 12-bit Scopes?

Why is it such a problem for "stand-alone" scope manufacturers to use 10- or 12-bit A/D converters?

I have seen a few PC-based 10-bit units and a 12-bit one, as well. (They do it.)

There is a flood of inexpensive scopes even at the 200 MHz range (with all kinds of bells and whistles).

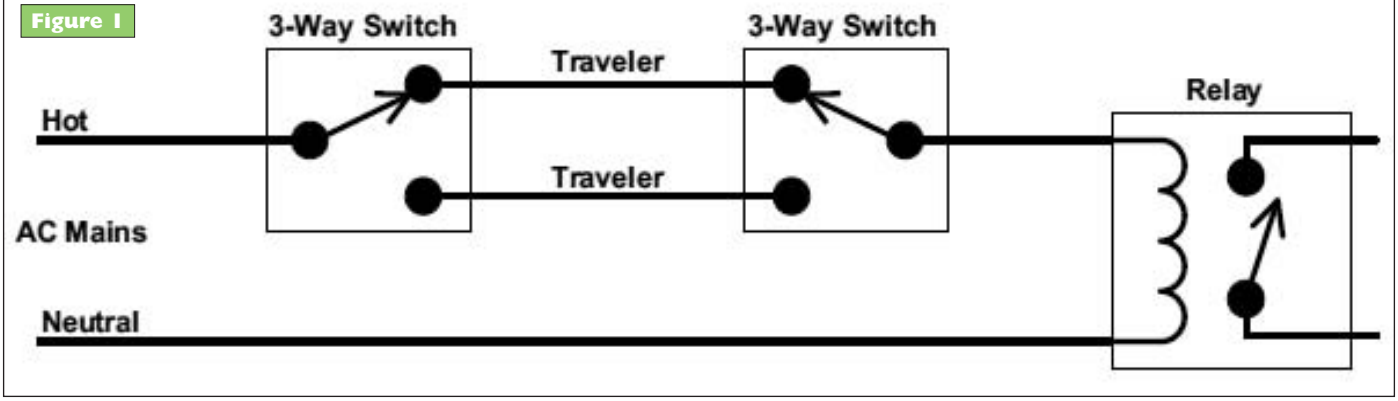
No way will I even consider upgrading my 20 MHz, eight-bit scope until I get more vertical resolution.

Any thoughts?

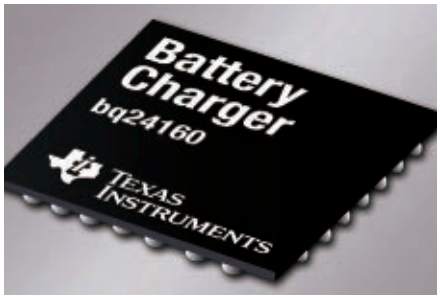
There is a digital oscilloscope from Yokogawa that might fill your needs. The DL850 ScopeCorder will sample at 20 MHz with a 12-bit resolution. Since this is a modular instrument, you will need to select the components to fit your needs. See **www.scopecorder.net**.

Lance Corey
via email

Figure 1



Continued from page 51



rates up to 2.5A (10.5W) from IN input, and 1.5A from USB input. Dual source inputs, AC adapter, and USB 2.0/3.0 compatibility provide flexibility in design and applications. A D+/D- auto adapter for USB input eases system design and reduces external components; 20V input with 10.5V over voltage protection supports low cost unregulated adapters and poor USB sources. An integrated power path allows system startup from deeply discharged or no battery power operating conditions. BC1.2 compliance, JEITA charging support, and thermal regulation protection help to provide safe and accurate battery operation. The bq24160/ bq24161/ bq24163/ bq24168 are highly integrated single cell Li-Ion battery charger and system power path management devices targeted for space-limited, portable applications with high capacity batteries. The two inputs are fully isolated from each other and are easily selectable using the I²C interface. The power path management feature allows the bq2416x to power the system from a high efficiency DC-to-DC converter while simultaneously and independently charging the battery. The charger monitors the battery current at all times and reduces the charge current when the system load requires current above the input current limit.

For more information, contact:
Texas Instruments Inc.
Web: **www.ti.com**

■ LOOK FOR ■ SEARCH FOR ■ FIND

Find your favorite advertisers here!

ADvertiser INDEX

AMATEUR RADIO AND TV
NightFire Electronics 49
Ramsey Electronics, Inc. 20-21
V-Module 48

AUTOMOTIVE
RockAuto LLC. 27

BATTERIES/CHARGERS
Cunard Associates 29

BUYING ELECTRONIC SURPLUS
Earth Computer Technologies 27
Jaycar Electronics 57
RockAuto LLC. 27
Weirdstuff Warehouse 29

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

CIRCUIT BOARDS
AP Circuits 36
Cunard Associates 29
Dimension Engineering 49
ExpressPCB 19
Front Panel Express LLC 37
PCB Pool 64
R.E. Smith Inc. 37
Saelig Company Inc. 64
V-Module 48

COMPONENTS
Cana Kit Corp. 75
Electronix Express 13
Fun Gizmos 29
NightFire Electronics 49
Noritake 18
V-Module 48

COMPUTER
Hardware
Earth Computer Technologies 27
Noritake 18
Weirdstuff Warehouse 29

Microcontrollers / I/O Boards
Abacom Technologies 8
Bitscope 43
Fun Gizmos 29
I/O Bridge 48
microEngineering Labs 13
MikroElektronika 3
Parallax, Inc. ..... Back Cover
Pololu Robotics & Electronics 5

DESIGN/ENGINEERING/ REPAIR SERVICES
Cana Kit Corp. 75
ExpressPCB 19
Front Panel Express LLC 37
PCB Pool 64
RockAuto LLC. 27

DIGITAL OSCILLOSCOPES
Rigol Technologies 29

EDUCATION
BaneBots 9
Bitscope 43
Command Productions 9
Global Specialties 7
GSS Tech Ed 79
I/O Bridge 48
NKC Electronics 29
Poscope 51

EMBEDDED TOOLS
NetBurner 2

ENCLOSURES
Front Panel Express LLC 37

EVENTS
Trenton Computer Show 56

KITS & PLANS
Cana Kit Corp. 75
Earth Computer Technologies 27
GSS Tech Ed 79
Jaycar Electronics 57
NetBurner 2
NightFire Electronics 49
NKC Electronics 29
QKITS 29
Ramsey Electronics, Inc. 20-21

MISC./SURPLUS
All Electronics Corp. 4
Front Panel Express LLC 37
Weirdstuff Warehouse 29

MOTORS
BaneBots 9

OPTICS
Noritake 18

PROTOTYPING & TRAINERS
Global Specialties 7

PROGRAMMERS
microEngineering Labs 13
MikroElektronika 3

RF TRANSMITTERS/RECEIVERS
Abacom Technologies 8

ROBOTICS
BaneBots 9
Fun Gizmos 29
GSS Tech Ed 79
Lemos International Co., Inc. 29
Lynxmotion, Inc. 37
Pololu Robotics & Electronics 5
Robot Power 29

SATELLITE
Lemos International Co., Inc. 29

TEST EQUIPMENT
Bitscope 43
Circuit Specialists, Inc. 82-83
Dimension Engineering 49
Global Specialties 7
Jaycar Electronics 57
NKC Electronics 29
Pico Technology 49
Poscope 51
Rigol Technologies 29
Saelig Company Inc. 64

TOOLS
MikroElektronika 3
NetBurner 2
PanaVise 36
Poscope 51

WAVEFORM GENERATORS
Rigol Technologies 29

WEB SERVICES
I/O Bridge 48

Abacom Technologies 8
All Electronics Corp. 4
AP Circuits 36
BaneBots 9
Bitscope 43
Cana Kit Corp. 75
Circuit Specialists, Inc. 82-83
Command Productions 9
Cunard Associates 29
Dimension Engineering 49
Earth Computer Technologies 27
Electronix Express 13
ExpressPCB 19
Front Panel Express LLC 37
Fun Gizmos 29
Global Specialties 7
GSS Tech Ed 79
I/O Bridge 48
Jaycar Electronics 57
Lemos International Co., Inc. 29
Lynxmotion, Inc. 37
microEngineering Labs 13
MikroElektronika 3
NetBurner 2
NightFire Electronics 49
NKC Electronics 29
Noritake 18
PanaVise 36
Parallax, Inc. ..... Back Cover
PCB Pool 64
Pico Technology 49
Pololu Robotics & Electronics 5
Poscope 51
QKITS 29
Ramsey Electronics, Inc. 20-21
R.E. Smith Inc. 37
Rigol Technologies 29
Robot Power 29
RockAuto LLC 27
Saelig Company Inc. 64
Trenton Computer Show 56
V-Module 48
Weirdstuff Warehouse 29

Programmable DC Electronic Load
0~80V / 0~40A

The 3721A Programmable DC Electronic Load provides excellent performance with sophisticated features found on much more expensive units. This 400 watt, 40 Amp, 0~80 volt Programmable DC Electric Load can be used to test all sorts of DC power sources including power supplies and is especially helpful to battery manufacturing processes. This DC load features constant voltage, constant resistance, constant current and constant power settings. The end user can design programs that control precisely all of the load values and time durations for each step of a test sequence. Up to nine 10 step programs can be internally stored in the 3721A Programmable DC Load.

4 basic functions: CC, CV, CR & CP

8 basic test modes: CCL, CCH, CV, CRL, CRM, CRH, CPV & CPC

Minimum operating voltage is less than 0.6v at the load's full rated current.

High-speed sequence, high-speed transient, short circuit, battery discharge and other functions.

Programable current slew rate.

Multiple groups of parameters and lists can be saved & recalled.

Supports SCPI and LabView with included software.

Current Rating: 0~40A

Voltage Rating: 0~80V

Power Rating: 400W at 40°C

Item#
CSI3721A **$720.00**

www.CircuitSpecialists.com/CSI3721A

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

60 Watt Digital Soldering Stations

For use with traditional or Lead Free Soldering

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. 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.Also included is a seperate iron holder. Circuit Specialists stocks a large supply of tips for this station.

Features:

* 60 watt dual core ceramic heater
* 150 to 450 degree Celsius Temperature range
* 302 to 896 degree Fahrenheit Temperature range
* Versatile easy to read liquid crystal display
* 3 preset & user definable temperature settings.
* Automaticly remembers previous temperature setting
* Display in Celsius or Fahrenheit scale
* 3 foot cord length from station to iron tip
* Broad selection of replacement tips available

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

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

Here is another 60 Watt soldering iron at a price that can't be beat. This is the "little brother" of our overwhelmingly popular CSI-STATION-3DLF except we have removed the Digital Display & Digital controls. But at 60 watts of power, this unit heats up extremely fast and is suitable for soldering lead free solder or traditional solder containing lead. The analog control knob is calibrated in Celsius (200deg to 480 deg) & Fahrenheit (392 deg to 896 deg). A front panel led lights when the system is heating up and a front panel calibration port is also available. Circuit Specialists stocks replacement soldering handles & a large selection of tips for this model. It may be viewed in greater detail at our web site.

Features:

* 60 watt dual core ceramic heater
* 200 to 450 degree Celsius Temperature range
* 392 to 896 degree Fahrenheit Temperature range
* 3 foot cord length from station to iron tip
* Broad selection of replacement tips available

Item#
CSI-Station-60W **$37.95**

www.CircuitSpecialists.com/CSI-Station-60W

BlackJack SolderWerks BK3050 Solder Pot

The BlackJack SolderWerks BK3050 Solder Pot is a durable, general purpose solder pot. It is an appropriate selection for traditional solder containing lead and also for lead free solder. This solder pot implements high power Infra Red (IR) heating technology for fast heat up and stable temperatures. There is an external sensor that feeds back actual temperature for precise temperature control.

Item#
BK3050 **$199.00**

www.CircuitSpecialists.com/BK3050

Helping Hand with cast iron base
ZD-10F
$3.19

Magnifer, Helping Hand & Soldering Stand
ZD-10G
$4.25

56 LED Table Lamp with Glass Magnifer Lens
ZD-129LED
$39.95

Magnifying Table Lamp with 22Watt Circular Florescent Light
8066D-1C
$29.99

3.0 Diopter Magnifier with Helping Hand
ZD-10H
$7.95

Helping Hand, Magnifier with LED Light and Soldering Stand
ZD-10M
$8.99

Soldering Iron Tip Cleaner with stand
TY-88
$4.95

De-soldering pump, full sized Powerful ESD design
ZD108K
$5.99

6 Piece Solder Aid Kit (Brush, Scraper, Knife, Hook, Fork, Spike)
ZD151
$3.66

www.CircuitSpecialists.com/soldering-tools

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

www.CircuitSpecialists.com

Best Value, Low Cost Station

CSI-Station1A

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

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

Item#
CSI-STATION1A **$29.95**

www.circuitspecialists.com/csi-station1a

1500 Watt Hot Air Gun for heat shrink tubing

Comes with FREE 154pc assortment of heat shrink tubing in a handy case.

1/16" 56 pcs
3/32" 35 pcs
1/8" 28 pcs
3/16" 18 pcs
1/4" 9 pcs
3/8" 8 pcs

An $8.95 Value!

The ZD509 is a 1500 Watt Hot Air Gun that is ideal for use with Heat Shrink Tubing or Packaging Film. Ideal for shrinking Circuit Specialists heat shrink tubing.

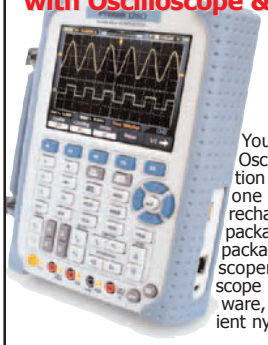
Features of the ZD509 Heat Gun:

* 1500 watts of power
* Rotating variable temperature control feature (on rear of body)
* 100 deg C- 550 deg C
* Air flow: 200-450 L/min
* CE approved
* Air flow concentrator attachment included
* Low setting provides approx 200 deg C & draws approx 800 watts
* High setting provides approx 500 deg C & draws approx 1500 watts

ZD509 $20.95

www.CircuitSpecialists.com/ZD509

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**

Hantek 5000B Series Digital Storage Oscilloscopes

Introducing the Hantek 5000B Series Digital Storage Oscilloscopes. Available in 60MHz, 100MHz and 200MHz Bandwidths. Each one provides real-time sample rates up to 1GSa/s and equivalent sample rates up to 25GSa/s. In addition, they have a maximum 1M memory depth for better observation of waveform details. The 7 inch color TFT LCD Display with Windows-style interface and menus provide easy operation.

Abundant menu information and easy-to-use buttons give you plenty of measurement information:

The multifunctional knobs and the powerful shortcut keys help save time during operation.

The Autoset function lets you detect sine and square waves automatically.

The Probe Check Wizard guides you to adjust the probecompensation and set the Probe option attenuation factor.

Three help methods (context-sensitive, hyperlinks, and an index).

You can quickly master all functions to greatly improve your efficiency in production and development.

Features:
- 60, 100 or 200 MHz bandwidth
- 1GSa/s Real Time sample rate
- 25GSa/s Equivalent sample rate
- Large (7.0-inch) color display,WVGA(800x480)
- Record length up to 1M
- Trigger modes: edge/pulse width/line selectable video/slop/overtime etc.
- USB host and device connectivity, standard
- Multiple automatic measurements
- Four math functions, including FFTs standard
- Provides software for PC real-time analysis

3 Models to choose from

DSO5062B
60MHz Digital Storage Oscilloscope
$385.00

www.circuitspecialists.com/dso5062b.html

DSO5102B
100MHz Digital Storage Oscilloscope
$499.00

www.circuitspecialists.com/dso5102b.html

DSO5202B
200MHz Digital Storage Oscilloscope
$599.00

www.circuitspecialists.com/dso5202b.html

Outfit your classroom with Activity Kits!

Save big on our most popular BASIC Stamp starter kit!

Bring your inventions to life with the BASIC Stamp Activity Kit! This beginner's tool kit includes everything you need to get started with electronics and microcontroller programming, following step-by-step instructions in the friendly 350-page *What's a Microcontroller?* text. Side-by-side schematics and wiring diagrams give you confidence in building the circuits. Each example program is followed by a detailed explanation, so you learn as you go.

Through 40 hands-on activities, you will:

- Build circuits on a breadboard
- Write programs in PBASIC to control the circuits
- Send signals by blinking LEDs
- Sense contact with pushbuttons
- Read a dial using a potentiometer
- Measure brightness with a light sensor
- Play tunes on a piezo speaker
- Display data on a 7-segment LED
- Combine several circuits and prototype an invention

~~$69.99~~ **$39.99 each**

BASIC Stamp Activity Kit - Serial

- Text version 2.2
- USB to Serial Adapter not included

Order #90010

Save even more with STEM classroom packs for your school or organization:

- **10-pack for $360.00**
- **20-pack for $680.00**

~~$79.99~~ **$49.99 each**

BASIC Stamp Activity Kit - Serial + USB

- Text version 3.0
- USB to Serial Adapter included

Order #90005

Save even more with STEM classroom packs for your school or organization:

- **10-pack for $450.00**
- **20-pack for $800.00**

For easy projects, videos, and code examples with Parallax sensors and accessories:

- http://www.parallax.com/go/WAM
- http://sites.google.com/site/parallaxinretailstores/

More at **www.parallax.com/go/ActivityKit**
Order online or call us toll-free at 888-512-1024 (M-F, 8 AM-5PM, PT).

Friendly microcontrollers, legendary resources.™

Prices subject to change without notice. Parallax and the Parallax logo are trademarks of Parallax Inc.

PARALLAX INC
www.parallax.com
"ParallaxInc" on Twitter, Facebook, and YouTube