

■ PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

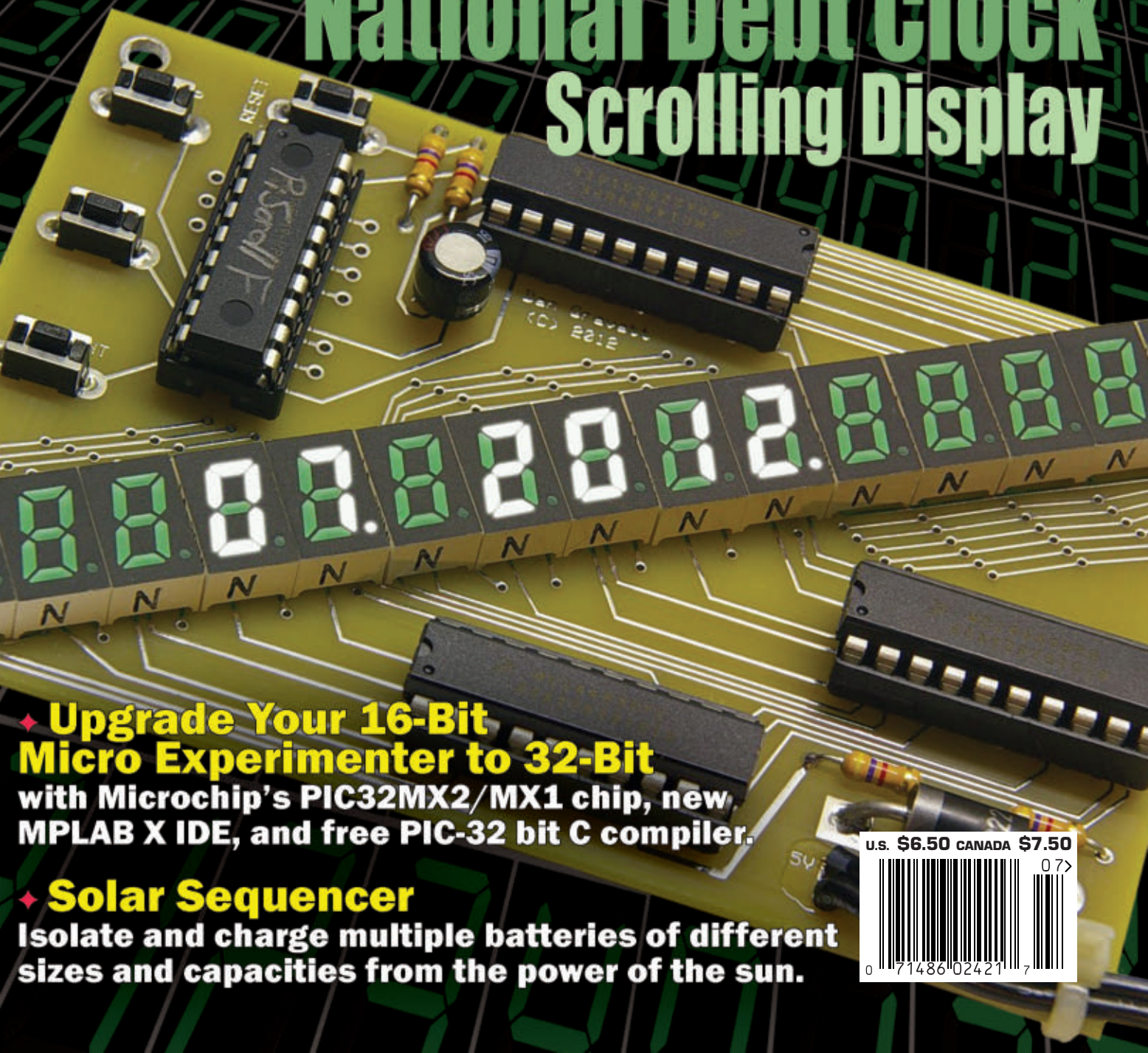
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July 2012

EVERYTHING FOR ELECTRONICS

Build A Desktop National Debt Clock Scrolling Display



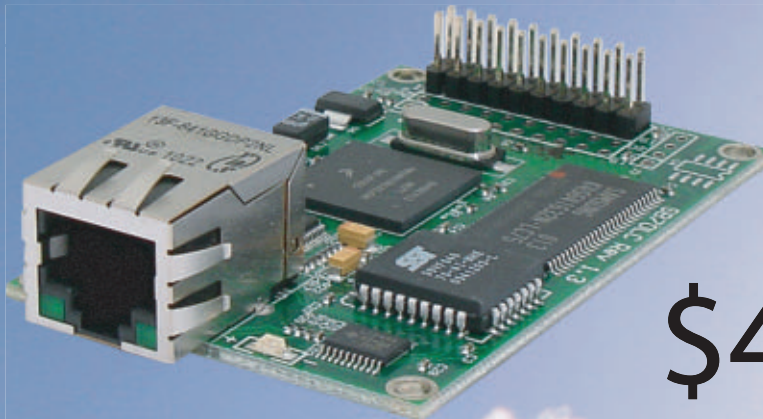
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The SB70_{LC} Development Kit

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Development Kit Part Number | NNDK-SB70LC-KIT
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Nifty fuse by Bourns type MF-R185 (commonly used in car circuitry, RVs, etc) is rated 30V. This fuse trips at 3.7A and then resets automatically when the "short" is removed. Hold current is 1.85A. These really work great and are interesting to experiment with. These look like a disc cap and are about 0.4" diameter x 0.06" thick with 1" long leads. Pricing is typically about 40¢ each. On tape and reel.



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Our best gear assortment contains 25 various gears from small to large sizes with various pitches, shapes, and teeth counts. Great for experimenting or use in robotics. Plastic and metal types. Some may have very unusual shapes!



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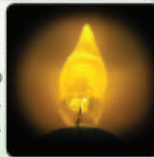


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"Flickering Candle" Yellow LED with Lens

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Stock# C17848

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Stock# C7541

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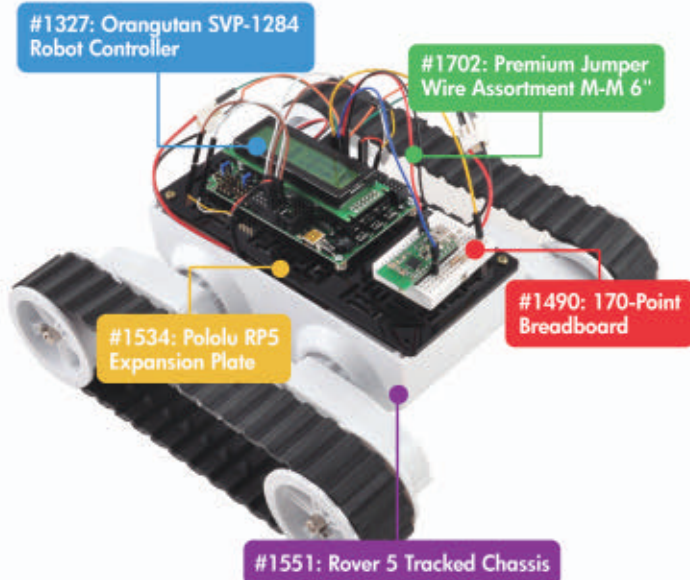


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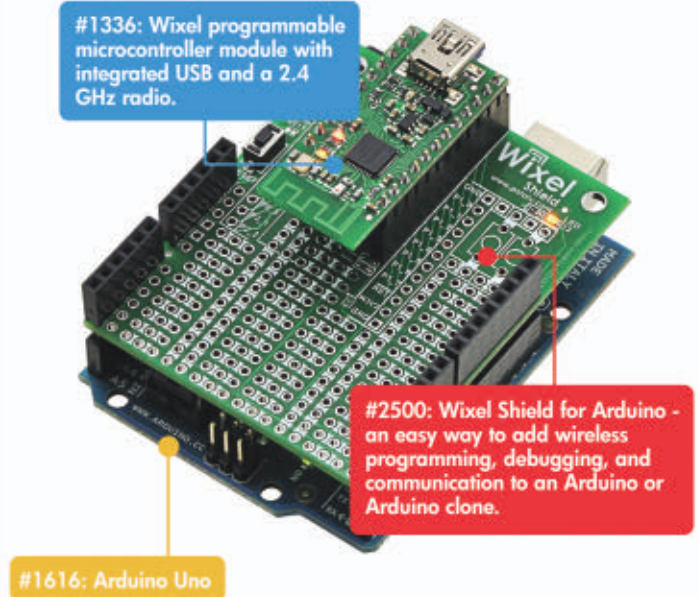
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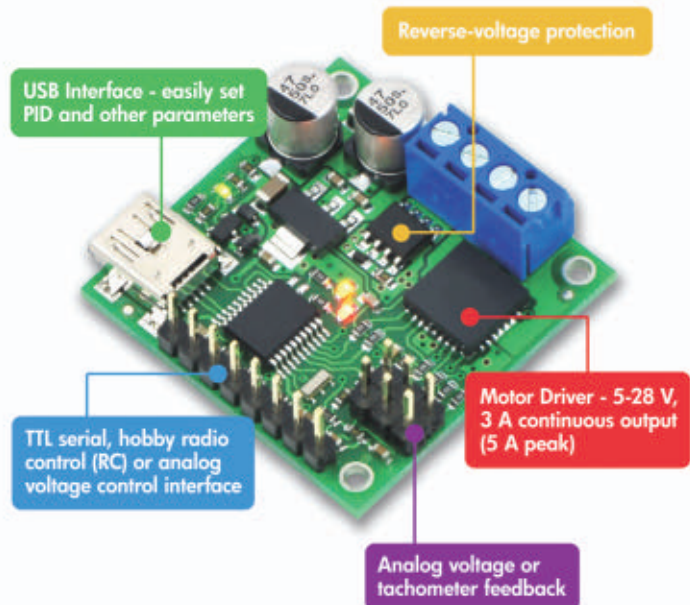
DIY Projects: Simple Tracked Robot



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



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Projects & Features



Page 31

31 Build the Solar Sequencer

This innovative system lets you charge multiple batteries of different sizes and capacities while keeping them isolated from each other ... all from the power of the sun.

■ By John Guyer

36 Build the Pi Scrolling Display

This versatile display lets you have your pi and see it, too! With 15 available digits, you can also use it to create your own desktop National Debt clock. (Of course, that may make you lose your appetite.)

■ By Dan Gravatt

42 Streamline Your Home Studio With a Sound Card Switcher

Get to the business of making music instead of messing with cords with this extremely useful and simple device. Makes a great beginner's project too!

■ By Thomas Henry

46 Upgrade Your 16-bit Micro Experimenter to 32-bit for 16x2 Processing Power

With Microchip's PIC32MX2/MX1 chip and the new MPLAB X IDE and free PIC32-bit C compiler, you can easily transition your 16-bit Experimenter to 32-bit processing.

■ By Thomas Kibalo

Columns

10 TechKnowledge 2012

Events, Advances, and News

Read about the world's largest digital camera, gigabit Wi-Fi, digital drinking, and the death of an industry pioneer ... plus some other interesting stuff.

14 The Spin Zone

Adventures in Propeller Programming

Track 'em Danno!

22 Q & A

Reader Questions Answered Here

Answers to questions on three-phase motor control, digital clocks, and multi-input A/V switches are some of the topics covered this month.

54 Smiley's Workshop

Programming • Hardware • Projects

It's About Time.

68 Near Space

Approaching the Final Frontier

A New BalloonSat Airframe Design.



Page 10

Departments

08	DEVELOPING PERSPECTIVES	64	NV WEBSTORE
09	READER FEEDBACK	67	ELECTRO-NET
28	NEW PRODUCTS	77	CLASSIFIEDS
30	SHOWCASE	78	TECH FORUM
		81	AD INDEX

FUNDamentals For Beginners

76 Build a Screaming Box

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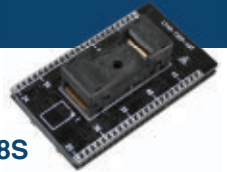
GSPA SOP-8B

8-Pin SOP to Through - Hole Prototyping Adapter



GSPA TSOP-48S

48-Pin TSOP to Through - Hole Prototyping Adapter



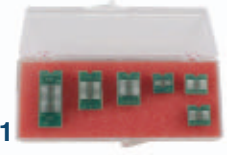
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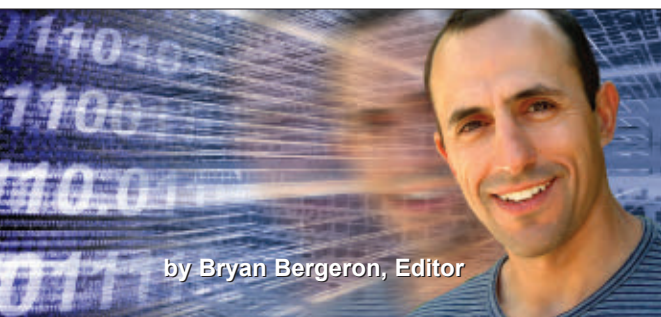
RDB-10 Resistance Decade Box

A compact, convenient tool for aiding in engineering design and testing as well as calibration of test equipment.



PRO-S Lab

Breadboard with External Power & Jumper Wires



by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

When Less is More: Designing for Minimum Mass

If you're a typical N&V reader, then sizing a component means defining its value, precision, power handling capacity, operating voltage, physical size, and precision. Take a typical carbon film resistor listed in the Mouser catalog (www.mouser.com) — a 2K ohm 1/4W 5% tolerance with axial leads. Although you may not have noticed in the past, if you download the full datasheet, you'll see that the mass is about 226 mg per resistor. Now, go to the equivalent SMT resistor. You'll see mass listings from 2-16 mg, depending on SMT size.

To be fair, the mass of the axial resistor includes the full lead, but we're still talking at least an order of magnitude difference in mass. If you look carefully at the datasheet for most components, you'll find the

mass values. Unfortunately, most parts search engines don't allow you to compare component mass.

Why does this matter? Because there are situations where mass really makes a difference. Take micro R/C work, such as my in-progress micro-quadcopter. Every gram saved translates directly to greater maneuverability, longer flight time, and the ability to provide more functionality in the same space. As such, SMT components rule.

So, if you're planning a move to the micro world, what are some additional means of shaving weight? Second to component selection on my list is mechanical connectors. Substitute nylon nuts, bolts, and washers for your sturdy (but massive) stainless steel hardware. Just make certain you're within the safety limits of the holding capacity of the nylon hardware. (See my previous editorial on where to find specs on hardware.)

My third-tier approach is to

minimize or discard all electrical connectors. Use micro-connectors instead of full-sized ones. For example, I'm a fan of the JST connector for all of my power connections. SparkFun (www.sparkfun.com) sells these little gems which are rated at 100V at 2A AC/DC for \$1. These connectors save space, as well as mass. Unfortunately, the datasheet doesn't list the mass, but it's essentially zero compared with typical Molex power connectors.

Related to minimizing connector mass, I also work to minimize the mass contribution of wiring. This means using a PCB tracing instead of wire when possible. Short of that, I use my lookup table of wire gauge vs. maximum handling current. For most of my short runs, I've found that 36 gauge wire-wrap wire works for all of my signal level needs. I sometimes double-up on power runs, using two 36 gauge wires in parallel to handle modest 5V demands — especially when powering a few ICs. Motors and other heavy draw devices get the usual treatment.

My last tactic for minimizing the mass footprint of a device is to modify or replace the supporting structure. For example, I use an electric drill to pepper holes into aluminum sheet metal. When that isn't feasible, I sometimes replace metal with plastic or even carbon fiber, depending on the application. I recently replaced the aluminum spars on my UAV prototype with carbon fiber tubing for a mass reduction of about 10% in the overall structure. Carbon fiber tubing isn't terribly expensive, but be sure to use a composition that provides adequate strength and stiffness. Aluminum tubing often bends when overstressed; graphite tends to shatter. My favorite source for

Sabertooth 2x60
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graphite and other exotic lightweight building materials is Kite Builder (www.kitebuilder.com). Make sure to check out their chart of weight vs. relative stiffness for their products. Another source for lightweight components, connectors, and 4-40 nylon hardware in bulk is Tower Hobbies (www.towerhobbies.com). They're also a good source for R/C airplanes and helicopters — great subjects for teardowns to learn about designing for minimum weight.

Good luck with your own weight loss program. **NV**

READER FEEDBACK

Consistent Color Coding

Bryan Bergeron's perspective on color coding got my attention. I tend to do the same thing documenting my stuff, not that I build much right now. However, I wanted to give a little info as to why bombs are color coded the same way every time.

This was learned — the hard way — during WW II. The Germans — who are very methodical — taught the rest of us that if we do not want to blow ourselves up with our own bombs when we have to defuse them, to ALWAYS color code the connections/wires the same. ALWAYS.

The quoted life expectancy in Britain during WW II for the men who defused unexploded bombs from German planes was six weeks. They

lost at least one man on almost every new bomb that was defused. The guy would be yelling which wire he was cutting before he did it so it could be documented before he died because it was highly probable that he'd cut the wrong wire in an unknown situation. Even with the "known" bombs, situations weren't always safe.

So, the bottom line is if you are planning on making more than one of the items that can kill you if you do something wrong, then ALWAYS color code your control wires the same. ALWAYS. This holds true for any device being built now. If you're making more than one, do all the wire color coding the same. It's much easier to troubleshoot that way.

73 de ke3fl,
Phil

Continued on page 53

The Standard for checking Capacitors in-circuit



Good enough to be the choice of Panasonic, Pioneer, NBC, ABC, Ford, JVC, NASA and thousands of independent service technicians.

Inexpensive enough to pay for itself in just one day's repairs. At \$229, it's affordable.

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Still cutting up the pcb, and unsoldering every part trying to guess at where the short is?

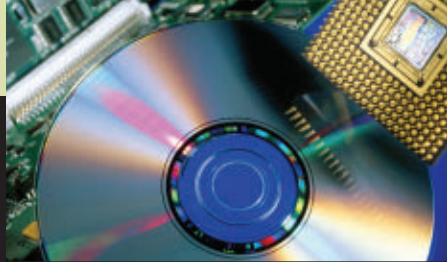
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Your DVM shows the same shorted reading all along the pcb trace. LeakSeeker 82B has the resolution to find the defective component. Touch pads along the trace, and LeakSeeker beeps highest in pitch at the defect's pad. Now you can locate a shorted part only a quarter of an inch away from a good part. Short can be from 0 to 150 ohms.

LeakSeeker 82B

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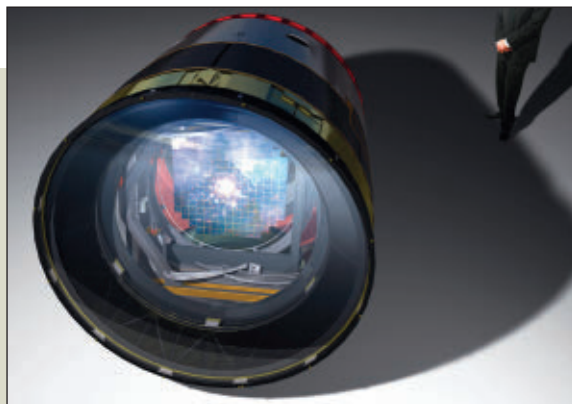
■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

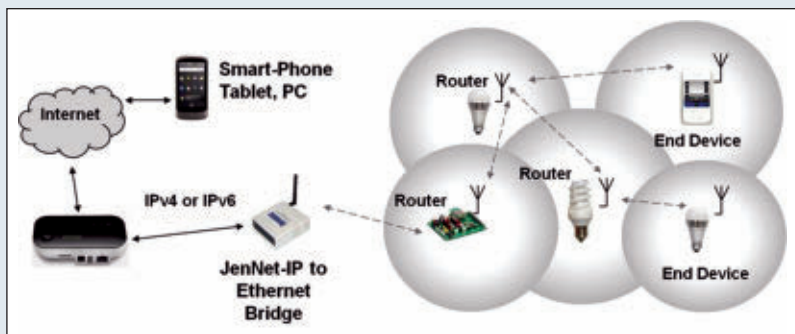
WORLD'S LARGEST DIGITAL CAMERA

The Large Synoptic Survey Telescope is still in the design and development phase, and full implementation is several years away. However, the goal is to build a facility in northern Chile that will photograph the entire sky every week via a wide-field reflecting telescope, capturing "the widest, fastest, and deepest view of the night sky ever observed." According to a project press release, "Its deep and frequent cosmic vistas will help answer critical questions about the nature of dark energy and dark matter, and aid studies of near-Earth asteroids, Kuiper belt objects, the structure of our galaxy, and many other areas of astronomy and fundamental physics."

At the facility's heart will be an advanced digital camera designed at the SLAC National Accelerator Lab (www.slac.stanford.edu) in Menlo Park, CA. The device isn't exactly your typical Canon Sure Shot, as it will be about the size of an average automobile and weigh about three tons. The detector will be made up of a mosaic of 16 Mpixel detectors providing a total of about 3.2 Gpixels. This translates into about six million gigabytes of data per year, which is going to take some pretty serious storage capacity. The camera recently was granted "Critical Decision 1" approval by the DOE which means that the LSST project can move to the engineering design, schedule, and budget phase. If all continues as planned, construction on the telescope will begin in 2014. To follow its progress, visit www.lsst.org. ▲



■ The LSST camera measures approx. 1.6×3 m (5×10 ft) and can capture 3.2 billion pixels. *Courtesy of LSST Corp.*



■ Diagram of a JenNet-IP wireless cluster.

CONTROL EVERYTHING FROM YOUR SMARTPHONE

Back in 1999, RFID guru Kevin Ashton coined the term "Internet of Things (IoT)." The concept basically refers to a world in which virtually everything we use on a daily basis has its own Internet address and at least can be tracked and — in many cases — controlled from afar. A decade ago, it seemed like a rather futuristic and complicated concept. But hang on to your hat, because it's coming at us very quickly. One

implementation takes the form of the JenNet-IP network software layer, originally developed by Jennic Ltd. JenNet-IP — based on the 6LoWPAN standard — is fully IPv6 compliant and makes it possible to establish two-way communication and control to a network of up to 500 devices, ranging from light bulbs to air conditioning systems in the home.

Two years ago, the company was acquired by NXP Semiconductors (www.nxp.com), formerly known as Philips Semiconductors. Not so coincidentally, NXP is a world leader in chip sets for near-field communication and energy management, so there is a logical pairing of its GreenChip technology and smart lighting. Later this year, the company plans to launch a certification program for JenNet-IP and "announce its roadmap for the open source release of JenNet-IP, as well as the retail availability of the first Internet-enabled lamps." What comes after smart bulbs? One can only imagine. A white paper published by Cisco predicts that 50 billion devices will be connected to the Internet by 2020 — more than six times the expected world population. According to Cisco, "As cows, water pipes, people, and even shoes, trees, and animals become connected to IoT, the world has the potential to become a better place." To download the paper, just aim your browser at www.jkeckert.com/iot.pdf. ▲

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

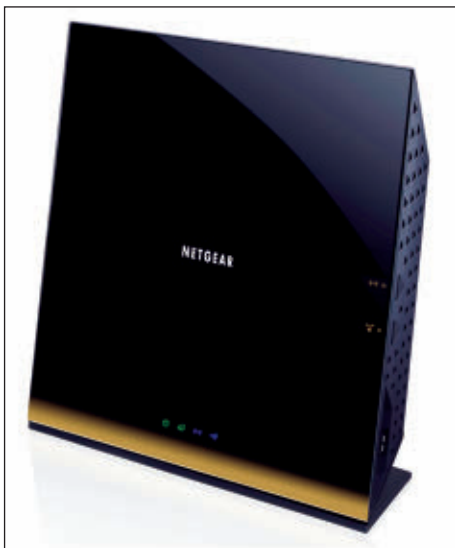
COMPUTERS AND NETWORKING

TABLETS OFFER DISPLAYS UP TO 13 INCHES

The latest news in the tablet market is Toshiba's trio of Android-powered devices, offering a choice of three display sizes: 7.7, 10.1, and 13.3 inches. All feature aluminum shells, Gorilla Glass displays, and NVIDIA Tegra 3 quadcore processors. Each is equipped with a 5 Mpixel camera on the back plus a 2 Mpixel front-facing one for video capture and chatting. You also get stereo speakers, as well as built-in Wi-Fi and Bluetooth connectivity. Even with the oversized display, the Excite 13 is only 0.4 inches thick and weighs 2.2 lb, making it less painful to carry around than one might expect. The 13.3 inch diagonal AutoBrite™ LED Backlit display offers 10-finger touch support, a cinematic 16:9 aspect ratio, and 1600 x 900 resolution, making it suitable for watching HD movies and videos. All come with a suite of Google™ Mobile Service applications, including Google Play™, YouTube™, Gmail™, and Google Maps™. MSRP's run from \$499 for the bottom shelf 16 GB, 7.7 in model to \$749 for a 64 GB, 13 in one. You can pick one up at a local retailer or from www.toshibadirect.com. ▲



■ Toshiba's Excite 13 has the largest tablet display on the market.



GIGABIT WI-FI ARRIVES

The IEEE is still working on the new 802.11ac Wi-Fi standard, but there is an old saying that "the IEEE publishes standards in writing only after someone else has published them in hardware." This seems to be the case with the R6300 router from Netgear (www.netgear.com) which is the first unit to comply with the 802.11ac specs. This configuration — based on Broadcom's 5GWiFi chips — embraces several enhancements over the common 802.11n standard, allowing data to zip along at up to 1.3 Gbps. Basically, this is because the new standard uses the 5 GHz radio band which offers an 80 MHz bandwidth and more channels than the old 2.4 GHz band. However, the R6300 is a dual-band device, backward-compatible with 802.11a/b/g/n technology, and will still deliver 450 Mbps in the 2.4 GHz band. The company believes that the unit is particularly advantageous with mobile devices, as it allows web content to download faster, and large video and music files to synch more quickly. It should be available by the time you read this, with a retail price of \$199.99. ▲

■ Netgear's R6300 router provides data transfer rates up to three times as fast as existing 802.11n units.

WEB-BASED FINANCIAL ADVICE

If the world of finance makes you feel like the proverbial stranger in a strange land, you aren't alone. It can be daunting to understand the details of 401(k) accounts, mortgages, budgets, and so forth. If you need a little help in achieving your financial goals, a good place to start might be YoBucko (www.yobucko.com) — a website billed simply as "your personal finance guide." YoBucko offers articles, videos, and calculators geared toward stepping you through such topics as investing, education, identity theft, car buying, insurance, taxes, and others. The site is the brainchild of Eric Bell, a former investment analyst at the Citi Private Bank. He is backed by half a dozen other financial professionals. In addition to receiving assistance online, you can sign up for a monthly newsletter that "helps you learn how to save money, pay off debt, and build wealth." Best of all, it's free, so drop in and get started. You'll have that 1987 Yugo paid off in no time. ▲

CIRCUITS AND DEVICES

HIGH-PERFORMANCE SURVEILLANCE CAMERA

It's not unusual to see surveillance cameras installed in businesses, schools, government facilities, and other locations that require 24/7 security. However, as we often see in news reports, conventional low light surveillance and security cameras often produce less than stellar images — particularly under adverse weather conditions. One solution is the WatchMaster® IP Elite infrared camera offered by DRS Technologies. According to the company, "The WatchMaster IP Elite detects infrared (heat) waves instead of visible light, allowing it to display a sharp 320 x 240 pixel image through haze, dust, smoke, light fog, and dark of night, conditions that severely limit performance of alternative imaging systems in low light, and other challenging environments. RSTA's infrared technology clearly displays potential threats that would be difficult or impossible to detect with conventional cameras." Traditionally, IR cameras have been too expensive for widespread implementation, but the new DRS model lists at \$1,999 for the 40° field of view model, bringing it closer to the price range of conventional low light cameras. The WatchMaster is a fixed-mount, fixed-focus model that conforms to the Open Network Video Interface Forum (ONVIF) standard, so it is compatible with a range of existing security products. The camera supports power over Ethernet (PoE) and consumes less than 15W while running video, camera control, and power over a single tamper-resistant cable connection. For more details, visit www.drsinfrared.com. ▲



■ The WatchMaster IP Elite camera provides IR surveillance in adverse conditions.



■ The USB shot glass holds 1 GB of data and a snort of booze.

DIGITAL DRINKING?

If you like to sit at your computer and get drunk at the same time (and who doesn't?), Ali Spagnola has a deal for you. (It isn't totally clear who Ali is, but on her Facebook page — www.facebook.com/alispagnola — it says, "Ali Spagnola makes pop art and art pop. She is a drinking composer with a music problem." What Ali has for you is a USB shot glass drive that simultaneously holds 1 GB of data and a couple ounces of your favorite source of inebriation. A nice feature is that the thing is on a lanyard, so if you fall down, you are unlikely to suffer any data loss. But that's not all.

Included on the drive is an album of 60 original one minute songs, performed by Ali herself. The playlist includes such gems as "Drinking with a Helmet," "Sandwich in a Can," and "Build a Beeramid." The concept is that you get some friends together (after all, it's not right to drink alone), listen to the album, and drink a shot of beer with every tune, thereby creating a "power hour." All you have to do to get started is visit www.powerhouralbum.com and shell out a mere \$29.99. Beer not included. ▲

INDUSTRY AND THE PROFESSION


RIP JACK TRAMIEL

Those of us who were here during the dawning of the PC age no doubt felt regret at the recent passing of Jack Tramiel at age 83. Jack was the computer pioneer who ran Commodore International which produced the Commodore VIC-20 — a primitive little \$300 machine with only 3,583 bytes of usable RAM. In 1982, the VIC-20 became the first computer of any kind to pass the one million sales mark. The company later created the more powerful Commodore 64, of which several million were sold.


All of this is common knowledge, but what many people do not know about Jack is that he was born in Poland as Idek Trzmiel. In 1939 at the age of 11, he and his family were forced into a Jewish ghetto, where he worked in a garment factory. Jack and his family were later sent to the Auschwitz concentration camp. There, he was examined by none other than Dr. Josef Mengele, who sent him and his father to a labor camp near Hanover, Germany. Tramiel was rescued from the labor camp in 1945 by the 84th Infantry Division and two years later, emigrated to the USA. After joining the US Army, he learned how to repair office equipment which set him on the path to founding Commodore. Commenting on how he survived the Holocaust and achieved success, Jack said, "Even if you came out from hell, you can still make it. I like to go forward, not backward ... I live in the future." He will live in history, as well. **NV**



■ Jack Tramiel (left) and marketing man Michael Tomczyk celebrate the sale of the one millionth VIC-20 computer, circa 1982.



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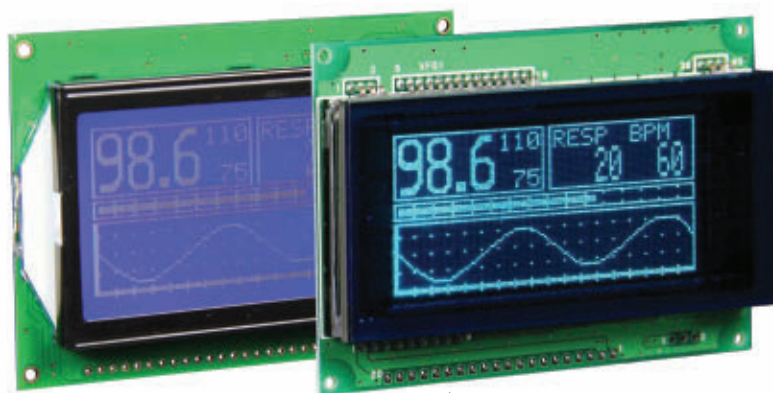
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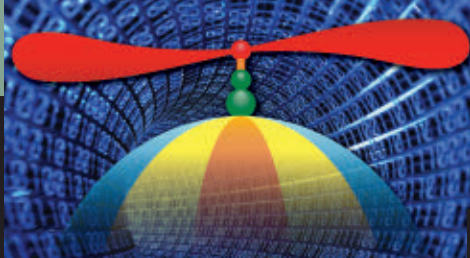
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■ BY JON WILLIAMS

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

TRACK 'EM DANNO!

While many are uncomfortable with the fast pace of technology, for hobbyists like you and me the speed at which things change means that more interesting components become available for us to experiment with. Take the trackball, for example. Now, trackballs have been around for a very long time — remember the monsters used in arcade games? At the leading edge of the smart phone revolution, miniature trackballs were installed in Blackberrys and similar devices. Now, they're available for us to use, too.

In the last Spin Zone column, we did a bit of a reboot and set up some guidelines for writing PASM code that will play nicely with Spin and other languages that run on the Propeller — PropGCC, for example. In this column, I'm going to show you a very practical example of that code style to create a nice little driver for a miniature trackball module. I'm using the module from Parallax (#27908), but the code should run with simple modifications for the button and LED(s) if you're using the SparkFun (COM-09320) board.

Figure 1 shows my test setup: a Parallax trackball module inserted into the groovy new Propeller Board-of-Education (a fantastic, fully-loaded, yet small platform). The

connections for the Parallax trackball are illustrated in **Figure 2**. Note that the direction outputs are labeled OPA, OPB, etc. They map to finger movement on the trackball like this:

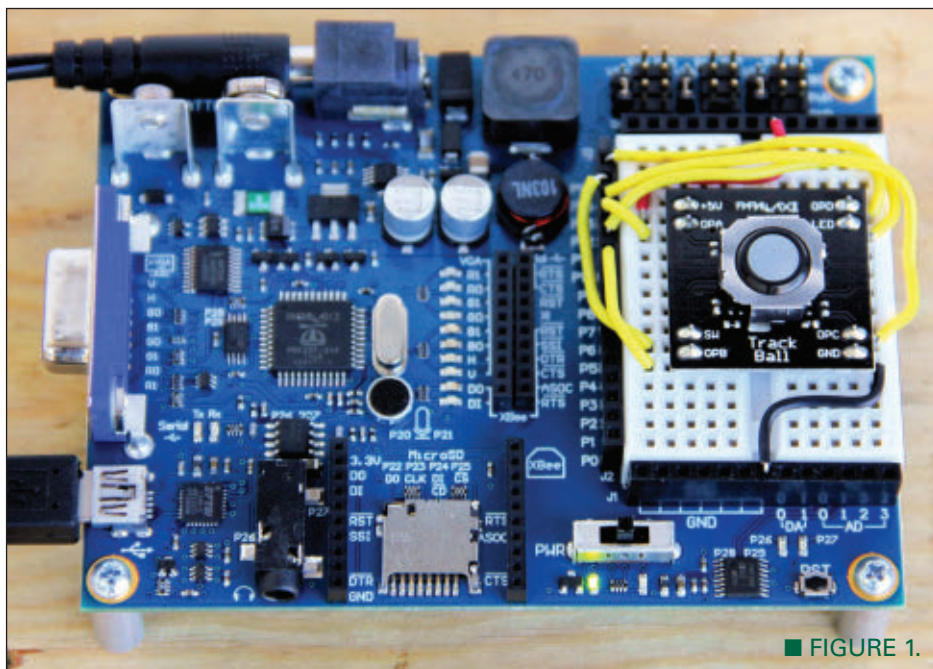
OPA	Up
OPB	Left
OBC	Down
ODB	Right

TRACKIN' THE BALL

The way the trackball works is actually very simple:

When there is motion on an axis, the corresponding direction pin will toggle between high and low. I put a 'scope on the pins and found that the delay between edges was never any less than about 2 ms. Could we write a driver in Spin? Probably, but the PASM code for this driver is so easy that we might as well do it that way and take advantage of the speed.

Before we get into the details, though, let's talk about goals. My thought is that a trackball can be treated like an upside-down mouse, and as there is a mouse driver in the Propeller standard library I had a look to see what methods we might want to support. It makes sense to keep the method calls as close as possible to simplify switching between similar devices for an application. Starting with the obvious, we would want to



■ FIGURE 1.

report x and y positions. It might also be useful to report the change from one point to another. Trackballs are often used with graphical output devices, so setting bounds on each axis is probably a good idea, too. Finally, we should probably have a method for resetting the present position and delta values.

CRACKIN' THE CODE

You'll recall that objects tend to use a method called **start()** to get things going, and this method usually accepts one or more parameters for this instance of the object. In the case of the trackball, we have up to six pins that could be used, though only four are mandatory for positions.

From experience, I'll tell you that passing six parameters in a method call can get a little unwieldy, so I have a trick for methods with a lot of parameters: I pass the address of a **DAT** table that holds the required parameters. Let me explain. In the main program, I will, of course, define pin constants for the trackball:

con

```
TB_LED = 15
TB_BTN = 14
TB_DN = 13
TB_UP = 12
TB_RT = 11
TB_LF = 10
```

Constants are values used by the compiler and to help make our listings easier to read — they do not have a structure nor address that we can pass as a parameter (i.e., when in a group, we can always pass individual constants by value). We can create a table to pass to an object using a **DAT** section of the code. This is what I've done for the trackball object:

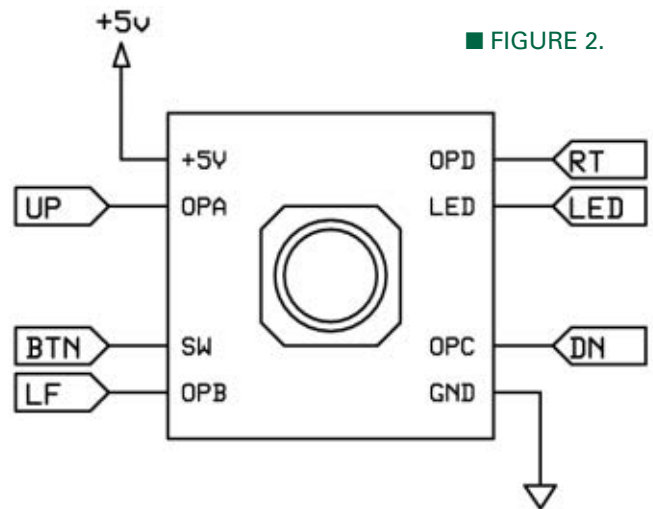
dat

```
TBPins  byte    TB_LF,  TB_RT,  TB_UP,  TB_DN
        byte    TB_BTN, TB_LED
```

Note that the order of the pins in the table corresponds to the requirement set out by the trackball's **start()** method. With this structure in place, we can start the trackball object like this:

```
tb.start(@TBPins)
```

What we're doing is passing a pointer to (*the address of*) the table which takes just one long, instead of all six elements as individual longs (parameters are always passed as longs). I find this helps keep listings orderly and updating pin groupings easier, especially if an object gets started way into the code.



■ FIGURE 2.

Let's get back to building the trackball object. Inside the object, we have the following variables:

var

```
long  cog
long  command
long  cmdparm
long  btnpin
long  ledpin
```

Note that we don't have variables for the direction pins; we don't need to save those as they will be used in the PASM cog. The variable *command* will be used to pass a command value to the driver, and *cmdparm* will pass values back and forth based on the command. If the application uses the button input and LED output, they will be handled in Spin methods, so we do have variables to hold those pin numbers. The trackball has four direction output pins and we only have 31 I/O pins on the Propeller. What this means is that we can use a byte per each pin number and pack four bytes into a long for a single hub read of the trackball pins. On the interface side, that happens in the **start()** method:

pub start(pinspntr)

```
stop
```

```
command := byte[pinspntr][0]
command |= byte[pinspntr][1] << 8
command |= byte[pinspntr][2] << 16
command |= byte[pinspntr][3] << 24
```

```
btnpin := byte[pinspntr][4]
ledpin := byte[pinspntr][5]
```

```
cog := cognew(@trackball, @command) + 1
```

```
return (cog > 0)
```



After stopping the PASM cog (if it was running), we compress the four direction pins into the command variable, with the left pin sitting in the low byte of *command*.

This code demonstrates the flexibility of Spin when we have a pointer to a variable. Remember that the only parameter used by the **start()** method is a pointer to a pin's definition sitting in a **DAT** table. The first element of that table is element 0, the next is 1, etc. The pointer passed to **start()** is a pointer to a byte. Hence, we use the **byte[]** array to retrieve the values. Of course, we can do the same thing for words and longs; the key is knowing what variable type the pointer is pointing to.

With the direction pins packed into *command*, we can copy the button and LED pins, and then launch the cog. There's a very important note here: In the **cognew** instruction, we are passing the address of *command*, not its contents. Once the PASM cog has a hub address, the contents can be retrieved using the **rdlong** instruction.

At the top of the PASM driver, we make a copy of *par* (which is holding the address of *command*), add four to it for the next long (address of *cmdparm*), and save it. The next step is to read the contents of *par* which is a long holding the packed pin definitions. You can see below how we can extract each pin and build a mask from it (I'm only showing the first two pins):

```
trackball      mov     t1, par
               add     t1, #4
               mov     paramhub, t1

               rdlong   t1, par

               mov     t2, t1
               and     t2, #$1F
               mov     tblmask, #1
               shl     tblmask, t2

               mov     t2, t1
               shr     t2, #8
               and     t2, #$1F
               mov     tbrmask, #1
               shl     tbrmask, t2
```

After the individual pin masks are created, we will put them all together into a single mask that will be used for sampling the inputs. With the pin's masks created, we can sample the inputs to get the current start of the trackball before initializing the position values and dropping into the main loop:

```
mov     tballmask, tblmask
or      tballmask, tbrmask
or      tballmask, tbumask
or      tballmask, tbdmask

mov     oldscan, ina
and     oldscan, tballmask
```

The interface section of the trackball object provides the following methods that tie into the PASM cog:

```
reset()
abs_x()
abs_y()
delta_reset()
delta_x()
delta_y()
set_bounds()
```

When the code requires more than a few commands, I tend to use the jump table approach in the code. For those of you with BASIC Stamp experience, what I'm about to show you is akin to the **BRANCH** instruction:

```
trackmain      rdlong   cmd, par  wz
               if_z     jmp     #update
               min      cmd, #0
               max      cmd, #8
               add      cmd, #jmptable
               jmp      cmd

jmptable       jmp      #cmdexit
do_cmd1        jmp      #cmd1
do_cmd2        jmp      #cmd2
do_cmd3        jmp      #cmd3
do_cmd4        jmp      #cmd4
do_cmd5        jmp      #cmd5
do_cmd6        jmp      #cmd6
do_cmd7        jmp      #cmd7
no_cmd         jmp      #cmdexit
```

At the top, we read the command value from the hub and if it's zero (no command), then we'll skip the jump table and update the trackball position values if there was any motion. If a command is present, the first thing to do is ensure that it's legal. We can use the **min** and **max** instructions to truncate an illegal value. The address of the jump table is then added to the command.

Note that in PASM, we use the hash symbol (#) to indicate the address (while Spin uses @). What we have now is an intermediate address in *cmd*; that is, it's to a

RESOURCES

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location inside the jump table which is comprised of a number of jumps, each going to the appropriate handler. I know it seems a tad wonky jumping to jumps, but it's very clean and easier to code than compare-and-skip when we have a lot of commands.

For the trackball object, the valid commands are one through seven, so you can see in the table the boundary values of zero and eight jump to an exit point. This simple bit of code clears the command value in the hub which serves as a flag to the interface methods that the command is finished:

```
cmdexit      mov     t1, #0
              wrlong  t1, par
```

Remember that **par** is holding the hub address of *command*, so this code is overwriting the last command value with zero.

Before we get to the individual command handlers, let's discuss the working part of the driver: the code that scans the direction inputs and updates position values.

```
update      mov     newscan, ina
              and     newscan, tballmask
              mov     changes, newscan
              xor     changes, oldscan  wz
if_z        jmp     #trackmain

if_c        test    changes, tbrmask  wc
              adds    xnow, #1
              maxs    xnow, xmax

if_c        test    changes, tblmask  wc
              subs    xnow, #1
              mins    xnow, xmin

if_c        test    changes, tbdmask  wc
              adds    ynow, #1
              maxs    ynow, ymax

if_c        test    changes, tbumask  wc
              subs    ynow, #1
              mins    ynow, ymin

              mov     oldscan, newscan
              jmp     #trackmain
```

The first step is to grab a copy of the inputs and then mask off all but the direction pins. We then make a copy of the new inputs and **xor** them with the last scan. If there are differences in any of the bits, the exclusive-or process will return a "1" for that input. If there was no change in the inputs (z flag is set) between scans, we can simply jump back to the top of the main loop.

Here's where we need the individual direction pin masks. We will test the bits in *changes* with each mask, and update the appropriate position variable. A change on the right input will increment the x position, and input on

the left input will decrement the x position. Similar tests exist for the y position. With the tests complete, the current scan (*newscan*) is saved into the *oldscan* variable for use in the next cycle.

The command handlers are all fairly simple. For example, command one resets the position variables:

```
cmd1      mov     xnow, #0
              mov     xlast, #0
              mov     ynow, #0
              mov     ylast, #0
              jmp     #cmdexit
```

Note that there are current positions and last positions; we need to keep track of the last position so that we can return the delta when requested. Here's how that works for command five, which returns the change (delta) in x position since the last time it was requested or reset:

```
cmd5      mov     t1, xnow
              subs    t1, xlast
              wrlong  t1, paramhub
              mov     xlast, xnow
              jmp     #cmdexit
```

Easy as pie, right? We copy the current position (*xnow*) into *t1*, subtract (using signed subtraction as our position values can be signed) the last marked position (*xlast*), and then write the result to the parameter location in the hub. Finally, we mark the new location by copying *xnow* into *xlast*. Yep, easy as pie.

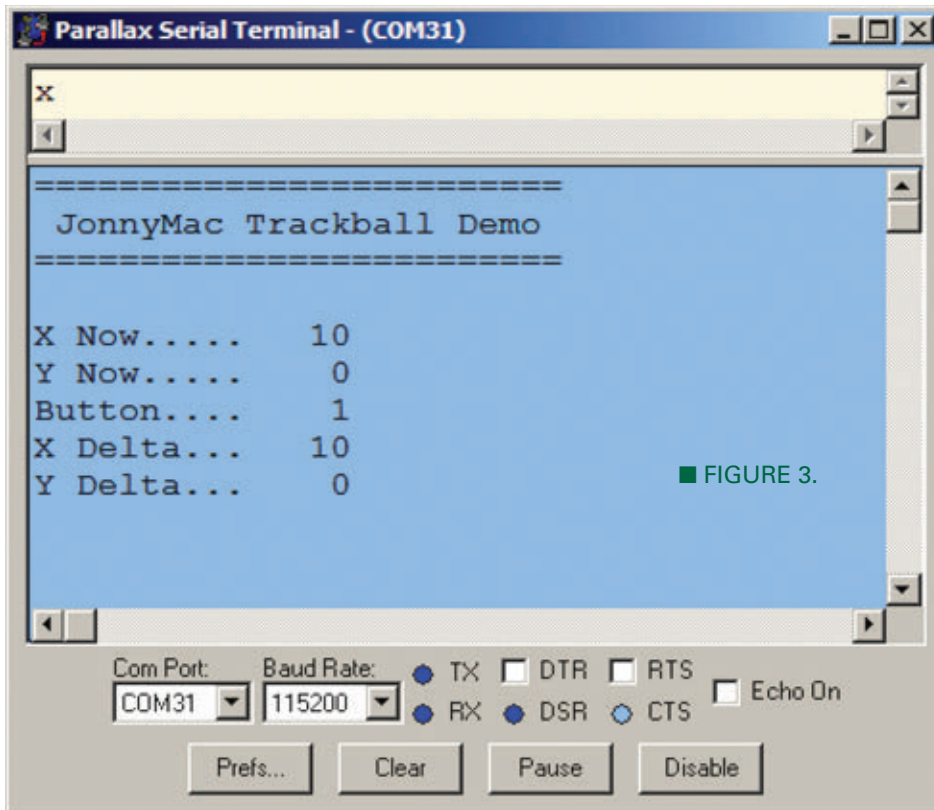
You'll find that the other code handlers are equally simple. Be sure and take a bit of time to explore them as they might come in handy in other objects.

Before we close, I want to show you the top part of the PASM variables. You'll remember from last time that in PASM, we can have initialized and uninitialized variables. For this driver, we have the following set of initialized variables:

```
xmin      long     -100
xmax      long     +100
ymin      long     -100
ymax      long     +100
```

Most of the time, we avoid using initialized variables because they consume space in the hub, but no more than initializing these variables in code. So, pre-initializing makes sense here. And, of course, we need to initialize the boundaries for the trackball driver to work correctly. You might think — as I did in my first version of the driver — that we should use initialized variables for *xnow*, *xlast*, *ynow*, and *ylast*. There is no need because we can simply jump to the **cmd1** handler which clears these values. You'll see in the full listing at the article link that we do this at the very end of the setup code.

Figure 3 shows the output from a little demo program



■ FIGURE 3.

I wrote to test the trackball object. It reports the current position and shows button status. When the button is pressed, the delta values from the last button press are displayed. Pressing the button also lights the LED, so all elements are tested.

So, there we are — a cool little driver for a mini trackball that can be used in myriad applications. I'm just starting to explore graphics on the Propeller, and this is likely where I'll go, though I'm also looking at replacing a standard button interface in an LCD HMI.

What will you do? Have fun, of course, and until next time, keep spinning and winning with the Propeller! **NV**

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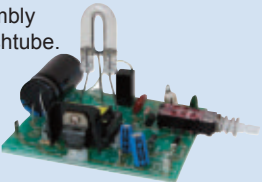
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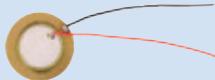


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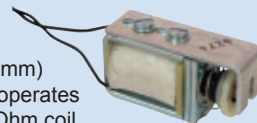
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Four-Mode Keyless Entry Test Set

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

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

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

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

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

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

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

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even add 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
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Laser Trip Sensor 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
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K2655	Electronic Watch Dog Kit	\$39.95
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PL300	300-In-One Lab Kit	\$109.95
PL500	500-In-One Lab Kit	\$249.95
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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!

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

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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

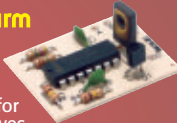
Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.



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

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



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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

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TFM3C Tri-Field Meter Kit \$74.95

Electret Condenser Mic

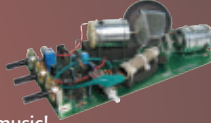
This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!



MC1 Mini Electret Condenser Mic Kit \$3.95

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LLS1 Laser Light Show Kit \$49.95

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K8062 USB DMX Interface Controller Kit \$67.95

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

Passive Aircraft Monitor

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



ABM1 Passive Aircraft Receiver Kit \$89.95

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

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 UT5AS relays, and directly interface all timer functions with onboard controls or external signals.



All connections are easily made through 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
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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

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

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

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

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SG7 Speed Radar Gun Kit \$69.95

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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. Asmb.



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Q&A

WHAT'S UP:

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

- ✓ Three-Phase Motor Control
- ✓ Digital Clock
- ✓ Multi-Input A/V Switch

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

THREE-PHASE MOTOR CONTROL

Can you provide an example of a non-microcontroller based design to invert 644 VDC to 460 volts three-phase AC? This is for a 200 HP, 460 volt, three-phase motor, turning 3,565 RPM. Current is 219 amps. Speed control and reversibility is required, as well.

I know I need to PWM (pulse width modulate) six power MOSFETs

or IGBTs, but the control logic to drive these mystifies me.

How was this done prior to microcontrollers? Additionally, can you recommend books that deal specifically with DC to three-phase AC inversion?

— Kenneth C. McGinnis

To answer your last question first, here are three book titles from Amazon.com which you may find useful:

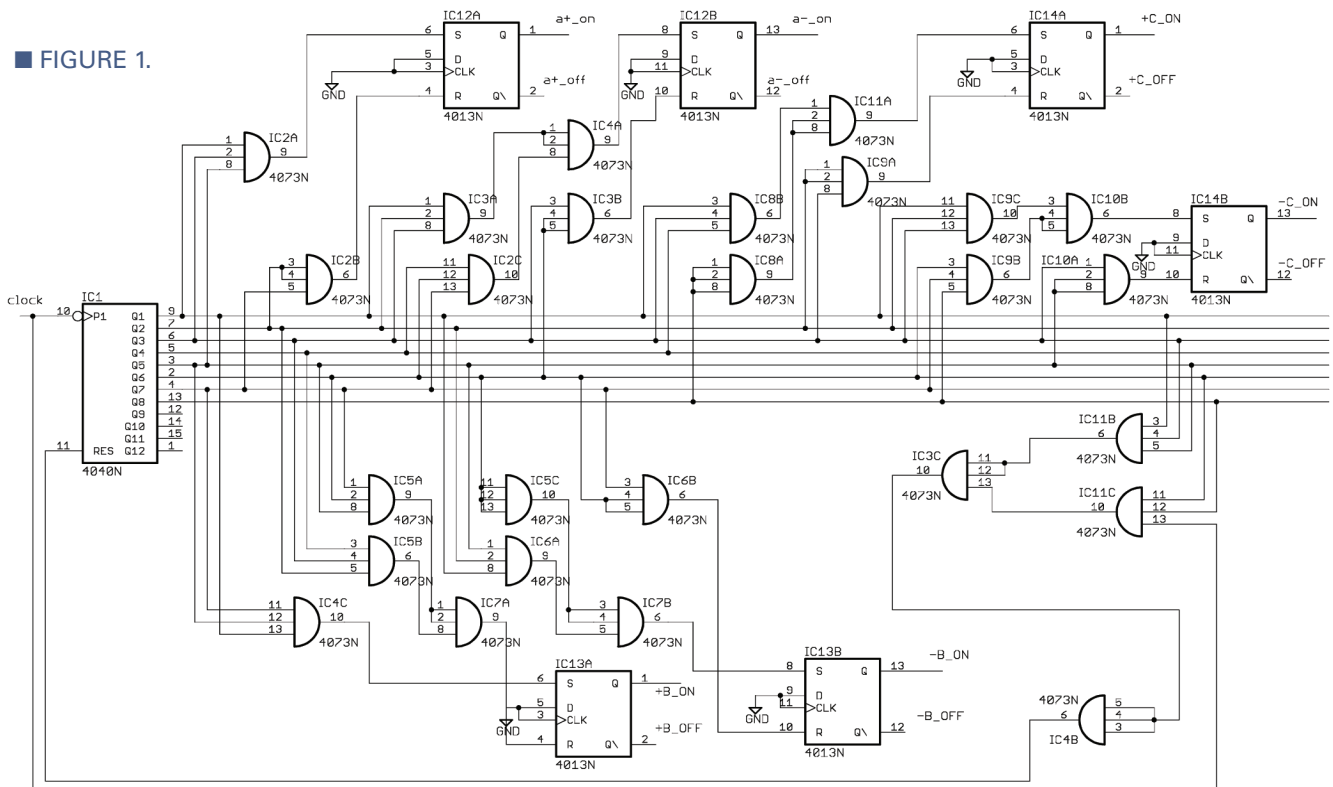
Practical Variable Speed Drives and Power Electronics (Practical Professional Books) by Malcolm Barnes (Aug. 13, 2003).

Electric Motors and Drives: Fundamentals, Types, and Applications (3rd Edition) by Austin Hughes (Nov. 19, 2005).

The Closed-Loop Control of a Three-Phase Inverter Using a DSPACE DS1102 DSP Board by Derek P. Frasz (1998).

The peak-to-peak voltage of 460 VAC is 1,297 volts. You will need a

FIGURE 1.



MAILBAG

Dear Russell: Re: PCMCIA Memory Card, April '12, page 23:

With reference to the question from Brent Lamb in the April issue, if all he needs is extra storage instead of USB functions, he should be able to get a Compact Flash-to-PCMCIA adapter for around \$5 on eBay. He should be able to use any of the CF cards; well, at least the ones under 2G in size. As far as I remember, CF is actually a PCMCIA device.

— Herbert Tai

There were several versions of the "PCMCIA" style interface, so Brent needs to obtain an adapter that is compatible with his system. The following website explains the differences: http://en.wikipedia.org/wiki/PC_Card. It may be easier to find a compatible Compact Flash-to-PCMCIA adapter since they are both parallel standards that share most of their pins. Compact Flash sockets are still available on many new PCs and on USB-to-memory card adapters.

— Bob Lacy

I've located a posting on a machinist website stating that a Sandisk SDAD-38-A10 PC-to-CF card adapter works fine: www.practicalmachinist.com/vb/cnc-machining/pcmcia-card-new-laptop-184633. I've used the Transcend CF 2G and 4G Compact Flash with several IDE adapter boards when building FreeNAS NAS (network attached storage), and they work wonderful. Extra Info: www.practicalmachinist.com/vb/cnc-machining/dnc-fanuc-21i-vmc-186821/; www.practicalmachinist.com/vb/cnc-machining/fanuc-pcmcia-compactflash-mem-changes-file-weird-problem-122580/.

— Larry Kraemer

I can help a little with the PCMCIA-to-USB adapter question. The news is not good though. Most of the machine tools (and some test equipment) use Static RAM (SRAM) cards rather than the more common Flash type. These battery backed-up CMOS cards also use random access

addressing, not the ATA hard disk emulation or block write used by PC Flash cards. I've not found an off-the-shelf solution to use either USB memory sticks or CF cards in equipment designed for SRAM cards. A solution would require a controller and enough buffer RAM to store data between block writes to Flash and to compensate for the faster access speeds of the SRAM cards. There is software by ELAN called Memory Card Explorer (www.pccard.co.uk/copy/aboutmce.php) that allows reading and writing SRAM cards on a PC, and thus provides a back-up solution. It is not cheap, though.

— Robert G8RPI

A possible solution to the PCMCIA memory card problem is called a PCMCIA CF adapter. This product adapts a Compact Flash (CF) memory card to the PCMCIA slot in the side of old laptop computers. I have a couple of old laptops using these adapters to access 8 GB CF cards. The last time I bought one of these was in 2008. Searching eBay on the quoted string (without the quotes) still returns vendors of this product.

There is a chance that the CF card in the PCMCIA CF adapter will work if the machine tool was using a PCMCIA Flash card. On the other hand, it may not work if the machine was using a really old PCMCIA static RAM card backed up with a coin cell. The reason I say that is because I bought a static RAM card for the PCMCIA slot in a palmtop computer running DOS in 1994. The reason I bought the static RAM was that I had to return a PCMCIA Flash card because the palmtop could not access it. To add insult to injury, in 1996 I found that the static RAM card which worked in the palmtop could not be read in a desktop computer with a PCMCIA slot. The reason was that the desktop was looking for a 16-bit bus, whereas the palmtop could handle the obsolete eight-bit bus used by the static RAM card.

— Dennis Crunkilton

Response: Thanks to all for your interest in this problem. The replies are posted without comment.

full bridge for each phase to operate with 644 VDC (12 transistors). Also, the motor will have to be wound with all three windings brought out individually — not star or delta connected. I will only provide the logic schematic here; whether you choose to use 1,288 VDC with six transistors or 644 VDC with 12 is up to you.

The quasi sine wave that has the same RMS and peak value is positive for 90 degrees, zero for 90 degrees, negative for 90 degrees, and zero for 90 degrees. This is not PWM; you just need a timer and switches to operate at the correct time. **Figure 1** is the timer schematic. The variable frequency clock provides speed control, and reversing one phase will reverse direction. Caution: Reversing a motor while it is going forward may throw it off its mount.

The timer consists of a counter and decoders. I first considered the 4024 seven stage counter but $2^7 = 128$ — that is not enough for 360 degrees, so I have to go to the 4040 12 stage counter. I started the count at the first zero crossing but that puts the beginning of the first pulse at 45 degrees, and decoding an odd number requires the clock. I can reduce the number of decode lines by using an even number.

Shifting the phase one degree gives a decode of 44: $2^2 + 2^3 + 2^5$. That was okay but at phase B positive turn-off, seven decode lines are

required. I want to use triple three-input gates and reasoned that numbers ending in 2 would be better. Sure enough, the decode was reduced to six lines so I went with a phase shift of three degrees. **Table 1** lists the phase values in degrees.

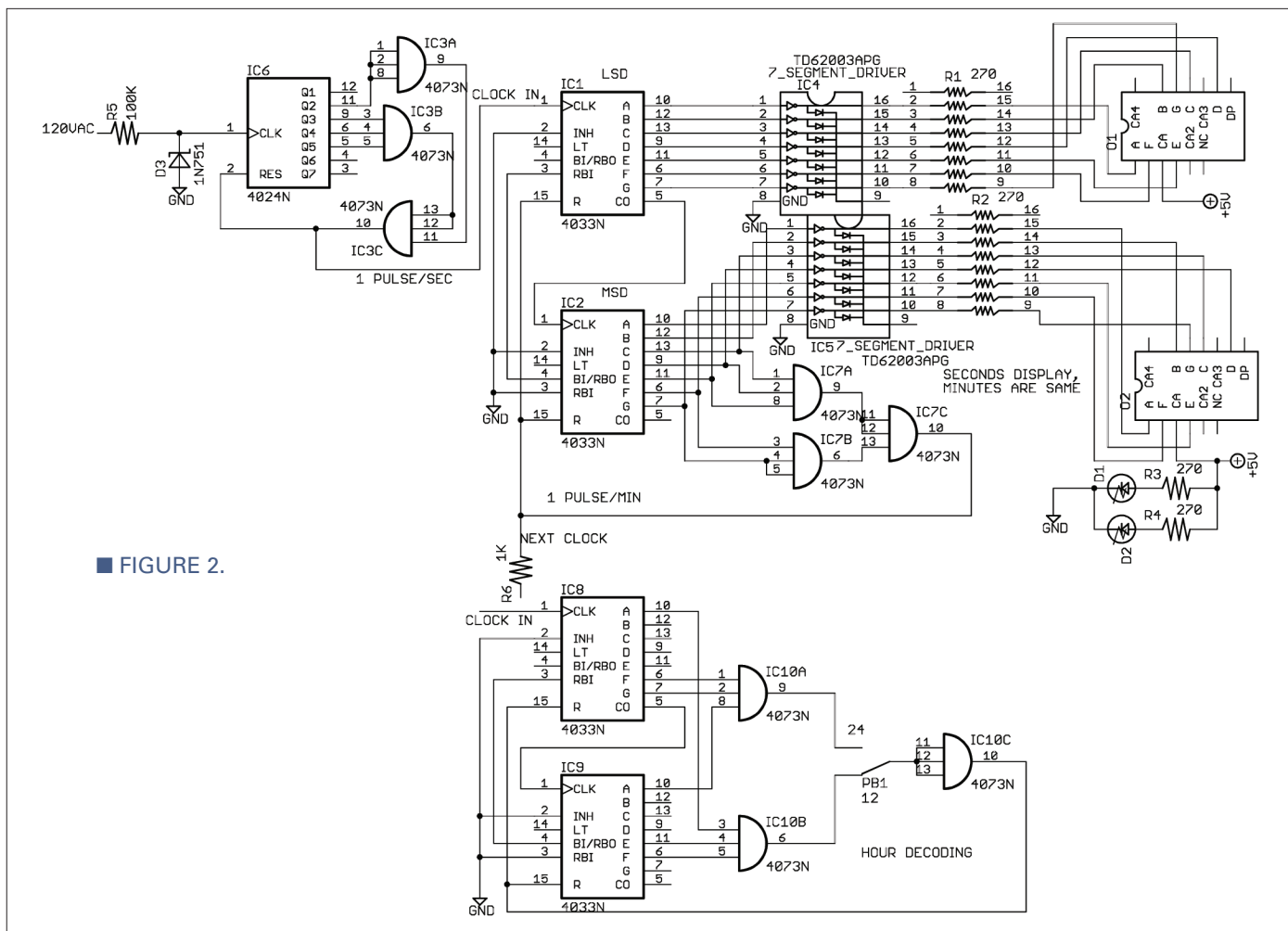
The counter resets every 360 degrees, and the waveform will not be correct until the first cycle has been completed. Considering that all of the ICs in **Figure 1** could be incorporated in one microcontroller or programmable logic array (PLA), do you really want to go this route?

PHASE	POS ON	POS OFF	NEG ON	NEG OFF
A	42	132	22	312
B	162	252	342	72
C	282	12	102	192

Table 1.

DIGITAL CLOCK

Recently, I received a beautiful 15-1/2 x 21 inch wooden top that came from a case of wine. I



framed it, and it would look great with a seven-segment digital display clock that has hours, minutes, and seconds spread across part of it. Perhaps a red display, about 0.6" in height. I have had several hours of electrical engineering courses at our university, but my field is civil engineering. I've been retired for some time.

The Internet is full of digital clocks but the schematics are complex. Most require multiple circuit boards and two or three voltages from power supplies. I can make a circuit board on a computer running an auto etching machine at school, but not a complex layout.

Could you design a schematic that isn't so complex? Perhaps a PIC or a not-so-complex circuit using non-programmable components? Or, maybe point me in the right direction to find one. It could use the power line frequency or a

crystal for accuracy.

— Frank Lemon

A I chose to use the CD4033 decade counter with a seven-segment decoder for the clock. CMOS does not have much drive capability, so a Toshiba TD62003APG driver is used. Resistor array R1 and R2 is used for current limiting (270 ohms); see **Figure 2**. The connection from pin 4 of IC2 to pin 3 of IC1 inhibits leading zeros. The display will be 2: 1 instead of 02:01. It is necessary to detect 60 seconds and 60 minutes in order to reset the counter and send a clock pulse to the next stage.

The number 6 uses segments c, d, e, f, and g; when all five are positive, the seconds and minutes are reset. **Figure 2** shows the seconds display; the minutes are identical. The hour display is the same also, but a different decode is needed. The

lower part of **Figure 2** shows the decode for **12** and 24 hour display. I didn't decode the whole number because it is only necessary to differentiate between 1 and 2, or 2 and 4. Number 1 uses e and f, and number 2 uses a, b, d, e, and g, but only a is needed to differentiate (could have used b, d, or g also). The number 4 uses f and g. That combination is not used by 1, 2, or 3, so (again) only a is needed to differentiate number 2. The power line frequency is divided by 60 to provide one second pulses to the seconds display. The circuit runs on one 5 VDC supply; a 5 VA transformer should be adequate.

To set the clock, a three-position switch to apply one second pulses to the minutes and hours displays will speed it up. A 1K resistor in series with the clock line will provide isolation from the normal pulse output.

You should be able to make a single-sided layout by using jumper wires where crossovers are needed.

MULTI INPUT A/V SWITCH

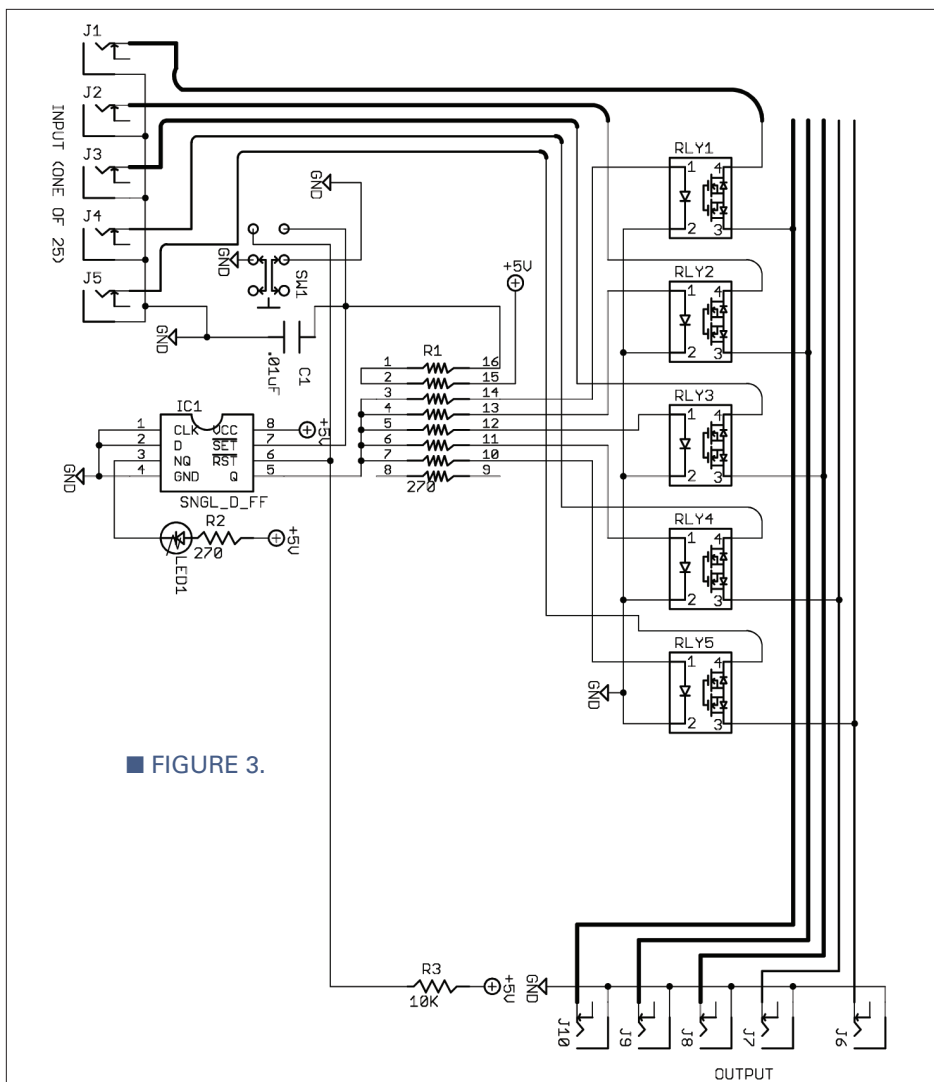
Q I have a collection of about 25 different video game systems. I have them all set up and ready to play but I have to “cable swap” every time I want to play a different system. I have a couple of four and six input switchers, but that gets complicated. The cables are composite A/V (red, white, yellow, and stereo audio). What I need is one circuit that can handle all 25 systems. What I would like is one pushbutton next to each system.

When you push the button, it will disconnect any other system that was selected and instead connect the system that is selected. Maybe an LED next to the selected system could be lighted. I have tried relays (my usual method) and PIC chips, but I am unable to figure out how to switch the sheer number of inputs that I need. Perhaps you can help.

— Derek Tombrello

A Twenty-five systems times five cables equals 125 signals to be switched to five outputs. My solution (Figure 3) uses a flip-flop which when set, enables five solid-state relays to feed signals to an audio/video bus. Flip-flops in the other 124 channels are reset, but the selected is not reset because C1 delays the set signal to insure that the flip-flop ends up in the set state. Figure 3 shows one channel which is to be repeated 25 times.

I did a preliminary layout to see how big the circuit board would be; I estimate that if half the ports are flipped to the other side of the bus, the board would be three feet by 6-1/2 inches. The board length could be reduced by using three vertical video jacks and two vertical audio jacks, but I did not find any in stock



■ FIGURE 3.

anywhere. Figure 4 is the Parts List.

The parts are mostly surface-mount except where not available. The RCA jacks need to be thru-hole for robustness and the pushbutton switch is called a “key switch.” I don’t know what that implies exactly, but I suspect it means you have to press the switch twice to effect a channel change.

SOLAR TRACKER CIRCUIT

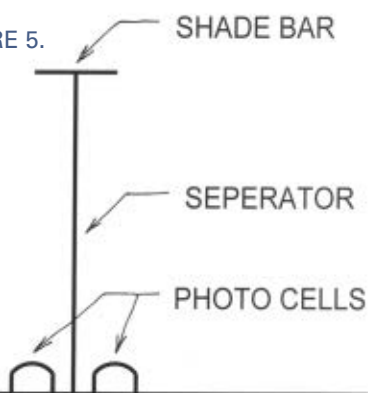
Q Over the years, I have found that the Q & A section of *Nuts & Volts* has always come to my rescue when I needed a circuit to solve a problem. At this time, I need a simple

PARTS LIST FOR VIDEO SWITCH

PART	DESCRIPTION	PART #	SOURCE
J1-J10	RCA JACK, THRU HOLE	PJRN1X1U01X-ND	DIGI-KEY
RLY1-RLY5	SS RELAY, 2 OHMS, 60V	653-G3VM-61D1	MOUSER
SW1	DPDT PUSHBUTTON	642-MHPS2266	MOUSER
R1	8 RESISTOR ARRAY, 270 OHMS	652-CAT16-271J4LF	MOUSER
R2	270 OHMS, 1%, 1/8W, 1206	660-RK73H2BTDD2740F	MOUSER
R3	10K, 1%, 1/8W, 1206	660-RK73H2BTDD1002F	MOUSER
IC1	SINGLE D FF	863-NL17SZ74USG	MOUSER
LED1	0805, SMD, GREEN	604-APT2012SGC	MOUSER

■ FIGURE 4.

■ FIGURE 5.



solar tracker circuit that I can build. All I need is the electronic part of the circuit; the mechanical part I will work out on my own. I am not familiar with microprocessors, so if possible, can you design or recommend a circuit to fill my need using conventional electronic components? Individual transistors and/or chips are fine. These components, in turn, would

activate a relay for switching the tracker motor on and off. This would also be a means of resetting the unit so it will start the next morning, along with limit switches.

— Anonymous

A I once built an antenna servo using LM324 op-amps and 12 volt servo motors; I think that would work here. No relays though; they are too slow. I don't know the mass of the system being moved but I don't think that will matter because it is moving so slow. The system will be way over-damped. The system will need a photo sensor — actually two of them in a balance circuit such that the one with the most light will move in that direction.

Figure 5 shows a possible configuration. The circuit (**Figure 6**) is for Azimuth; if you want elevation, it is the same

PART	DESCRIPTION
FUSE	250 mA, 250V
FUSE HOLDER	5 MM x 20 MM PANEL MOUNT
T1	12V CT/115 VAC TRANSFORMER
D1, D2	GREEN LED, 2.1V
D3	BRIDGE RECTIFIER, 200V, 1A
C1, C2	1,000 μ F, 16V
IC1	QUAD OP-AMP, LM324
Q1, Q2	PHOTOTRANSISTOR
RLY1	DPDT, 6V
LIMIT SWITCH	SPDT, LEVER ACTION
D4	DIODE, 1N4148
RESISTORS ARE 1/4 WATT, SIMILAR TO 81832	
MOTOR	6V, 100 mA
MOTOR	6V, 100 mA

JAMECO PART#

103887
102832
29226
156962
103042
330722
212169
373001
2135291
2117333
743285

PARTS LIST FOR SOLAR TRACKER

■ FIGURE 7.

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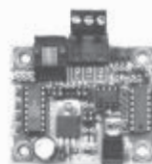
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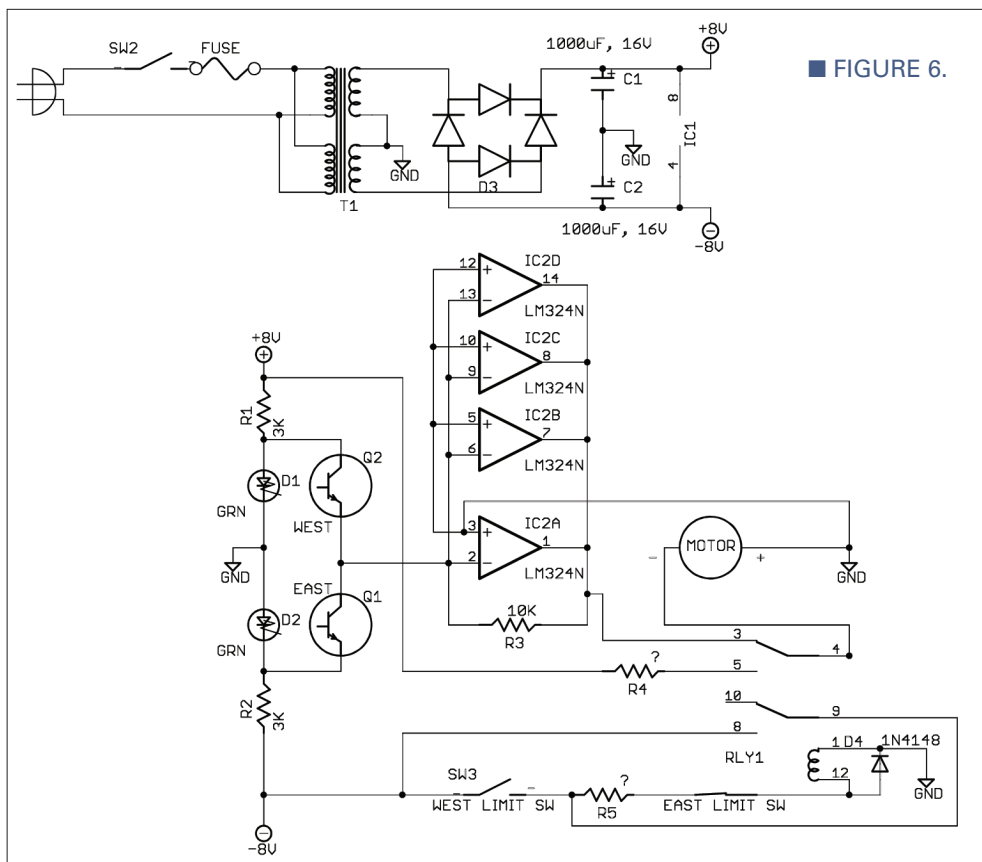
The Parts List is in **Figure 7**.

When Q1 has more light than Q2, the op-amp output is driven negative which drives the motor forward. If the motor doesn't move fast enough, the gain can be raised by increasing R3.

When the west limit is reached, SW3 closes which latches the relay and connects the motor through R4 to the positive supply which reverses it. R4 is to be selected to limit the motor speed.

It would seem best that the array reach the east limit when it is quite dark, so the phototransistors are inactive. At the east limit, the east limit switch opens and unlatches the relay, leaving the system ready for sunup.

R5 is a limit resistor in case the relay overheats on eight volts (probably not needed). **NV**



■ FIGURE 6.



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Continued on page 74



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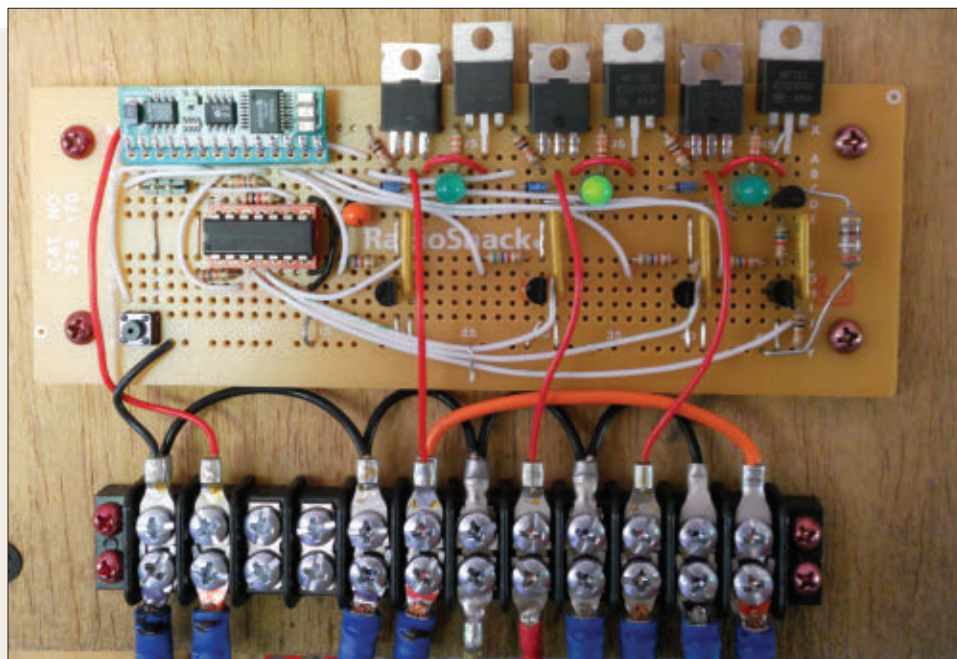


By John Guyer

BUILD THE SOLAR SEQUENCER

This article describes how to build a solar sequencer which enables a single solar panel to charge multiple batteries of different sizes and capacities, keeping them isolated from each other. This article also covers how to use a solar panel and battery to run a garage door opener in a building without access to utility power. The Solar Sequencer

provides a maintenance charge to 12 volt lead acid automotive batteries from a 45W solar panel. My unit has been in operation for three years now.



■ FIGURE 1. Solar sequencer prototype.

Solar Panel

The solar panels are from Harbor Freight's 45 watt solar panel kit. The panels face due south and are mounted at 30 degree angles to each other in order to spread the capacity over as much of the day as possible. If they are mounted as shown in the kit directions, the current can be over three amps at noon, but not much in the morning and evening. The mount was made out of 1" aluminum angle purchased from the hardware store.

Garage Door Opener

The garage door opener I used is a Craftsman/Chamberlain belt drive with a battery backup. It is designed to run from a 12 volt 5 Ah lead acid battery (included), but only as a backup. Everything but the lights work with no AC power, and it draws about 40 mA when in standby. It does need AC power applied initially, but

will work from the battery afterward. I used a long extension cord at first, but switched to a cheap 400 watt modified sine wave inverter to get it started, then disconnected the inverter. This garage door opener uses four amps DC to open the door and 3.5 amps to close it. Both take about 20 seconds.

Battery

The small battery included with the garage door opener only lasts about six months. It is only intended as a backup — not a primary power source. I replaced it with a lead acid battery that was still good but out of warranty, which I removed from a Jeep Grand Cherokee. It is a size 26 battery which has a standby power number of 150, meaning it can supply 25 amps for 150 minutes. I plan to add another opener and this should be more than enough to power both. It also can run the lights that came with the solar panel kit. The Jeep's battery is on a shelf in the

back of the garage and wired to the garage door opener with 14 gauge wire.

Hardware

Figure 1 shows a photo of the prototype that is still in operation. (The circuit is simple enough to build and use on a prototyping board.) **Figure 2** is a printed circuit board (PCB) version that is more professional looking and easier to hook up. **Figure 3** is the schematic, and **Figure 4** shows a wider angle with the sequencer connected to the garage door opener, garage battery, truck, and ATV.

I chose the Parallax BASIC Stamp 1 microcontroller, mainly because I had one from another project and it is easy to use. It also has an onboard regulator, brown-out circuitry, and a reset input pin. The Stamp reads an 0834 Analog-to-Digital Converter (ADC) which is covered in the BASIC Stamp applications manual.

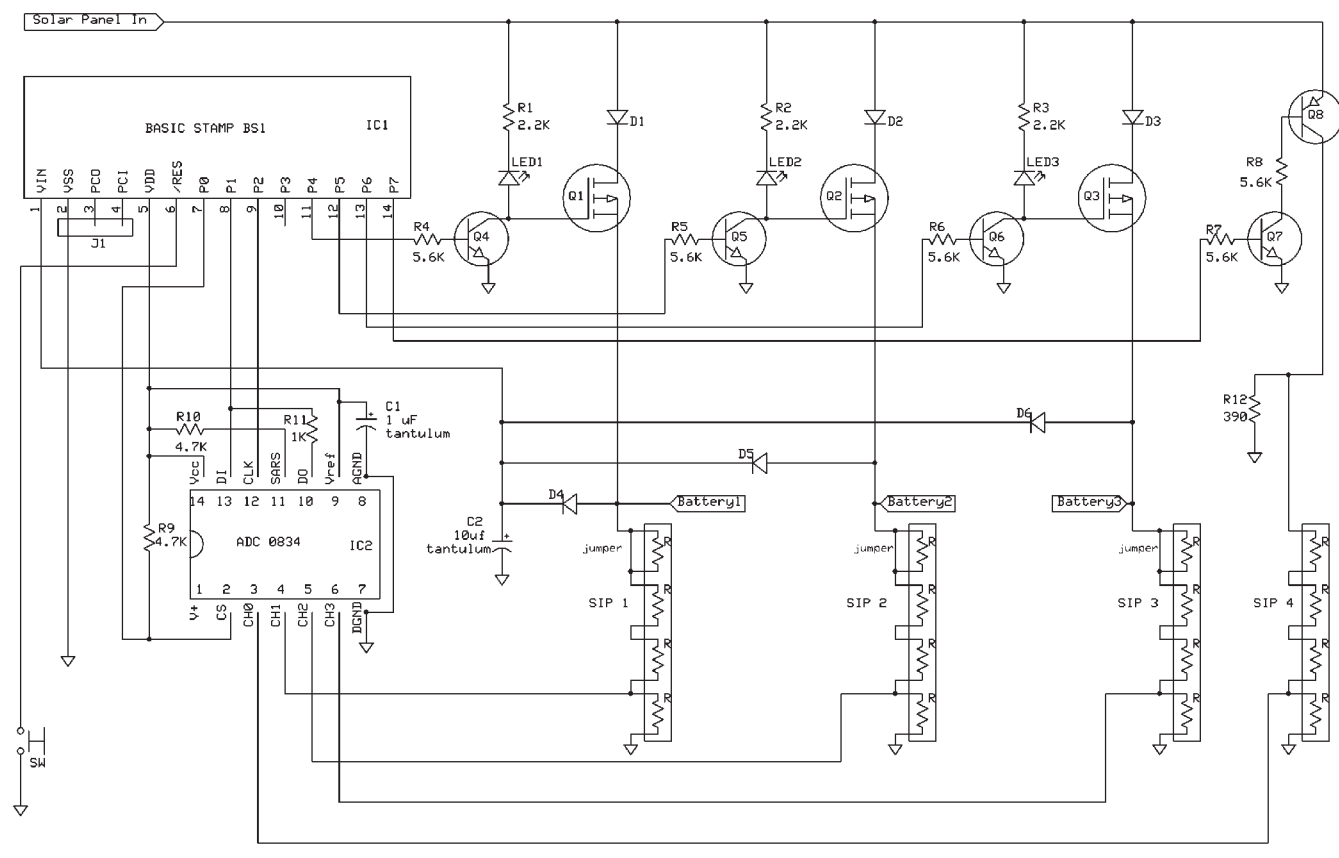
Because the ADC inputs can only measure up to five volts, the battery voltage is divided by three, using a resistor divider with an isolated 10K eight-pin Single In-line Package (SIP) resistor network. Since the resistors in the SIP are made using the same process, their values are all very close to each other. The tolerance is 2%. This can also be done with discrete resistors, but with less accuracy unless the resistors are matched.

This load is on the battery all of the time; the current draw should be as low as possible. I used a 10K SIP — with three of the resistors in series — which uses 0.45 mA (13.5/30K). A higher value SIP resulted in less accurate readings due to the higher input impedance on the ADC input. The open circuit voltage of the solar panels can be as high as 23 volts; the ADC input for them is divided by four. It uses all four resistors in the SIP. During the load test of the solar panels, dividing by four keeps the voltage on the ADC input less than five volts. Power for the Stamp and ADC is supplied by the battery(s) through diodes D4, D5, or D6. That way, it doesn't matter which output is connected to a battery or left open.

Power Circuit

In order to reference the ADC to ground, P-channel MOSFETs (Q1, Q2, and Q3) are used. The MOSFETs need very little current to be turned on, and have a very low on resistance. It is a P-channel IRF 5305 which has a built-in bypass diode. The bypass diode will allow a charged battery to push current to a charging battery when the MOSFETs are off. The purpose of diodes D1, D2, and D3 is to block this current. They are Schottky MBR2535CTs which have a lower voltage drop than standard diodes. The diodes are rated for 30 amps, and the MOSFETs are

■ FIGURE 3. Schematic.



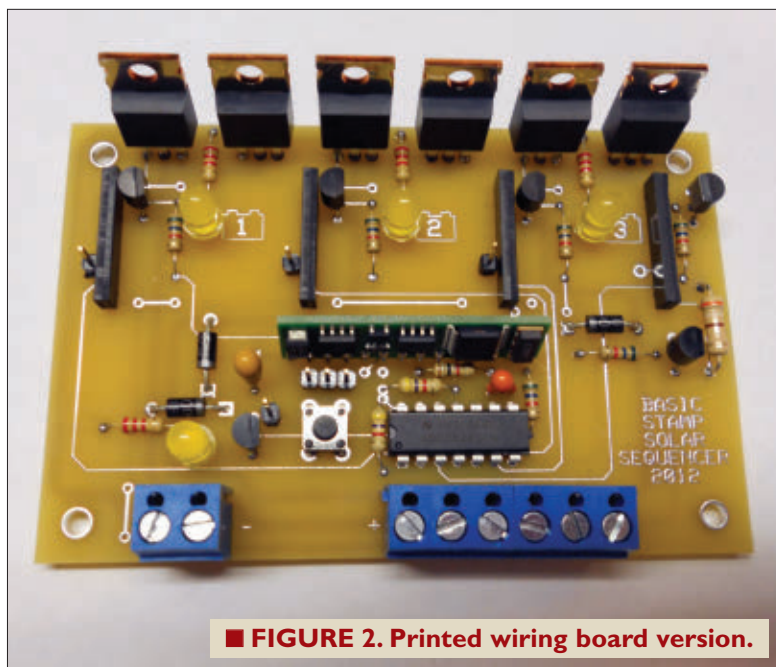
rated for -31 amps. The MBR2535CT has two diodes in a TO-220 package — both of which are used in parallel.

Cheaper components with less current handling capability could be used — especially for a lower capacity panel — but a MOSFET with a low on resistance typically has a high current rating. I originally thought this could be used with a 120 VAC charger capable of 10 amps, but never used it that way other than for testing. The voltage drop across the diode and MOSFET is less than 0.5V, and most of that is across the diode. Since the maximum current is less than two amps, neither device requires a heatsink.

Each particular MOSFET is turned on by the Stamp 1 using a 2N3904 NPN transistor, along with the charging LED. The LED is not very bright because the 2.2K resistor sets the current at about 5 mA, which is a trade-off between being able to see it and current consumption. I also considered using a PNP power transistor and using the base current to light the LED, but the on resistance was high. A relay would work too, but the coil current is wasted and rather high. The MOSFET is ideal for this application.

Software

The details of the code (available at the article link) are included in the code comments, but here is a brief summary of how it works. When the program starts, the Charge routine load-tests the solar panel capacity by turning on Q4, which causes about 30 mA to flow through the 390 ohm resistor. This value was chosen only because it is close to the standby current of the garage door opener. If the ADC reading is greater than the startCharge value (13 volts), the Charge1 routine is executed. If not, it calls Night which sleeps 10 minutes and tries again. The Charge1 routine checks the first battery. If it is less than 13 volts but greater than 10 volts, it calls the ChargeLoop subroutine. If not, it checks the next battery. Since the battery voltage drops very slowly, at the end if none of the batteries have been charged, it waits for a minute then executes again. ChargeLoop is called if any of the batteries need to be charged, and it turns on a MOSFET allowing the solar panel to charge the battery. It checks the voltage every five seconds until the voltage is greater than



■ FIGURE 2. Printed wiring board version.

stopCharge (14.2 volts), then turns off the MOSFET and returns to the Charge routine.

The ChargeLoop subroutine also stops charging approximately every 20 minutes, load-tests the solar panel capacity, and (if it is still high enough) resumes charging. If not, it calls the Night routine and sleeps for 10 minutes. The Stamp uses very little power during sleep.

Construction

The prototype circuit was constructed on a



■ FIGURE 4. Garage installation (note circles which show locations of system components).



■ **FIGURE 5.**
Solar panel
setup.

RadioShack prototyping board (as shown in **Figure 1**). It is simple enough to build with point-to-point wiring. I soldered a wire over the circuit trace at the top that carries the solar panel current (because it isn't intended to carry much current). I also covered the entire trace with solder between the MOSFET and the wire leading to the barrier strip. The input from the solar panel and output to the battery(s) is wired to a barrier strip. All of the ground leads are connected together on the barrier strip. From that strip, the truck's battery is connected with the same type of large clamps that an AC charger uses. The ATV and lawn mower use cigarette lighter plugs.

Be extra careful when making these connections, since lead acid batteries can push a lot of current and

burn up components — not to mention cause a fire.

The layout of the parts on the board is the same as shown in the **schematic**. There are a few traces that are cut between the Stamp and ADC. Pins P1 and P2 on the Stamp line up with pins 13 and 12 on the ADC; the other traces between those two components were cut. Traces between SIP pins were also cut; refer to the **schematic** and cut where there is no connection between pins. The two terminals on the right of the barrier strip are really not needed, so I used them to connect to a cigarette lighter socket; the orange wire connects it to the garage battery. This socket is used to power a 12V trouble light from the garage battery. There are two pushbutton switches on the left in **Figure 1**. The lower one is connected to the Stamp reset pin; the upper one isn't used and not necessary (it's left over from an earlier design).

The six-pin SIP I used on the prototype isn't available from Jameco anymore; the one on the **Parts List** has four resistors (eight-pin). The **schematic** shows how the first resistor is just shorted out on the battery dividers.

The circuit board and barrier strip are mounted on a piece of 1/4" plywood. The blister pack that the RadioShack prototyping board comes in can be used as a cover for the circuit board by cutting some slots in the top for the diode and MOSFET tabs to go through.

The printed wiring board is the same basic **schematic** but the layout is different, and the solar panel and batteries are connected to it with a separate terminal strip. Although I made various mistakes on this version, it still works fine. An improved design has the screw terminal blocks mounted directly on the board, with no separate barrier strip to mount and wire. It also has an LED driven by the Stamp pin P3 that is on when there is enough solar panel capacity but none of the batteries are charging. That way, the only time there is no LED lit is when the Stamp is in the sleep state.

PARTS LIST

ITEM	DESCRIPTION	QTY	SOURCE
IC1	BASIC Stamp 1	(1)	Jameco 127693,
IC2	ADC 0834	(1)	Jameco 1252331
Q1, Q2, Q3	IRF 5305	(3)	Jameco 1559965
D1, D2, D3	MBR2535CT	(3)	Jameco 618097
Q4, Q5, Q6, Q7	2N3904 NPN	(4)	Jameco 178597
Q8	2N3906 PNP	(1)	Jameco 178618
D4, D5, D6	1N4001	(3)	Jameco 35975
LED1, LED2, LED3	LEDs (yellow)	(3)	Jameco 34825
C1	1 μ F tantalum	(1)	Jameco 94388
C2	10 μ F tantalum	(1)	Jameco 94080
SIP1, SIP2, SIP3, SIP4	10K isolated SIP	(4)	Jameco 856909
R1, R2, R3	2.2K 1/4 watt	(4)	
R4, R5, R6, R7, R8	5.6K 1/4 watt	(5)	
R9, R10	4.7K 1/4 watt	(2)	
R11	1K 1/4 watt	(1)	
R12	390 1/2 watt	(1)	
SW	Pushbutton switch	(1)	Jameco 153252
J1	Pin header	(1)	Jameco 103393
Barrier Strip, eight-position or			
Connector Terminal Block	Two-position	(1)	Jameco 152347, 5.08 mm
Connector Terminal Block	Three-position	(2)	Jameco 152355, 5.08 mm
16 or 14 gauge red/black DC power wire			
Battery clamps or cigarette lighter plug			

Testing and Operation

The solar panel is connected to the solar input, and a lead acid battery is connected to one of the battery outputs; double-checking the positive and negative connections. Connect wires to the barrier strip first, then connect to the battery. If the battery

The parts list is slightly different for the PCB version. There are terminal blocks on it and an extra 2N3904 transistor, LED, and 5.6K and 2.2K resistors. Those parts are not on the schematic, since they were added onto the PCB only and are not on the prototype board, either. It will still work fine without them. Check the article link for details on how to get the printed circuit board if you're interested.

voltage is less than 13V, the LED for that battery output will light. If the LED does not light and the battery voltage is above 13V, connect a load such as an automotive light bulb to the battery. If the battery is in a vehicle, opening the door will load it when the interior lights turn on. This will usually lower the voltage enough that the LED will light. Close the door or remove the load.

Once the battery voltage is above 14.2V, the LED will turn off. This will happen rather quickly if the battery is near full charge on a sunny day. This procedure is repeated for the other battery outputs. For operation, connect the other batteries to the barrier strip first, then the battery, and let the sun do the rest. To get the garage door opener working, connect its battery power leads to a 12 volt lead acid battery (it uses 1/4" female quick connectors) and the battery to the solar sequencer. It won't come on unless it is plugged into AC power. Connect a power inverter to the battery and plug the garage door opener into it, or use a long extension cord (or generator) to plug into AC power. I used a 400 watt inverter, but 100 is probably enough as long as it doesn't have to open the door. The garage door opener's LCD display will show "charging battery."

Unplug it and it will continue to run on the battery. The display will still alternate between time and temperature, and the time can still be set. The only things I don't like

are the display always scrolls "battery backup enabled" across the bottom; if the voltage drops below 12.5, it will beep every minute, and there is an orange LED on all of the time. The lights also don't work — they need AC power — but the Harbor Freight solar panel kit comes with two nice 12 volt fluorescent lights that can be wired up separately (just not turned on by the garage door opener). I have been using the prototype version of this design with the garage door opener for a year now, but only for six months with the Jeep's old battery. It was a fun project, and a great way to use solar energy to power the garage. **NV**

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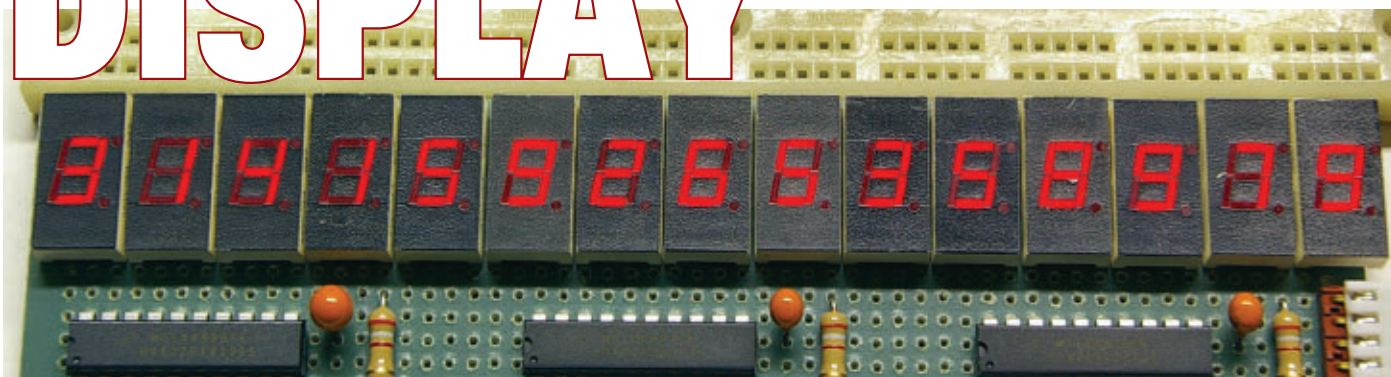
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BUILD THE PI SCROLLING DISPLAY



By Dan Gravatt

I like the look of seven-segment LED displays and came up with a couple of fun applications for them: a scrolling display of the digits of pi (3.14159...) and my own desktop version of the National Debt clock. The five-digit Freescale MC14489 can be daisy-chained to support displays of more than just five digits, so I settled on stringing three of them together for a 15-digit display. This is long enough to give a pleasing appearance when scrolling, and to display all the digits of the national debt (at least for now). This is a versatile system which can be adapted to plenty of other uses, too.

Coding and Math

My original plan for the scrolling pi display was to use a PIC microcontroller to actually calculate the digits prior to displaying them. There are some fairly sophisticated formulae called “spigot algorithms” (see [sidebar](#)) available which can calculate each successive decimal digit without having to calculate the previous digits. It looked like they could be converted into PIC code. I found that my math skills weren’t sufficient to get these algorithms to work (even in a spreadsheet), though, so I never got to try to write the PIC code. Instead, I settled for downloading the first 1,100 or so decimal digits of pi and storing them in the PIC which displays them in a loop. The pi data is stored in the PIC’s Flash memory during device programming with the POKECODE instruction (take a look at the source code file at the article link). Be careful not to overwrite the program code!

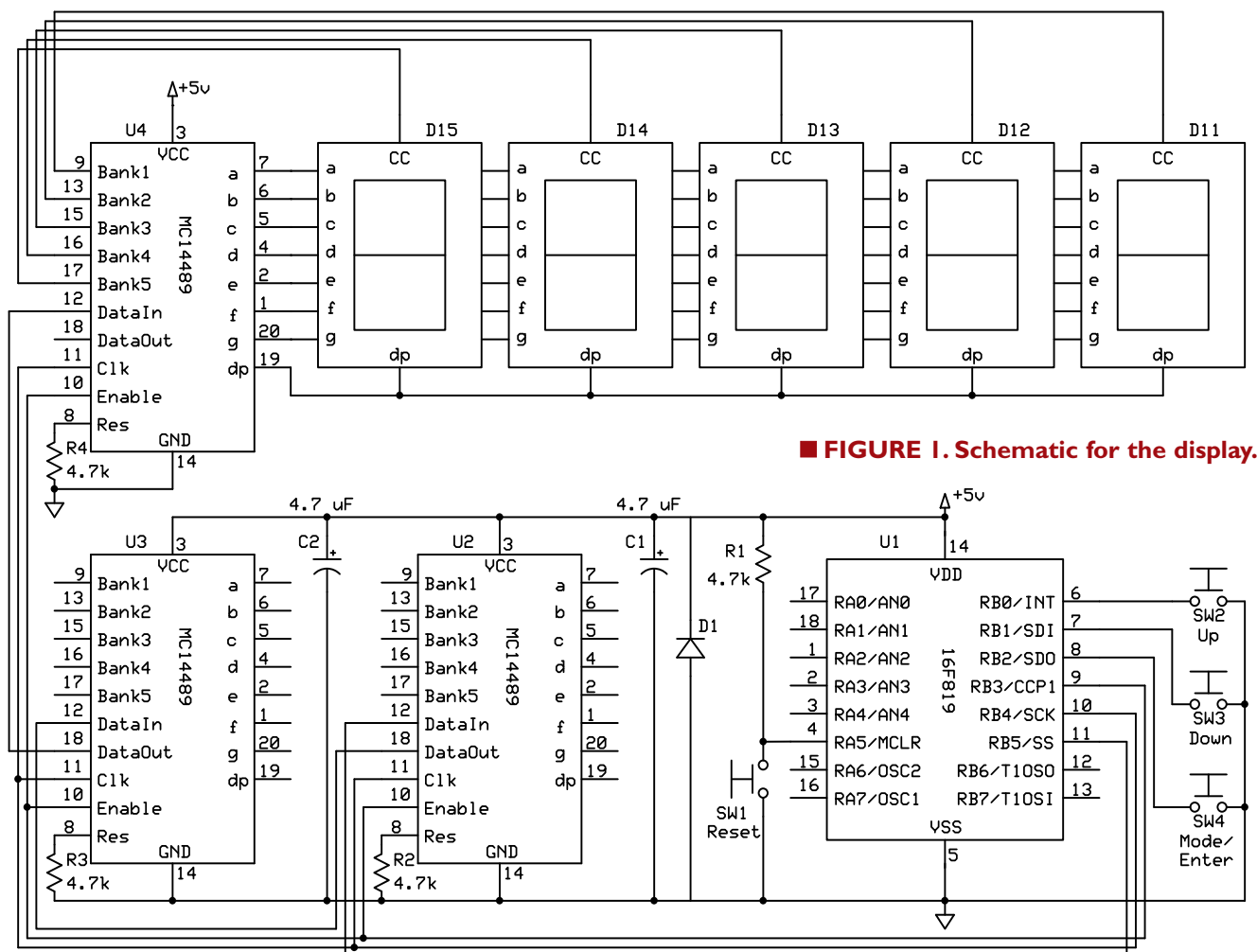
The math for the National Debt clock is very straightforward — all we need to do is look up the current amount of debt and the rate of increase, enter them into the PIC, and then keep a running total with time. This information is available at www.brillig.com/debt_clock, among other places. Take a look at the PICBASIC PRO

code (listing available at the article link) and the embedded comments to see how a 15-byte array variable is used to hold either the pi digits or the national debt value. Addition of the numbers for the national debt is done on a byte-by-byte basis within the array variable, carrying from one byte to the next as necessary.

Design

The MC14489 display drivers use a synchronous serial interface requiring three wires: data, clock, and enable. I selected a straightforward three-button user interface (up, down, and enter) to set the values for the National Debt clock. Since the display and the user interface are the only external interfaces for the PIC, a low pin count device is all that is needed.

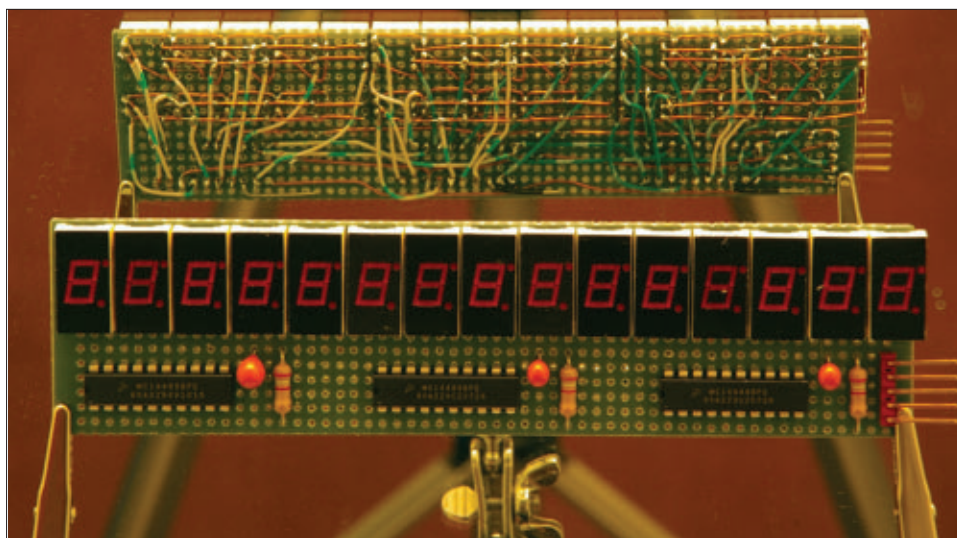
I did want to store as many pre-calculated digits of pi in the PIC as possible, so I looked for a device with a fair amount of memory. The closest device I had on hand was a 16F819: an 18-pin device with 2K words of Flash. Other 18-pin devices with more memory (such as the 16F87 or 16F88) could also be used. The schematic is shown in **Figure 1**. I have omitted the LED displays for digits 1-5 and 6-10 for clarity, since they wire up the same as for digits



11-15. The user interface and MC14489 interface are on port B. This takes advantage of the available weak pull-ups on this port for the input buttons; it also reduces the parts count. The 16F819 has the option of using an internal oscillator and internal MCLR pull-up resistor which can free-up additional pins on port A. In this design, I have MCLR pulled up externally so the PIC can be easily reset. I am using the PIC's internal oscillator to free-up I/O pins RA6 and RA7 for future use, and I set the oscillator frequency to 4 MHz by configuring the OSCCON register in the code. Several other I/O pins on port A and port B are available to add other functions, sensors, etc., to the circuit, or to interface the display module to external systems.

When you program your PIC, you will need to select the

"INTIO2" oscillator configuration option to enable the internal oscillator. Note that not all programmer software



■ **FIGURE 2. Front and back of the prototype display; note the rat's nest of point-to-point wiring.**

The National Debt Clock

The official National Debt clock is a billboard-sized running total dot-matrix display which constantly updates to show the current United States gross national debt and each American family's share of the debt. It is currently installed on Sixth Avenue (Avenue of the Americas) in Manhattan, New York City.

The idea for the clock came from New York real estate developer Seymour Durst, who wanted to highlight the rising national debt. In 1989, he sponsored the installation of the first clock which was erected on 42nd Street close to Times Square. At the time, the national debt remained under \$3 trillion, but was rising. The clock was temporarily switched off from 2000 to 2002 due to the debt actually falling during that period.

In 2004, the original clock was dismantled and replaced by the current clock at the new location one block away. In 2008, the US national debt exceeded \$10 trillion for the first time, leading to press reports that the clock had run out of digits.

The original clock outlived Seymour, who died in 1995, with Seymour's son Douglas taking over the responsibility for the clock through the Durst Organization. As of September 2009, Douglas Durst's cousin Jonathan "Jody" Durst — with whom he shares a co-presidency of the company — is in the process of taking over the day-to-day operations as president. In an interview with *The New York Times*, Jonathan Durst has said that maintenance of the clock is planned "for years to come."

Douglas Durst has been quoted as saying that the clock represents a non-partisan effort; he has further explained the motivation behind the project in terms of intergenerational equity: "We're a family business. We think generationally, and we don't want to see the next generation crippled by this burden."

According to Douglas, his father had been toying with the basic idea of drawing attention to the growing national debt since at least 1980, when during the holiday season he sent cards that said "Happy New Year. Your share of the national debt is \$35,000" to senators and congressmen. In the early eighties (when Durst first developed the idea of a constantly updated clock), the technology required to implement the project was not yet available.

First Clock

With the national debt at 2.7 trillion, the original 11 by 26 foot (3.4 × 7.9 m) clock was constructed at a cost of \$100,000. It was mounted a block from Times Square on a Durst building at Sixth Avenue near 42nd Street; it faced the north side of 42nd Street and Bryant Park across the intersection. Built by the New York sign company Artkraft Strauss, the clock featured a dot-matrix display with the then-typical character resolution of 5x7. Similar to the second clock, the updating mechanism was such that the display was set to the estimated speed of debt growth (odometer-style) and adjusted weekly according to the latest numbers published by the US Treasury. Up until the week before his death, Seymour himself adjusted the tally via modem. Since his passing, Artkraft Strauss has been keeping the figures current.

In 2000 — due to an improving debt situation — the clock started to run backwards. With the original purpose of the clock being to highlight the rising debt and the reverse giving a mixed message (and with the display not



being designed to properly run backwards), the clock was unplugged and covered with a red, white, and blue curtain in September 2000, with the national debt standing at roughly \$5.7 trillion. The clock was not dismantled, however, and in July 2002 the curtain was raised and the clock once again picked up tracking a rising debt, starting at \$6.1 trillion.

Second Clock

In 2004, the original clock was moved from its location near 42nd Street; the building has since made way for One Bryant Park. An updated model — which can run backwards — was installed one block away on a Durst building at 1133 Avenue of the Americas (Sixth Avenue). It is mounted on the side wall of the building which faces West 44th Street. The new clock is outfitted with a dot-matrix display of higher resolution than its predecessor which emulates the customary seven-segment numeral patterns, allowing the numbers to be read more easily.

In the midst of extensive media attention during the financial crisis beginning in 2007, some news reports mentioned the National Debt Clock, highlighting the fact that its display had run out of digits when the US gross federal debt rose above \$10 trillion on September 30, 2008.

An overhaul or complete replacement adding two more digits to the clock's display is being planned.

Similar Projects

The German National Debt clock is located at the Berlin headquarters of the taxpayer watchdog group, Bund der Steuerzahler.

The idea of conveying a message through a periodically updated clock found an earlier expression in the Doomsday clock. However, the innovation of the National Debt clock was to feature a constantly running counter; it has since inspired similar projects elsewhere, both in the US and further afield. Various tracking counters of national debt are also kept online.

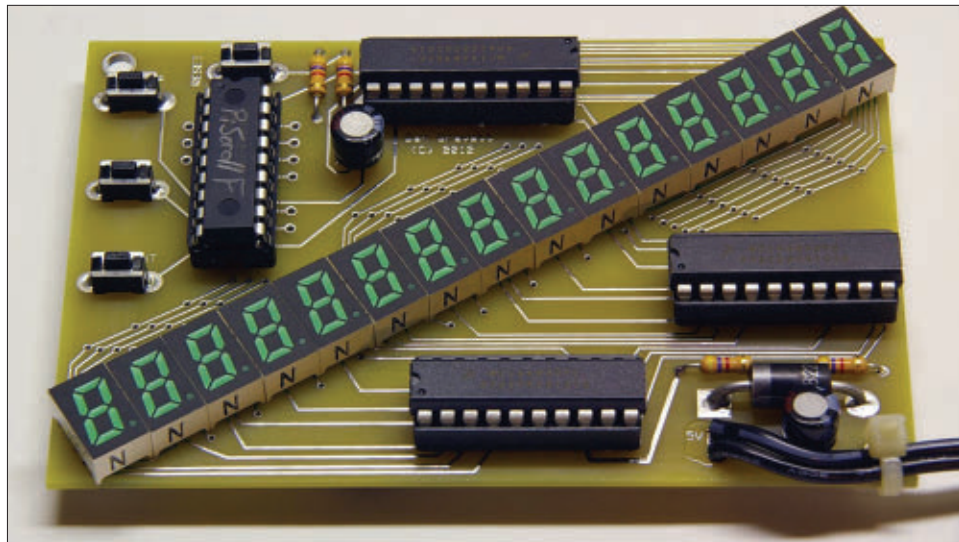
The National Debt clock has been credited as the inspiration behind other running totalizers, for example, an AMD campaign employing an electronic billboard; instead of a debt, it tracked the supposed additional cost of using a rival chip.

For more details on this, visit Wikipedia.org.

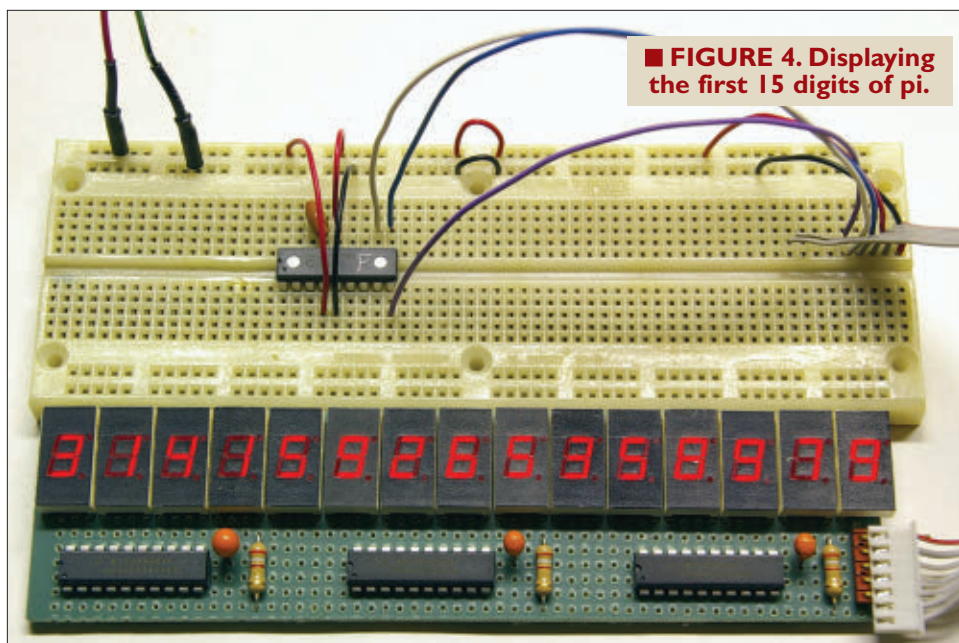
SPIGOT ALGORITHMS

A **spigot algorithm** is a type of algorithm used to compute the value of a mathematical constant such as π or e . Spigot algorithms are unique because they do not require the total number of digits to be fixed beforehand, and do not require the computation of several intermediate results which are combined to produce the final result. There are two kinds of spigot algorithms: (1) those that can produce a single, arbitrary digit (also called **digit extraction algorithm**); and (2) those that produce a sequence of digits, one after the other. The Bailey-Borwein-Plouffe formula is a digit extraction algorithm for π which produces hexadecimal digits.

A sequential spigot algorithm for π was produced by Stanley Rabinowitz and Stanley Wagon (this algorithm is sometimes referred to as “the spigot algorithm for π ”). Spigot algorithms that produce a sequence of digits begin producing digits and produce them continuously, rather than waiting for the entire algorithm to finish. Spigot algorithms are known for π and e . Spigot algorithms typically work in a particular radix, such as hexadecimal or binary number. [From Wikipedia.]



■ FIGURE 3. Layout of the PCB with a diagonal arrangement of the LED displays.



■ FIGURE 4. Displaying the first 15 digits of pi.

Dan Gravatt can be reached at dgravatt@juno.com.

uses Microchip’s standard name for this option; my software calls it “IntRC.”

The Build

The MC14489 makes it very easy to interface a microcontroller with common-cathode LED displays, but there is still a lot of wiring needed to multiplex those displays and connect them to the drivers (**Figure 2**). This is clearly a project that needs a custom printed circuit board (PCB) to be practical. I like ExpressPCB’s mini-board service because it’s very reasonably priced, but the fixed

board size (3.8” by 2.5”) seemed too small to hold 15 LED displays plus the PIC and driver chips. After scouring parts suppliers to find small displays and dusting off my trigonometry skills to align them diagonally across the board, I came up with the board layout in **Figure 3**. ExpressPCB doesn’t allow components to be placed at odd angles like this, so I had to create a custom pad array from scratch to fool the software into aligning the displays at the proper angle of about 31°. The displays I selected are made by Rohm; they come in several colors, and each LED display is only 7 mm wide with a character height of 8 mm or 0.31 inches. It’s a tight fit with a lot of curving

PARTS LIST

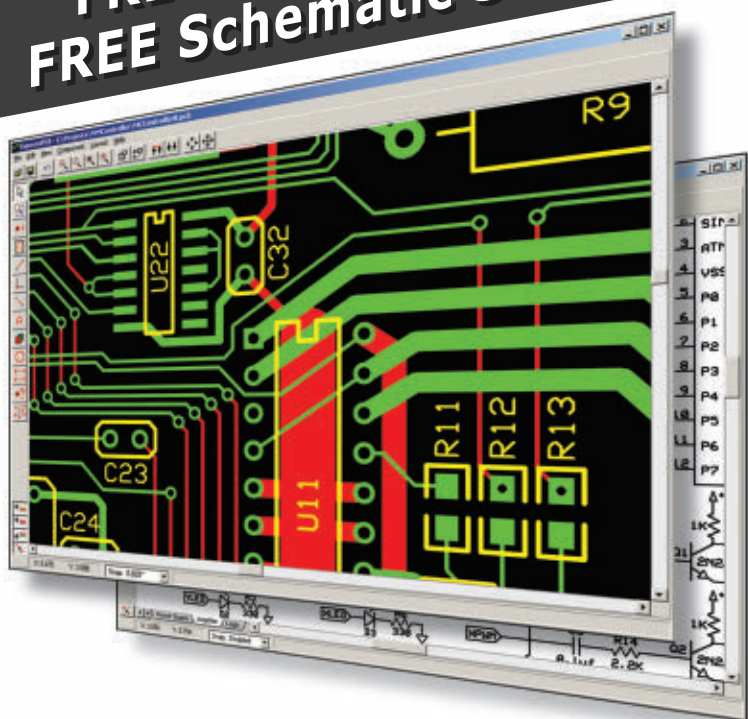
ITEM

PIC 16F819 microcontroller, 18-DIP
 (3) MC14489 five-digit LED display driver, 20-DIP
 (15) Seven-segment common-cathode LED display
 (4) Pushbutton momentary switch
 (4) 4.7K ohm 1/4 watt resistor
 (2) 4.7 μ F tantalum capacitor
 1N5401 diode
 (For info on programmed PICs and circuit boards, check for details at the article link.)

DIGI-KEY PART#

PIC16F819-I/P-ND
 MC14489BPE-ND
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traces around the displays but it works, and the diagonal line of displays complements the look.

I recommend using sockets for the four ICs to reduce the risk of damaging them during soldering. However, if you plan to mount the board behind a panel or in an enclosure, note that the height of the chips in their sockets exceeds the height of the displays themselves. The bypass capacitors can also be mounted horizontally to keep them below the plane of the displays. I have included extra pads on the unused I/O pins on the PIC so you can "roll your own" ICSP interface if you choose to solder the chips to the board (though you will have to add a diode between the MCLR pin and its pull-up resistor to protect the rest of the circuit from the programming voltage).

Scroll That Beautiful Pi Footage

The display defaults to scrolling the digits of pi on power-up (**Figure 4**). After scrolling all the digits, the display will pause and then restart from the beginning. If you press and hold the mode/enter button while powering up or resetting the PIC, the display enters National Debt clock mode.

First, you will enter the current value of the debt, starting with the most significant digit and using leading zeros as necessary. Select each digit with the up and down buttons, then press enter to adjust the next digit. Then, enter the rate of increase of the debt — in dollars per second — in the same manner.

Now, you can watch our debt pile up in near real time, or have a more relaxed experience watching pi scroll by. **NV**

Projects for the Electronics Enthusiast

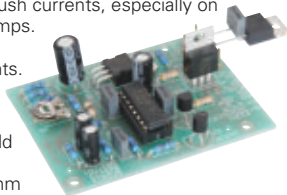
AUTOMOTIVE KITS

10A 12VDC Motor Speed Controller

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Ideal for controlling 12V DC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. You can also use it for headlight dimming and for running 12V DC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Includes PCB and all electronic components.

- Kit includes PCB plus all electronic components to build the 10A version.
- PCB size: 69 x 51mm

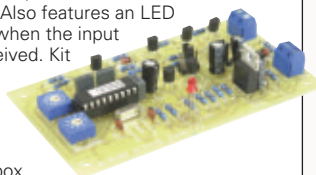


Speedo Corrector MkII

KC-5435 \$39.75 plus postage & packing

When you modify your gearbox, different ratio or change to a large circumference tyre, it may result in an inaccurate speedometer. This kit alters the speedometer signal up or down from 0% to 99% of the original signal. Also features an LED indicator to show when the input signal is being received. Kit supplied with PCB with overlay and all electronic components.

- Recommended box UB5 (use **HB-6013 \$2.50**)
- PCB size: 105 x 61mm

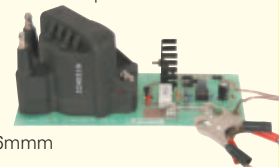


Jacob's Ladder High Voltage Display Kit MK2

KC-5445 \$31.00 plus postage & packing

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

- PCB size: 170 x 76mm



KIT OF THE MONTH

Ultrasonic Antifouling for Boats

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

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

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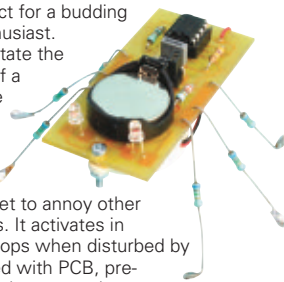


Crazy Cricket and Freaky Frog Kit

KC-5510 \$14.50 plus postage & packing

A fun first project for a budding electronics enthusiast. Designed to imitate the chirping noise of a cricket or gentle croaking of a frog (alternates at power up), while keeping its location secret to annoy other family members. It activates in darkness and stops when disturbed by light. Kit supplied with PCB, pre-programmed IC, battery and electronic components.

- PCB size: 30 x 65mm



Marine Engine Speed Equaliser Kit

KC-5488 \$25.00 plus postage & packing

Avoid unnecessary noise and vibration in twin-engine boats. The Engine Speed Equaliser Kit takes the tach signals from each motor and displays the output on a meter that is centred when both motors are running at the same RPM. When there's a mismatch, the meter shows which motor is running faster and by how much. Simply adjust the throttles to suit. Short form kit only, requires moving coil panel meter (**QP-5010 \$11.25**).

- 12VDC
- Kit supplied with PCB, and all electronic components
- PCB size: 105 x 63mm



Frequency Switch

KC-5378 \$27.50 plus postage & packing

The switch frequency can be set to trip when it is rising or falling, and it features adjustable hysteresis (the difference between trigger on/off frequency). You could configure it to trigger water spray cooling on deceleration, shift light activation, adjustable aerodynamics based on speed, intake manifold switching and much more. It uses a standard tachometer, road speed, or many other pulse outputs to switch a relay. Kit supplied with PCB, and all electronic components.

- PCB size: 105 x 60mm



Car Battery Monitor

KA-1683 \$13.00 plus postage & packing

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- Kit includes PC board and all components
- PCB size: 62 x 39mm



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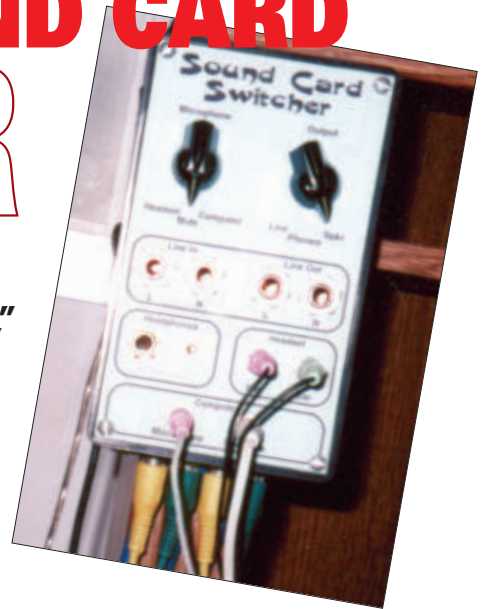
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STREAMLINE YOUR HOME STUDIO WITH A SOUND CARD SWITCHER

BY THOMAS HENRY

Way back, in a previous “Developing Perspectives,” editor Bryan Bergeron sketched out some of the logistics of setting up a legitimate home recording studio. This article focuses on one of the more important parts of any setup: the computer sound card.



This device is at the heart of all the analog-to-digital and digital-to-analog activity in the typical home studio. For example, the sound card interacts with the following equipment in my arrangement:

- Computer loudspeakers
- Large over-the-ears headphones
- Small foam-type headphones
- PC mounted microphone
- Headset with earpiece and microphone
- Cassette deck
- Guitar amplifier
- Musical instruments (guitar, synthesizer, drum box, etc.)
- MIDI gear

The trouble is, the typical sound card does so much that it's often a hassle to dig around behind the computer to unplug the patch cords and hook up different ones for a new task. After tolerating this awkwardness for way too many years, I finally decided to do something about it and came up with the sound card switcher. Now, with the flip of a switch (and no rummaging around on my hands and knees behind the computer case) I can rapidly reconfigure things for any number of different audio operations. Sure, it's a simple idea, but you simply wouldn't believe how quickly I can get down to making music now instead of fighting patch cords. If this sounds like something that would improve your efficiency, then read on.

Connect it Once and Leave it Connected

The general idea is to come up with a rig that will

accommodate all of your gear. Any patch cords are left connected, and then it's the switches on the front panel that steer the signals to various points. For example, I enjoy burning old tapes to CD, so I leave a cassette deck permanently connected. Sometimes I like to record my electric guitar or homebrew synthesizer; again, I leave both in place. Often, I'll use the computer speakers for playback, but at other times I might prefer headphones. I might even employ a joint headset (microphone and earpiece) for vocal narration. In each of these cases, however, all I have to do is flip a switch to arrive at the patch I want. I'll show you the way I set up my sound card switcher, but obviously, you can readily customize it to match your own requirements.

Incidentally, this makes an excellent weekend project for newcomers to electronics. There's nothing particularly hazardous or difficult about its construction. Since it uses point-to-point wiring throughout and not a printed circuit board, it offers a chance to practice good soldering techniques with very little up-front investment. Last but not least, the beginner will also learn something about the logic of circuit tracing as he or she chases down the signals from one jack to the next. All in all, the sound card switcher is an excellent learning exercise besides being eminently useful.

How it Works

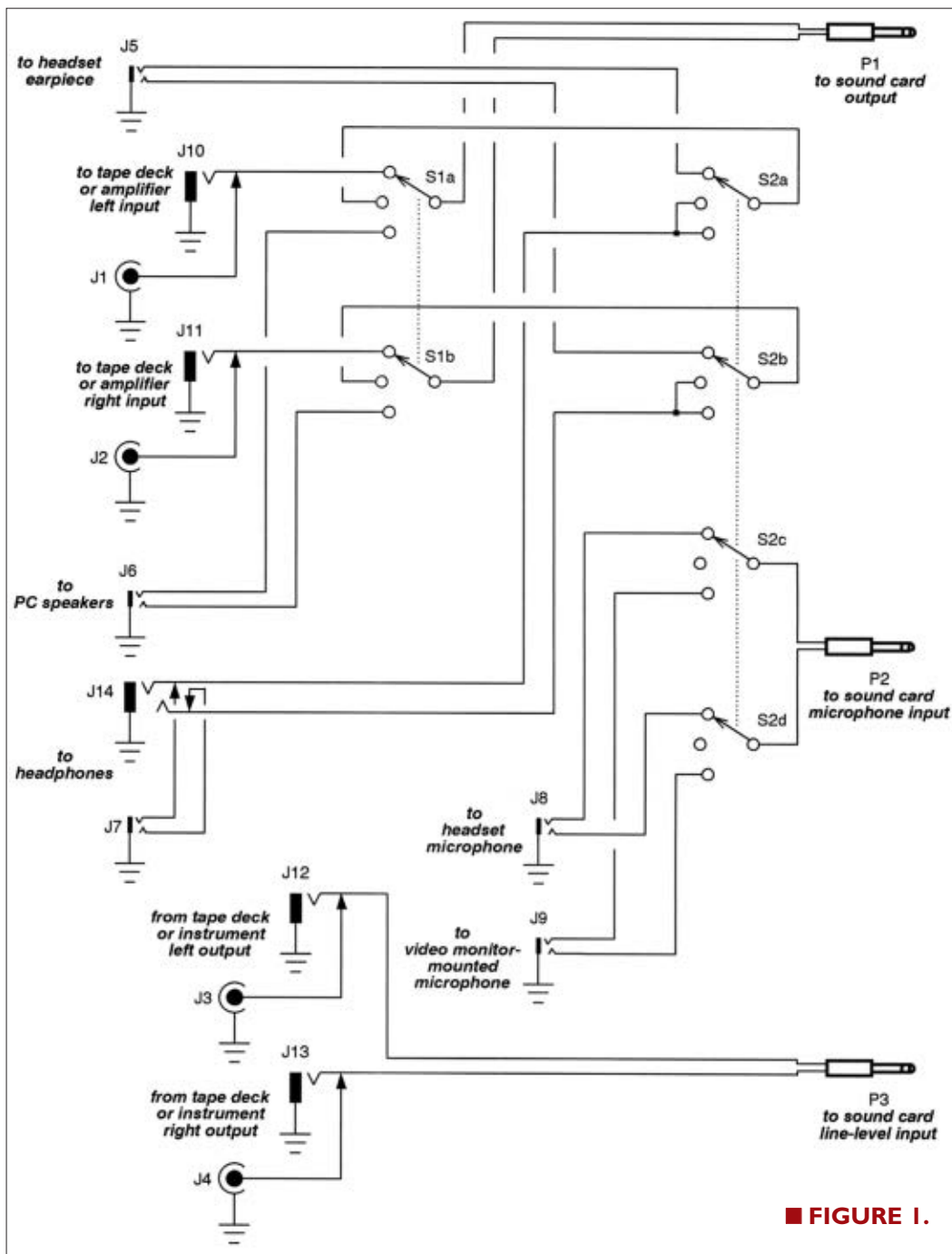
Refer to **Figure 1** which shows the schematic. To avoid getting lost in the spaghetti wiring, keep the overall idea in mind. In particular, there are two main controls: the output switch (S1); and the microphone switch (S2).

Obviously, the latter chooses among the various

microphones in the system, while the former routes the output signal to whatever speakers, headphones, amplifiers, etc., you may have. If you've got the big picture in mind, then the details shouldn't be too troublesome.

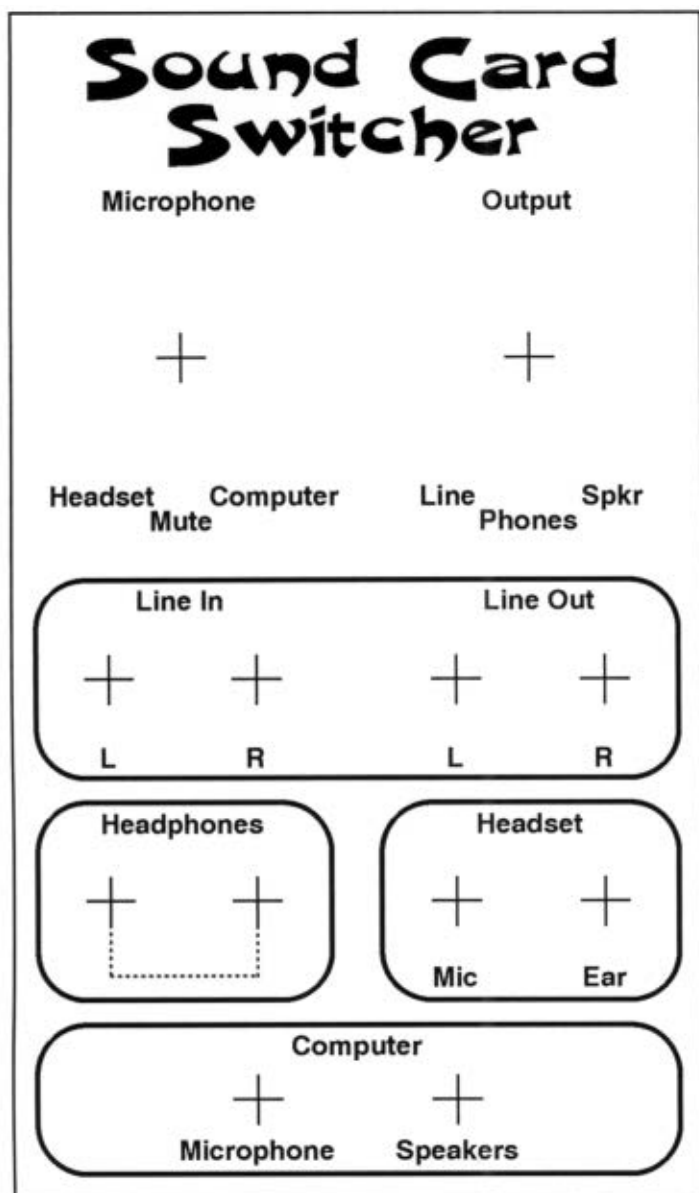
Let's handle the line-level inputs to the computer's sound card first. (Most sound cards have a line-level input, as well as a separate low level microphone input). J3 and J4 are RCA jacks which is the type commonly used on cassette decks. So, the left and right outputs of the deck connect to these guys. Notice that J12 and J13 are normally-closed switching jacks; these are 1/4 inch phone jacks — the size most often needed by musical instruments. If nothing is plugged into them (which is the norm in my studio), then the cassette deck signals make it through unimpeded. If you plug a guitar or music synthesizer into either J12 or J13, then the cassette connection is broken automatically and replaced with an instrument. In this neat way, we can cut down on the number of switches required. By the way, plug P3 is permanently connected to your sound card line-level input. The size is 3.5 mm which is also referred to as a mini-phone plug.

What about the microphones? I have a neat little one permanently connected to the front of the PC video monitor at mouth level, but sometimes I also use the one which is part of a headset. The sound card switcher can accommodate both. The headset mic connects to jack J8, while the monitor-mounted one goes to J9. Both of these are mini-phone jacks, but note they are two conductor types (ring and tip, with ground assumed) since microphones for PCs are generally powered affairs. One conductor provides DC to the microphone, while the other passes the audio.



■ FIGURE 1.

Let's pause for a moment to look over S2 — the microphone switch mentioned earlier. This consists of four electrically independent sections which are mechanically switched simultaneously as the knob is turned. In brief, S2 is a 4P3T rotary switch which is a pretty standard item even if it does sound weird. Now, J8 and J9 thread their way to switch sections S2c and S2d, respectively. Observe that the center terminal of both are left unconnected. This allows you to rapidly mute the microphones with a twist of the wrist should acoustic feedback get the better of you. The upshot is, then, that you can select one microphone, the other, or none at all if silence is what



■ FIGURE 2.

PARTS LIST

ITEM	DESCRIPTION
Plugs	
P1 - P3	Stereo 3.5 mm mini-phone plug
Jacks	
J1 - J4	RCA jack
J5 - J9	Stereo 3.5 mm mini-phone jack
J10 - J13	1/4 inch, mono N.C. phone jack
J14	1/4 inch, stereo N.C. phone jack
Switches	
S1	DP3T rotary switch
S2	4P3T rotary switch
<i>(S1 can also be a 4P3T switch; just ignore two of the sections).</i>	
Miscellaneous	
Shielded cable, solder, knobs, project case, etc.	

you're after. Finally, the wipers of S2c and S2d lead to mini-phone plug P2 which is permanently connected to the microphone input of the computer's sound card.

We'll get back to the other two sections of S2 in a moment, but let's see how the loudspeakers are handled next. Jack J6 (a stereo mini-phone affair) is where these connect. If you trace the wiring, you'll see that these (left and right channels) work their way to the bottom lugs of S1a and S1b. Obviously, S1 is a DP3T switch and is the unit called output referred to previously. To make inventory control manageable, you can simply use a duplicate of S2 by just ignoring two of the sections.

Okay, supposing the wiper of S1 is in the lower position, then the speaker lines are routed directly to mini-phone plug P1 which is permanently attached to the speaker output of the computer's sound card. We therefore have normal loudspeaker operation accounted for. Remember, though, there are a couple of options for headphones, as well. Let's tackle them next.

Most fancier over-the-ears headphones terminate through a larger 1/4 inch stereo phone plug, while smaller foam types or ear buds sport a 3.5 mm connector. The sound card switcher can handle both. J14 is the larger of the two, while J7 is the mini unit. Both are stereo, obviously, but notice that J14 is a normally-closed switching jack. Thus, anytime you plug in the big set it will override the smaller phones automatically. Again, this cuts down on the number of switches needed. Obviously, you'll only want one set of headphones operable at any given moment.

So, J14 or J7 wind their ways to S2a and S2b. You'll note that in either the middle or bottom position of these switch sections, the headphones are permitted to pass on to S1. The middle position of S1, in turn, shoots the signal to plug P1 as we saw earlier. In a nutshell, S1 chooses between the loudspeakers or the headphones.

Sometimes a person likes to use a headset (microphone and earpiece all in one). We've already seen how the microphone connection of this was handled via J8, S2c, and S2d. Now, notice that mini-phone jack J5 accepts the earpiece connection in the headset. This goes directly to switch sections S2a and S2b, and the signals can be routed to plug P1 in much the same way as the external headphones were through S1.

Finally, there will be occasions when you don't want the sound card output to go to the loudspeakers or the headphones but rather to a tape deck, stereo system, guitar amplifier, etc. You'll observe that this is possible through the top position of switch S1. In particular, the output from the computer feeds plug P1 which then goes to the wipers of S1a and S1b. These, then, are passed to 1/4 inch phone jacks J10 and J11.

You could patch these to a guitar amplifier, for instance, since that's the normal size connector employed. Or, if you want to send the output to a cassette deck, say, then use RCA jacks J1 and J2. Notice that J10 and J11

implement the usual switching/override business.

So, What's Possible With It?

The convoluted wiring of **Figure 1** may have left you scratching your head a bit. Just to make sure you understand what all is possible as you customize things for your own setup, let me tell you how I flip the switches in my rig. Recall that S1 is the output switch, while S2 is the microphone switch. You might want to peek ahead to **Figure 2** which shows what the front panel looks like. On that, you can see the switch labels for each of the three positions which are:

S1 — Output:

- *Line*: The sound card output is routed to either J1/J2 (cassette deck) or J10/J11 (guitar amplifier).
- *Phones*: The sound card output is routed to headphones; S2 determines if these are headphones connected to J7 or J14, or the earpiece in a headset connected to J5.
- *Spkr*: The sound card output is routed to the PC loudspeakers.

S2 — Microphone:

- *Headset*: The microphone in the headset is used at J8, and the sound card output is routed to the earpiece in the headset at J5.
- *Mute*: No microphone is connected, but any headphones or speakers selected continue to work as usual.
- *Computer*: The monitor-mounted microphone is selected at J9, and the headphones at either J7 or J14 are used (not the headset).

Warm Up the Iron

Of course, your arrangement may turn out differently from mine depending on the gear you expect to hook up. To let you in on the possibilities, here's how I built my sound card switcher.

You'll want to start by gathering all of the components. The **Parts List** shows the items I used, but your shopping list will probably be a little different to cover your requirements. In any event, none of the parts are particularly hard to come by. For example, Jameco and All Electronics (both advertisers in this magazine) have a very wide selection of switches, plugs, and jacks sure to match what you need for your rendition.

By the way, I was able to find everything I required in my electronics junk box and so didn't have to spend a cent.

I housed the entire thing in a plastic project box rescued from the trash, believe it or not. The front cover is aluminum and secured in place with four small machine



■ **FIGURE 3.**

bolts. The dimensions weigh in at 6 x 3-1/2 x 2 inches. This appears to be a standard size (at least the cover plate is), so you could probably employ the front panel design shown in **Figure 2** without change. What I did was print the pattern out on a light blue card stock, laminate it with clear sticky-back film, and glue the entire label to the aluminum panel with rubber cement. You could follow suit, if desired, simply by photocopying **Figure 2** on some card stock of your own choosing. By the way, the **figure** also serves as the drilling guide; the crosshairs show where to aim the drill bits.

Figure 3 is a photograph of my rig mounted right on the computer desk within easy reaching distance. As you can see, both switches and most of the jacks appear on the front panel. However, the four RCA jacks (which go to the cassette deck in my situation) are mounted on the bottom of the case. The three sound card cables also exit the box at the bottom.

As for the wiring, as mentioned previously everything was done point-to-point inside the enclosure. Since this was mostly plastic, you might be concerned about 60 cycle hum. It wasn't a problem since I used shielded cabling throughout and also kept the connections short.

Keep in mind that most sound cards also come with a MIDI port. This needs a few additional components to make it match the true MIDI electrical standard, but it could easily be combined with the sound card switcher to unlock every aspect of the card. (I gave the details in "A Do-It-Yourself Sound Blaster 16 Interface," in the April 1997 issue of *Nuts & Volts*, pp. 41-43.)

The sound card switcher has revolutionized the way I work at the computer. Instead of putzing with cables, I can literally start recording or playing back any audio project within one second. So, while this passive gadget will hardly win awards for intricacy, it surely deserves points for usefulness. Anyway, that's my story and I'm sticking with it! **NV**

UPGRADE YOUR 16-BIT MICRO EXPERIMENTER TO 32-BIT FOR 16x2 PROCESSING Power!

BY THOMAS KIBALO

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

The 16-bit Experimenter was introduced in the December '09 issue of Nuts & Volts. This Experimenter targeted Microchip's 16-bit microcontrollers and is equipped with a +3.3V regulated power supply, a 16x3 LCD display, four pushbuttons, a 32K EEPROM, 10-pin I/O expansion bus, a 32 kHz clock crystal, and the Microchip ICSP interface for programming and debugging. The Experimenter form factor was made for easy insertion into solderless breadboard environments. Now, what if we told you that you can now use a 32-bit processor with this same Experimenter? Take a look at Figure 1.

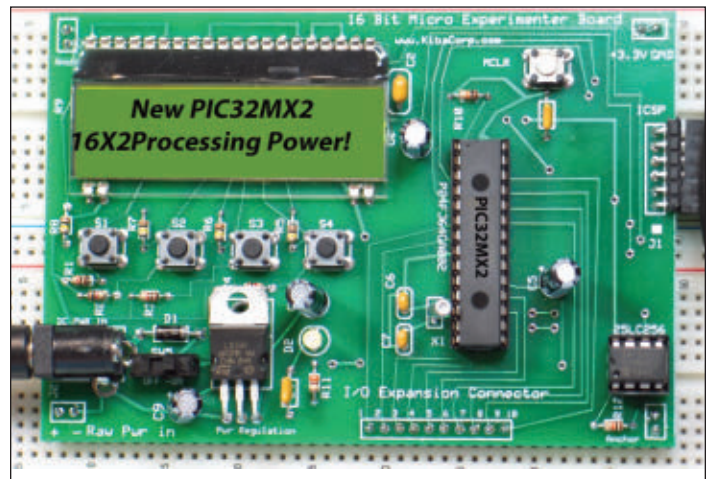


FIGURE 1. The 16-bit Experimenter upgrade.

The folks at Microchip have created a PIC32MX2/MX1 chip that is a 28-pin SDIP which is pin-compatible to the Experimenter. With this simple chip replacement and the new MPLAB X IDE and free PIC32-bit C compiler, you can easily transition to 32-bit processing.

Let's call the new configuration the "16x2 Experimenter" to usher in a new era for 32-bit Experimenter processing power. Sound interesting? Well, we are going to walk you through this. As an added feature, we will also briefly cover the newly released MPLAB X IDE, and show how this — along with the 16x2 Experimenter — can work in a series of 32-bit processing demos using either the PICkit3 or the Microstick II series of programmer/debuggers. All the demos are written in C code using the PIC32 library. Explanations will be kept straightforward, but some familiarity with C programming is required.

Let's kick it all off with an in-depth look into the

PIC32MX2 microcontroller before launching MPLAB X and the demos.

The New Microchip PIC32MX2 Microcontroller — An Overview

The PIC32 32-bit microcontroller is the top performer in Microchip's product family. The PIC32 offers significant enhancements in speed and performance over all the other members of the Microchip product family. If you require high-end performance for your microcontroller application and want to explore the best in class for 32-bit microcontrollers, then the PIC32 is the processor for you.

Microchip recently released their new PIC32MX1 and MX2 series (see **Figure 2**). This small form factor PIC32 comes in a skinny DIP 28-pin part, and is our ticket for an Experimenter upgrade. To understand the significance of

the upgrade, let's compare the PIC32MX2 to the PIC24FJ64GA002 (the original 16-bit microcontroller used on the Experimenter), then to the PIC16F887 (a widely used eight-bit microcontroller).

In **Table 1**, the MIPS (Millions of Instructions Per Second) metric is used to capture execution performance. As illustrated, the PIC32 runs 2X faster than the PIC24F, and 5X faster than the PIC16. The PIC32MX2 also executes instructions with 32 bits, versus 16 and eight bits used by the other family members.

Note the block diagram of the PIC32 internals in **Figure 3**. Like the PIC24F, it is also a +3.3V part; however, it can accept +5V logic level inputs on certain pins without damage. The PIC32 has two internal busses. The top bus is the faster of the two and runs at the system CPU clock rate. This bus allows simultaneous communications for devices without bus contention. Devices on this bus are the 32 Core CPU, the eight channel DMA (Direct Memory Access) controller, and USB. Other components on this bus are Flash, RAM, an interrupt controller, all the digital ports, and a peripheral bridge (a connection to all the on-chip peripherals). It is interesting to note that digital ports reside on the high speed bus. This means they can be toggled (on/off) at the 40 MHz rate, to be able to generate digital signals of up to 20 MHz if needed. With the use of DMA, this port (or any other peripheral) can access memory directly without CPU (software) intervention for data transfers.

The other bus is the peripheral bus that connects to all the on-chip peripherals. It does not need to run as fast as the previous bus, and can be slowed down to a factor of 1 to 8 (peripheral clock rates are not required to be run as high as 40 MHz). On this bus, there are five 16-bit timers, an RTCC (Real Time Clock Calendar), two UARTs (Universal Asynchronous Receiver Transmitters), two SPIs (Serial Peripheral Interfaces), two I²Cs (Inter-Integrated Circuits), 13 channel 10-bit ADCs (Analog-to-Digital Converters), one PMP (Parallel Master Port), five CCP (Compare/Compare Ports), three analog comparators, and the new CTMU (Charge Time Measurement Unit) peripheral.

Upgrading the Experimenter

A block diagram of the Experimenter is shown in **Figure 4**. The only real change is the replacement of the existing PIC24F 16-bit part with the PIC32MX2 32-bit part. It is that simple. The rest of the hardware remains the same because the folks at Microchip have maintained a common pin-out and functionality across the device class of 28-pin SDIP microcontrollers. This fact also allows the Experimenter to use not only the PIC32MX2, but also the new advanced dsPIC33, PIC24H 16-bit machines. Note that because the PIC32MX2 PPS (Programmable



FIGURE 2. Microchip's new PIC32MX 2 small form factor.

PIC32MX2	PIC24F	PIC16
32-bit	16-bit	Eight-bit
32 Flash	64K Flash	8K Flash
8K RAM	8K RAM	386 RAM
40 MIPS	16 MIPS	5 MIPS
3.3V operation	3.3V operation	5V operation

Table 1.

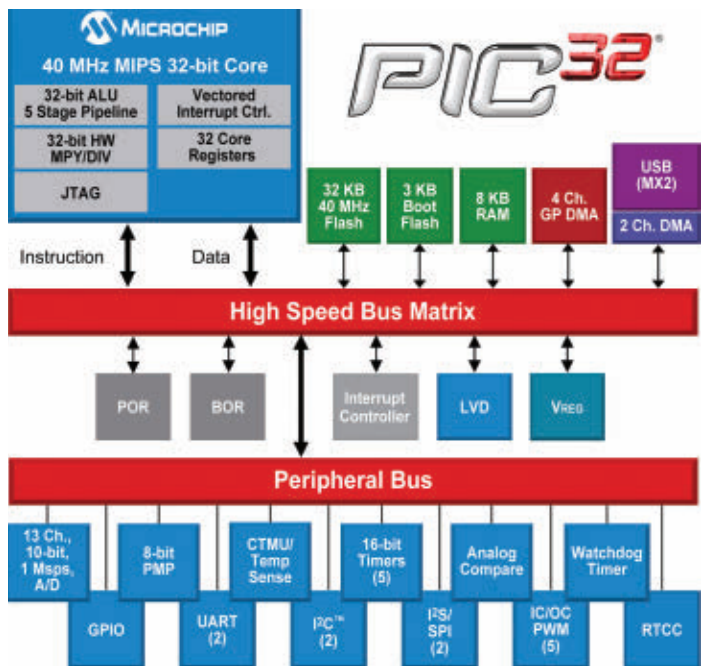


FIGURE 3. PIC32MX block diagram.

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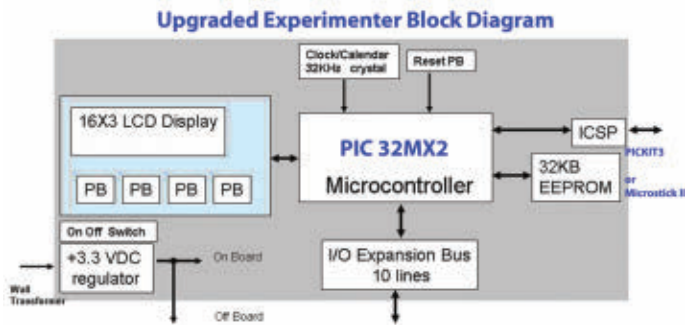


FIGURE 4. The 16x2 Experimenter block diagram.

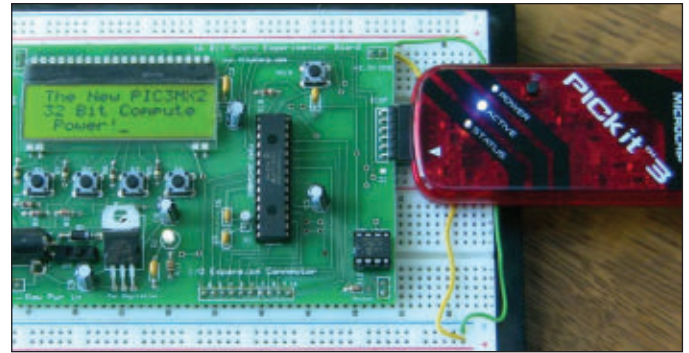


FIGURE 5. The 16x2 Experimenter using PICKit3.

Peripheral System) is slightly more restrictive than the 16-bit family's PPS, the Experimenter 32KB EEPROM cannot be accessed onboard by the PIC32MX2.

To access it, you must remove it from the board, plug it into a solderless breadboard, and use the I/O expansion bus for connection. (If you'd like some help with these new advanced 16-bit processors, *Nuts & Volts* is offering a new book, the *Beginner's Guide to Programming the PIC24H/dspPIC33* that focuses on these 16-bit parts.)

Programming and Debugging Options

The PICKit2 originally used with the 16-bit Experimenter does not support the new PIC32MX parts. Some low cost options that are available include the PICKit3 or the new Microstick II programmer/debugger. The PICKit3 uses the existing 16x2 Experimenter ICSP interface in the same manner as the PICKit2. It just plugs in from the side (see Figure 5). The Microstick II is made

for directly plugging into solderless breadboards. With an adapter, it can plug directly into the 16x2 Experimenter processor onboard CPU socket and function as the debugger/programmer (see Figure 6). This adapter (see Figure 7) is also available from the *Nuts & Volts* webstore.

As with the PICKit3, the adapter requires external power to the Experimenter. To use the adapter, you need to remove the existing Experimenter microcontroller from its socket to enable plug-in; make sure the Microstick II is using the PIC32MX2. Both the PICKit3 and Microstick II with adapter work directly with MPLAB X.

MPLAB X

MPLAB X (see Figure 8) has become all the rage with the electronics community, and has recently received several industry awards. MPLAB X represents a significant departure from Microchip's existing 8.xx IDE series. It is part of a movement to open source framework based on Java NETBEANS versus proprietary based custom designed software. With MPLAB X, a whole new series of tools are made available, as well as potential enhancements from third party vendors. MPLAB X is required when using the new PIC32 MX2 parts. Some new MPLAB X features are:

- One-click make, program, and debug/execute operation.
- Support for multiple configurations within projects.
- Support for multiple debug tools of the same type, as well as support of multiple versions of the same compiler.
- Easy import of existing MPLAB 8 projects.
- Tracks changes within users own systems using local history.
- "Tasks" window to keep track of "loose ends" in code.
- New all-encompassing "Project Status" window.
- New "Navigation" window for fast, easy access to code.
- Built-in source code control.
- A new call graph feature for navigating complex code.

MPLAB X can reside with MPLAB-8.x.x installs, so you can retain both sets of tools. MPLAB X can be downloaded from www.microchip.com/pagehandler/

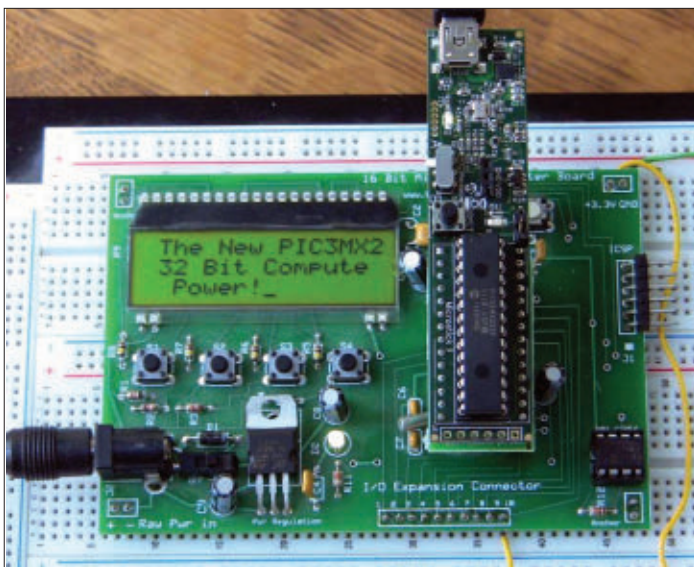


FIGURE 6. The 16x2 Experimenter using Microstick II.

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en-us/family/mplabX. It is aware of all the other Microchip system compilers and optional tools you may have installed on your system, and allows these components to exist simultaneously without conflict. You can set which component or tool set to use during initial project builds and then update or change them using the project dashboard.

We will use MPLAB X for our demos. In addition, we will use a new version of the C32 compiler to support the PIC32MX2 part. This can be downloaded from www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en534868.

The Demos

There are three demos to help you gain familiarity with the new PIC32MX and MPLAB X with the 16x2 Experimenter. These demos are briefly described here. The really cool thing about using the PIC32MX is that a lot of the original code written for the 16-bit microcontrollers can be directly ported to 32-bit operation with little modification. This is due in large part because of the compatibility that exists between the 32-bit and 16-bit on-chip peripheral set.

System.h contains all the PIC32 specific configuration settings and standard reference libraries (see below). For all the demos, a System.h is included in the project. It is here that the settings for the PIC32MX device configuration registers 3, 2, 1, and 0 are set and the reference is made to the PIC32 standard library. Note that all the demos are configured using the internal 8 MHz RC oscillator.

```
#include <plib.h>
// DEVCFG3
// USERID = No Setting
#pragma config IOL1WAY = ON
// Peripheral Pin Select Configuration
// DEVCFG2
#pragma config UPLLEN = OFF
// USB PLL Enable (Disabled and Bypassed)
// DEVCFG1
#pragma config FNOSC = FRC
// Oscillator Selection Bits Fast RC 8MHZ
#pragma config FSOSCEN = ON
// Secondary Oscillator Enable (Enabled)
#pragma config IESO = OFF
// Internal/External Switch Over (Disabled)
#pragma config POSCMOD = OFF
// Primary Oscillator Configuration
#pragma config OSCIOFNC = OFF
// CLKO Output Signal Active on the OSCO Pin
#pragma config FPBDIV = DIV_1
// Peripheral Clock Divisor
#pragma config FCKSM = CSDCMD
// Clock Switching and Monitor Selection
```

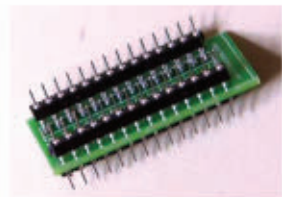
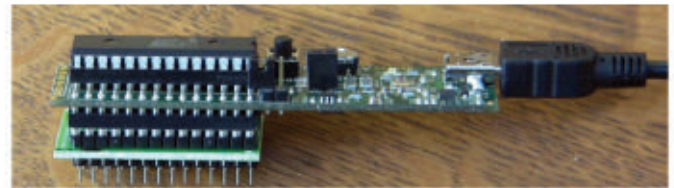


FIGURE 7. Microstick II adapter for the Experimenter.



FIGURE 8. MPLAB X.

```
#pragma config FWDTEN = OFF
// Watchdog Timer Enable
// DEVCFG0
#pragma config JTAGEN = OFF
// JTAG Enable (JTAG Disabled)
#pragma config ICESEL = ICS_PGx1
// ICE/ICD Channel Select
#pragma config PWP = OFF
// Program Flash Write Protect (Disable)
#pragma config BWP = OFF
// Boot Flash Write Protect bit (Protection
// Disabled)
#pragma config CP = OFF
```

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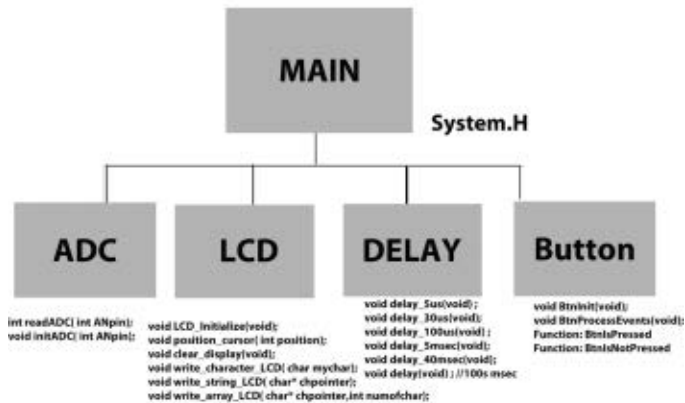


FIGURE 9. Custom 'C' library and associated API.

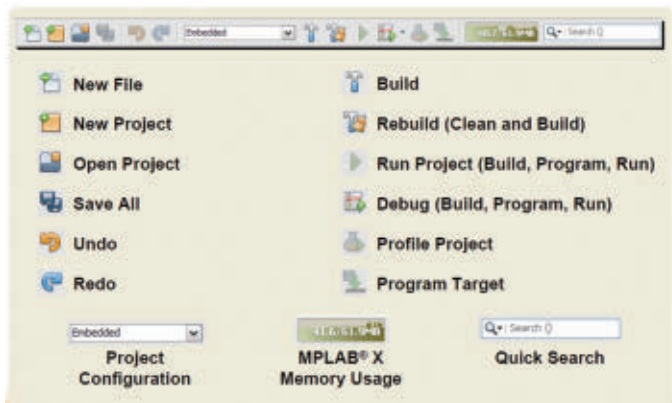


FIGURE 10. MPLAB X main tool bar icon description.

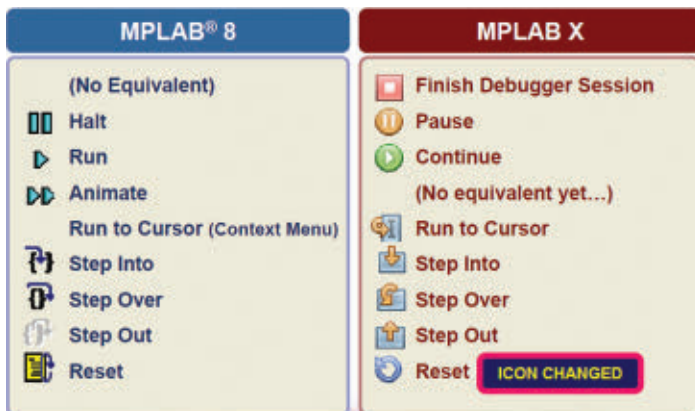


FIGURE 11. MPLAB 8 to MPLAB X debugger icon comparison.

The demos also use a number of 'C' custom library functions, as well as the standard PIC32 reference library. A pictorial of the custom library collection is shown in **Figure 9**. Each demo uses a combination of these library elements. The unique code for each demo is really carried out in "Main."

The custom libraries are pretty self-explanatory. The

ADC library handles initializing the 10-bit ADC in the PIC32 for one of its 13 channels, and then collects sampled data from that channel. The LCD library allows for initializing of the LCD, clearing the display, setting the cursor position, and writing to the display.

The DELAY library provides for a number of software-based delays that are used through the library and in Main. The BUTTON library handles initializing digital input for four buttons, and then debouncing and reading button states.

Demo software is provided in the form of three MPLAB X projects, as described below.

1. BUTTONDEMO (LCD and buttons): This is a basic demo that starts with a splash display highlighting the new PIC32 part and its capabilities. It then prompts the user to push a button and then displays which button was pressed. Uses LCD, Delay, and Button libraries.

2. ADCDEMO (ADC operation): This is a demo of the PIC32MX2 10-bit ADC using the ADC library. A 10K potentiometer is required to be wired up with wipers connected to pin 10 of the Experimenter J3 expansion I/O connector (see the board silkscreen in the downloads for actual pin position). The other two ends of the potentiometer are wired to +3.3 VDC and ground from the Experimenter (again, see the board silkscreen for +3.3V and ground output pins). The display will automatically update the ADC count and ADC voltage as the potentiometer position changes. Uses ADC, LCD, and Delay libraries.

3. PWMDEMO (LED dimmer operation): This demo uses the ADC and the PWM output from the Output Compare module 2 (OC2) to control brightness to an LED. A potentiometer is hooked up to the Experimenter as in #2 above. In addition, OC2 is configured using PPS for pin 5 of J3 (see the board silkscreen for actual pin position). Also on pin 5 J3, a 470 ohm resistor in series with an LED anode (with the cathode to ground) is needed. As you rotate the pot, the PWM to the LED changes duty cycle from 100%-0%, thereby affecting its brightness. The Main code illustrates the use of the Programmable Peripheral System (PPS) feature of this device by allowing a user to configure a programmable pin with a peripheral output. In this case, RB8 is configured for an OC2 peripheral. Use of the PIC32 peripheral library for selecting OC2 under PPS and enabling it (as well as setting pulse width for PWM) is demonstrated here. The project also uses ADC, LCD, and Delay Libraries.

Using MPLAB X

MPLAB X is new and there are a lot of features — way too many to cover here. So, since pictures are worth a

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Haven't got your Experimenter yet? Well, you're in luck! It can be purchased online from the *Nuts & Volts* Webstore at www.nutsvolts.com or call our order desk at 800-783-4624.

thousand words, let's walk through some of the major tool bars. If you are familiar with the current MPLAB 8.xx series of Microchip's IDE, there are similarities that will help you get started. **Figure 10** shows the main tool bar. Here, we have quite a few similar functions to the existing MPLAB 8.xx tool bar, but the new one uses different icons.

Figure 11 is a side-by-side comparison of the debugger tool bars. **Figure 12** shows the Editor tool bar with its new icons, but with additional functionality that was not present in MPLAB 8.xx.

Working With the Demos

The demos have already been configured for you as MPLAB X. To open a project, you navigate to the folder of the project demo you downloaded, and open the X extension as shown in **Figure 13**.

The demos are configured with specific compiler selections and the PICkit3 debugger. You may have to change these for your system's compiler locations and debugger selection. (We will show you how.) You will still need to apply power to the Experimenter board and add any additional hardware the project may require. Then, simply compile, download, and run.

As you open each of the projects, you will find that MPLAB X supports multiple projects. The screenshot in **Figure 14** shows MPLAB X once all the demos have been opened. Each project is organized into file folders designated as: Header, Library files, Linker files, Object files, Source files, and Important files. We use both the header and source folders. You select which project (in the project window) to make active by right-clicking your mouse on the project tile and selecting it as your active main project. In this case — within the Projects window — PWMDEMO is selected and the main file in the source folder for PWMDEMO is open in the Edit Window. The Output window is also shown. It is displaying the results of the last build.

MPLAB X has a new all-inclusive Project view with the Dashboard view. Under "Window" on the tool bar, select Dashboard and you should see what's shown in **Figure 15**. With one view, you see the device, compiler tool chain, memory utilization, active breakpoints, and debugging tools. On the left side of the dashboard are several other important icons. When clicked, the PDF image automatically displays the device's datasheet; when selected, the circular arrow icon resets the device; when selected, the wrench icon brings up another window to allow you to change any of the major settings in the

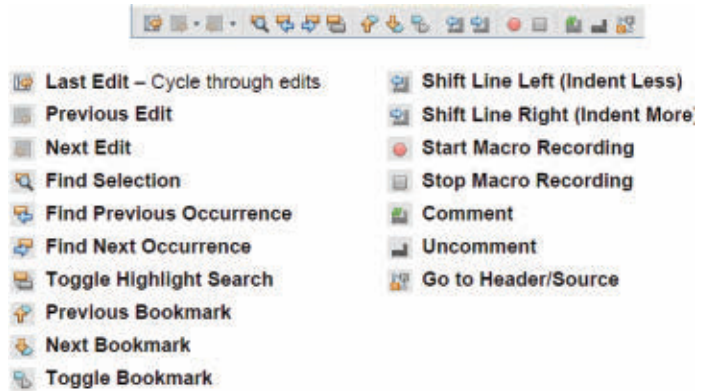


FIGURE 12. Editor tool bar.

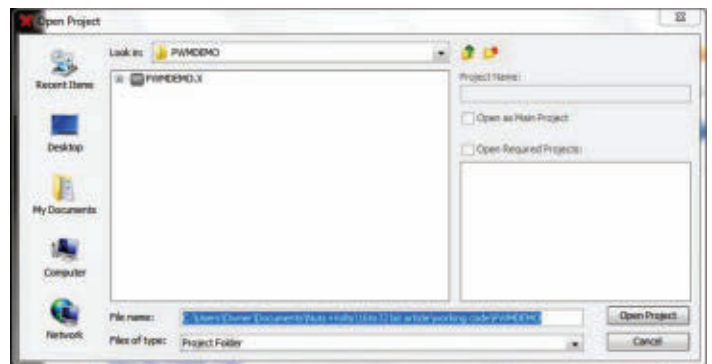


FIGURE 13. Opening a demo project.

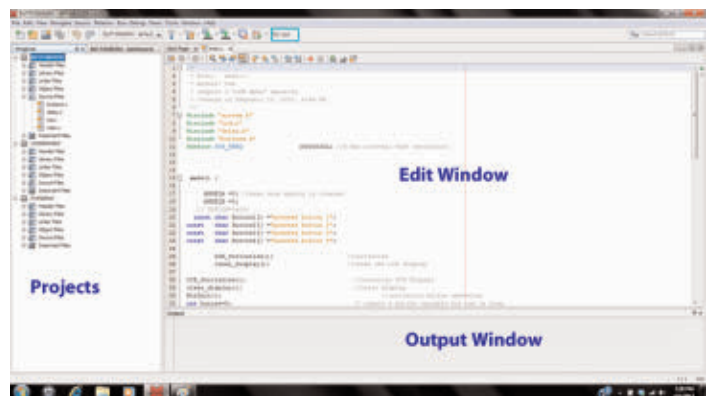


FIGURE 14. MPLAB X with demos.

project. Refer to **Figure 16**.

Under this window, you can switch debuggers between Microstick II and PICKIT3, or even select a different compiler.

Ideas for the Future

Now that we have covered an important 32-bit upgrade for the Experimenter while also illustrating a new set of tools and methods, we hope you will be anxious to try it yourself. The Experimenter remains a viable learning

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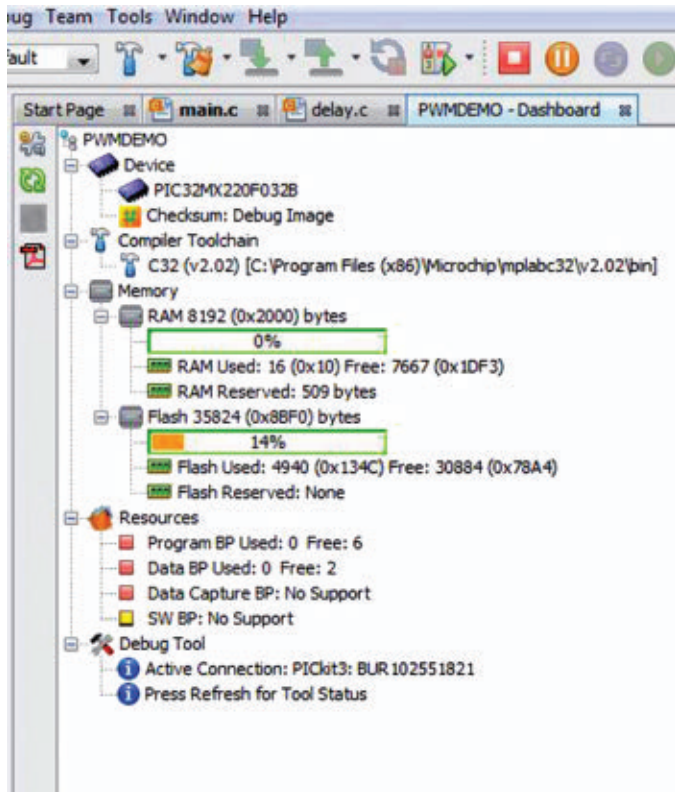


FIGURE 15. Dashboard.

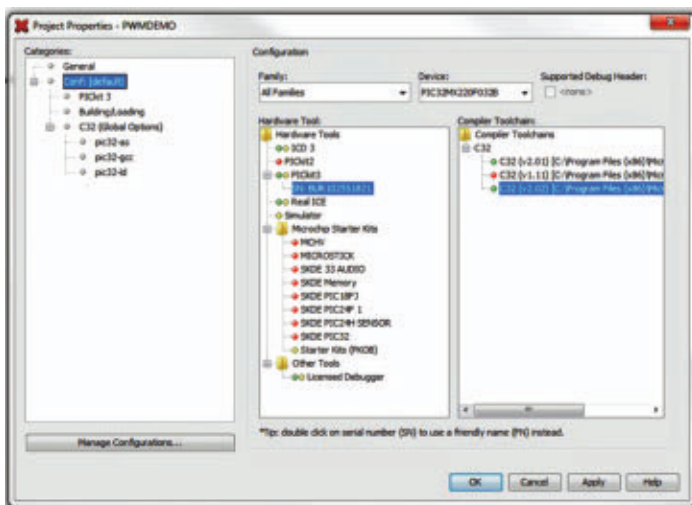


FIGURE 16. Changing project settings.

tool that is easily adapted to new technologies. We have touched on many areas including the new MPLAB X and Microstick II. For those wanting to use the Microstick II with the Experimenter in place of the PICkit 3, an adapter is provided. Working the software demos will help to solidify your understanding of both the PIC32MX2 and MPLAB X. But we are not done! In fact, we are just touching the surface! **NV**



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READER FEEDBACK

Continued from page 9

Thanks Phil. I appreciate the feedback. I know the German mentality. I spent a year there a while back and was there again recently. I somehow suspect that modern bomb makers may not be so disciplined, but I certainly don't want to find out.

Bryan

Recycling Parts

I found Bryan Bergeron's editorial on component defects interesting. I have been recycling several hundred thousand parts a year in my hobby/business since 1977. I have found that while electrolytic capacitors have a definite deterioration over time, many ICs and other durable parts (flameproof resistors) and the like have a life span of many years. I probably have 100,000+ semiconductors that I would like to think will outlast any storage. If I knew of a definite rate of deterioration of these parts, I would radically change my views on salvage. Some technician friends of mine have suggested that these salvaged parts aren't as good as new, however, I have found that if they were good parts to begin with, then they would be suitable for reuse. Also, I contend that parts of older manufacture are better. Case in point: Many older electronics from the '70s and earlier are still functioning well, while newer ('90s and beyond) components have already failed. So, I believe we have a definite deterioration in manufacturing reliability. Also, newer electronics that contain SMDs are not economically viable for reuse.

Mike Jobe

Thanks Mike. I appreciate the feedback and agree with you on current 'quality.' Even though I have a hot air reworking station, I rarely salvage anything useful from an SMD board.

Bryan

Ham Fodder

As an ARRL VE (volunteer examiner), please allow me to correct

a few points in Louis Frenzel's fine article in the April '12 issue about how to get your ham radio license.

First, the cost to take the exam is determined by the VEC (volunteer examiner coordinator). The current cost to take the test through the ARRL is \$15. The fine gentlemen who give the ham tests at the Dayton Hamvention operate through the Laurel VEC and they charge the princely sum of \$0. That's right, nothing. VEs are not commissioned by the FCC. The VEC groups are, and they then register their VEs. One can be a VE for more than one VEC.

There are currently five classes of license, two of which are grandfathered and are not available to new or upgrading licensees. These are Novice and Advanced.

As a new licensee, you are required to pass the Technician Element 2 before you attempt the Element 3 General test, but you do not need to "get some experience" before you can try. In fact, I routinely suggest to those who pass Element 2 at a test session I run that they should try for General. Why not? They're at the test site, they've already gone through the registration process, and after passing the Tech test they can try the General for free!

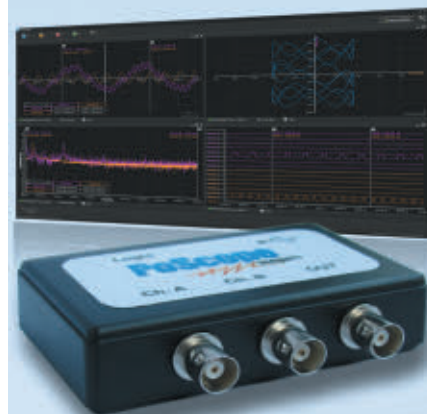
Finally, even the lowly Technician can apply for a vanity callsign. They cannot get the highly prized 1x2 calls that Amateur Extras can, but they have the pool of 1x3 and 2x3 to select from. So, if you're going for your test and are good at memorizing or are already proficient in electronic theory, you really should scan the General questions ahead of time and take a shot. You have nothing to lose other than a half hour or so of your time. I'm happy to take the time grading your exam because I also like shaking someone's hand and saying "welcome, new ham."

John Stanley N8GFO

Thanks for clarifying the details of getting a ham license. Even those of us who should know this have trouble in understanding the complex process

Continued on page 63

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#48 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

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

It's About Time

Recap

Last month, we learned some theory about C arrays and then did a lab project that used the Simple Chaser Lights kit to build a POV (Persistence Of Vision) wand. This month, we are going to look at some C theory for structuring data and then do some hands-on lab work using a DS1307 real time clock IC on a breadboard.

***"Does anybody really know what time it is?
Does anybody really care?"***

The Chicago Transit Authority, 1969.

Well, I for one care, and I have read enough of the physics and philosophy of time that I can safely say I don't have a clue what time it is. Before I did all that reading, I thought I knew what time is. Now, I'm befuddled. I'm pretty sure time has to do with things falling apart (which is verified by my mirror), but beyond that ...

For this article, let's settle on the Wikipedia definition that *time is what clocks measure*. Since computers have clocks, let's start to learn about those clocks and how to use C to keep track of time.

C Theory

C provides some features that help us organize and manipulate data. We've already looked at how arrays help us work with large blocks of data of a single type. We use some concepts that duplicate what we could do with pointers, but make the work somewhat more intuitive than pointers and therefore easier. Remember that in C, the name of an array is equivalent to the address of the first element of that array. This is the same as a pointer is to the first element of a section of memory. We can use arrays which we may already be familiar with from our math studies (for many folks, arrays seem like obvious ways to group data) or we can use pointers to do the same thing in a much less intuitively friendly fashion.

Let's look at a couple of other C features that will

help us deal with data: enums and data structures. Enums are simple and only occasionally needed; data structures can be quite complex and are used everywhere in C to handle all but the simplest work with data. We will learn about these using examples that we will run under Pelles C to help us master the concepts. [Pelles C was introduced in Smiley's Workshop in the June '09 *Nuts & Volts*. You can get a copy from www.smorgasbordet.com/pellesc.] Then, we will see how these concepts can be used in actual examples of computer time keeping. These high level software data handling concepts for manipulating data — when applied to time as that data — will soon lead us to some very low level hardware concepts involving the AVR timer/counter peripherals. This is another case where it is difficult to know the order to present the information, so bear with me. Hopefully, things that seem to be presented out of sequence will eventually start to line up and make sense.

Enums

The C keyword enum (from enumeration) conveniently provides a way to give names for constant sequential numbers. Enums let you think of the data as a name, not a number, and lets the computer worry about the number for you. For instance, you might say:

```
enum boolean { NO, YES }; // NO is 0, YES is 1
```

The computer will automatically assign the number 0 to NO and the number 1 to YES. You can then use these names in the code. For instance, you might query a user with a yes or no question and call one of three functions depending on the answer:

```
if (answer == YES) sheSaidYes();  
else if (answer == NO) sheSaidNo();  
else sheIgnoredYou();
```

You could just as easily use:

```
#define NO 0  
#define YES 1
```


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.

Nuts & Volts now carries the entire line of Smiley Micros books and kits. Some are shown in the magazine and others in their web shop. If you just can't wait and want to get a leg up on 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, or if you are a complete novice try *The Arduino Workshop* and projects kit.

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

Enums come in really handy when you want to assign a longer sequence of words that naturally associate with sequential numbers, such as many words that are used in time keeping. For instance, the month of the year. We might write a date as 5/6/12 or we might write it as May 6, 2012. The 5 and May are equivalent. (This is true in America, but other countries list numerical dates differently so they may think 5/6/12 is actually 5 June 2012.)

When you define a sequence of names in an enum, the default behavior is for the first name to be defined as 0. If you specify a number for the first, the enum will assign the numerical sequence that follows for the rest of the numbers. For example:

```
enum months { JAN = 1, FEB, MAR, APR, MAY, JUN,
JUL, AUG, SEP, OCT, NOV, DEC };
```

If you are dealing with a calendar, you don't care what the number of the month September is, you just want to deal with September. A simple example for using this follows:

```
#include <stdio.h>

enum months { JAN = 1, FEB, MAR, APR, MAY, JUN,
JUL, AUG, SEP, OCT, NOV, DEC };

int main(int argc, char *argv[])
{
    enum months myMonth;
    int mth,oldMth;
    int go = 1;

    printf("Enter 0 or any number > 12 to
    exit\n");

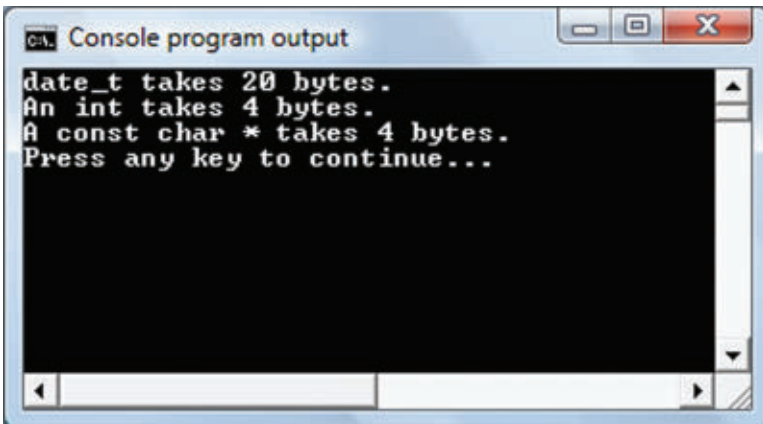
    while(go)
    {
        printf("What is the number of the month you
        were born?\n");

        oldMth = mth;
        scanf("%d",&mth);

        if(oldMth != mth)
        {
            myMonth = mth;

            switch(myMonth)
            {
                case JAN:
                    printf("You were born in January\n");
                    break;
                case FEB:
                    printf("You were born in
                    February\n");
                    break;
                case MAR:
                    printf("You were born in March\n");
                    break;
                case APR:
                    printf("You were born in April\n");
                    break;
                case MAY:
                    printf("You were born in May\n");
                    break;
                case JUN:
                    printf("You were born in June\n");
                    break;
                case JUL:
                    printf("You were born in July\n");
                    break;
                case AUG:
                    printf("You were born in August\n");
                    break;
                case SEP:
                    printf("You were born in
                    September\n");
                    break;
                case OCT:
                    printf("You were born in October\n");
                    break;
                case NOV:
                    printf("You were born in
                    November\n");
                    break;
                case DEC:
                    printf("You were born in
                    December\n");
                    break;

                default:
                    printf("What, were you hatched?\n");
                    go = 0;//
                    break;
            }
        }
    }
}
```



■ FIGURE 1. Size of date_t.

You can find this example in the source code file at the article link.

Structures

A structure is a collection of variables that may be of different data types, all grouped together under a single name. This is similar to an array that groups data under a similar name and locates it in contiguous memory. Unlike an array in which all the data must be of the same type, a structure can have data of different types. They are like records in other programming languages and form a data unit that is convenient to handle. This convenience is very useful in large programs because it allows us to group related variables of different types and handle them as a unit rather than as individuals. It also allows us to pass the entire structure to a function by only passing the name of the structure which (like for arrays) is the address of (a pointer to) the first element of the data.

We usually declare structures near the start of a file or in a header. For example, we can declare structures for the date as follows:

```
struct date_t
{
```

```
    int year ;
    int month;
    const char *month_text;
    int day;
    const char *day_text;
};
```

This declaration tells the compiler that you want to store two ints, a constant character pointer (a pointer to a string), another int, and another pointer to a string all together in a package that you can handle as a unit. The compiler will determine how much memory space is actually needed to store this data. If our system defines an int as two bytes and the address of a string as four bytes, then this structure will occupy 14 contiguous bytes of memory. We don't need to know how the compiler defines these data types nor do we need to know how it allocates memory for it. Since we are curious folks, however, let's look to see how Windows stores this data. In Pelles C, write and run the following:

```
#include <stdio.h>

// Declare date_t
struct date_t
{
    int year ;
    int month;
    const char *month_text;
    int day;
    const char *day_text;
};

int main()
{
    struct date_t myDate;
    // define an instance of date_t

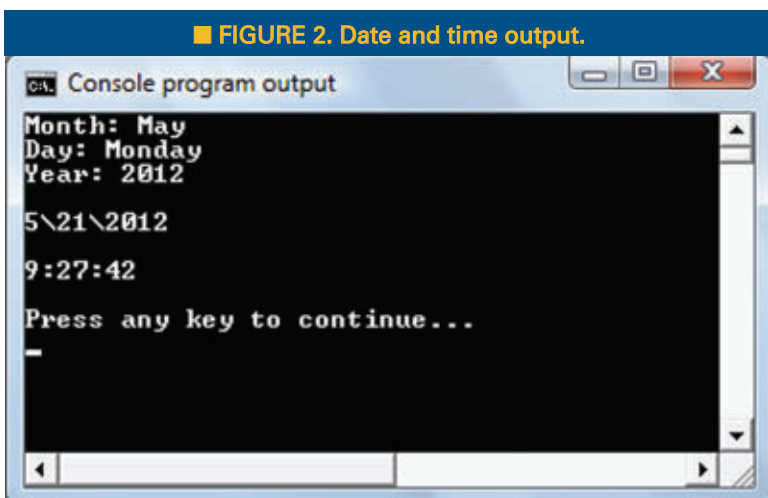
    printf("date_t takes %d
bytes.\n", sizeof(myDate));
    printf("An int takes %d
bytes.\n", sizeof(myDate.year));
    printf("A const char * takes %d
bytes.\n", sizeof(myDate.month_text));
}
```

This results in the output shown in **Figure 1**. So, I guessed wrong about the data sizes since an int is four bytes in Windows.

Notice in the above source code that the date_t structure is **declared** outside a function and **defined** within the function. The **declaration** tells the compiler what a date_t structure looks like; the **definition** creates a specific instance of that structure. You may also note that when we want to access a specific element of the structure, we use the **dot operator**, so we see myDate.year for the year element of the myDate structure. We'll see another way to access these elements later.

Now, we have the date aspect of date-time defined; let's look at the time aspect:

```
struct time_t
```



■ FIGURE 2. Date and time output.


```
{
    unsigned int hour;
    unsigned int minute;
    unsigned int second;
};
```

We might have an application like a real time clock that needs to use the date and time as a unit, so we can declare a structure that contains both the data and time structures — a nested structure — as follows:

```
struct rtc_t
{
    struct date_t myDate;
    struct time_t myTime;
};
```

At this point, we have declared three structures but we haven't created an instance of any of them. We have seen how to create an instance of a structure by defining it within a function. However, we could instead add a name following the final bracket to create the instance:

```
struct rtc_t
{
    struct date_t myDate;
    struct time_t myTime;
}myRTC;
```

This use does the same thing as writing the following in a function:

```
struct rtc_t myRtc;
```

The difference is that the former creates an instance that is available to all functions in the module (the .c text file), while the latter creates an instance that is only available to the function in which it is declared. Either way, by declaring myRtc we are also declaring instances of the date_t and time_t structures.

As with arrays, we pass structures to functions using pointers. This requires that we use two sorts of operators to access the data in a structure. In the function where the structure was declared, we use the '.' operator. If we pass the structure to another function, we access the elements of the structure with the '->' operator. The following example creates an instance of rtc_t in main, then uses the '.' to load it with data. Next, it sends it to the function showDateTime, passing it as a pointer. In the function showDateTime, the data is accessed using the '->' operator.

```
#include <stdio.h>

struct date_t
{
    int year ;
    int month;
    const char *month_text;
    int day;
    const char *day_text;
};
```

ADDRESS	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	FUNCTION	RANGE
00h	CH	10 Seconds			Seconds				Seconds	00-59
01h	0	10 Minutes			Minutes				Minutes	00-59
02h	0	12	10 Hour	10 Hour	Hours				Hours	1-12 +AM/PM 00-23
		24	PM/AM							
03h	0	0	0	0	DAY				Day	01-07
04h	0	0	10 Date		Date				Date	01-31
05h	0	0	0	10 Month	Month				Month	01-12
06h	10 Year				Year				Year	00-99
07h	OUT	0	0	SQWE	0	0	RS1	RS0	Control	—
08h-3Fh									RAM 56 x 8	00h-FFh

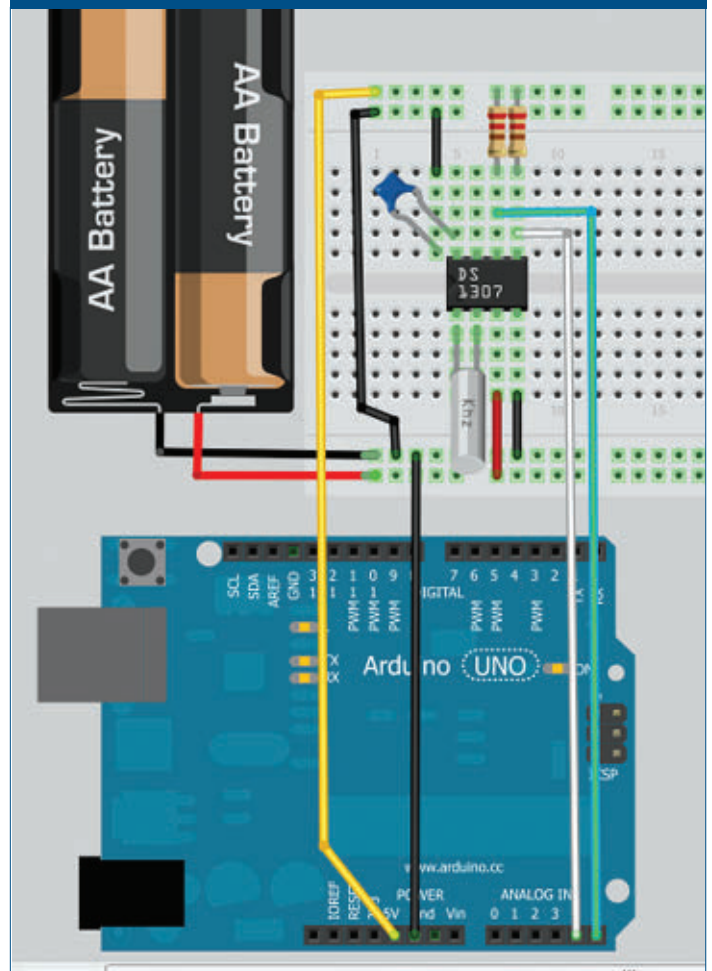
0 = Always reads back as 0

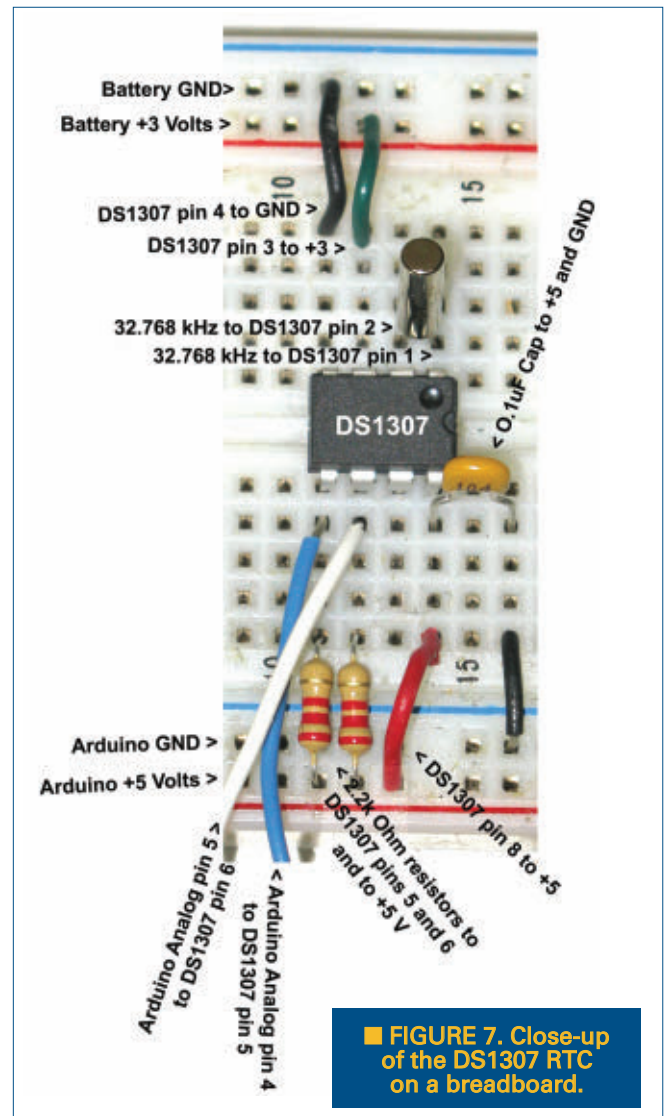
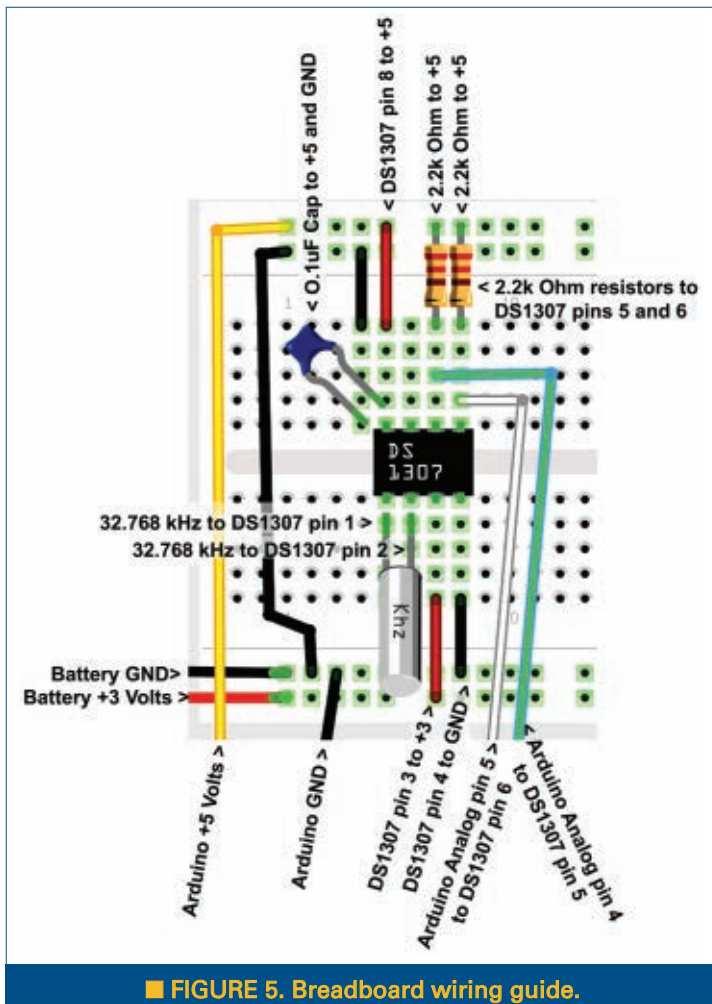
■ FIGURE 3. DS1307 timekeeper registers.

```
struct time_t
{
    unsigned int hour;
    unsigned int minute;
    unsigned int second;
};

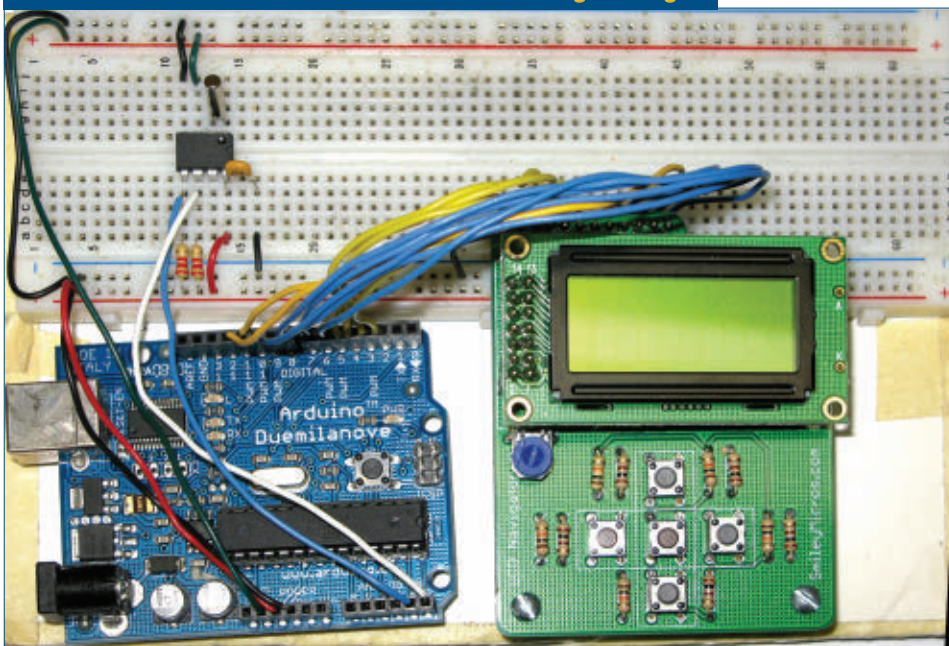
struct rtc_t
{
    struct date_t myDate;
    struct time_t myTime;
};
```

■ FIGURE 4. Arduino/DS1307 RTC on a breadboard.





■ FIGURE 6. DS1307 RTC on a breadboard using Fritzing.



```
void showDateTime(struct
rtc_t *myRtc);

int main()
{
    // Declare an instance of
    // rtc_t
    struct rtc_t myRtc;

    // Load it with data
    myRtc.myDate.year = 2012;
    myRtc.myDate.month = 5;
    myRtc.myDate.month_text =
    "May";
    myRtc.myDate.day = 21;
    myRtc.myDate.day_text =
    "Monday";
    myRtc.myTime.hour = 9;
    myRtc.myTime.minute = 27;
    myRtc.myTime.second = 42;

    // Send the address-of to
    // show the date and time
    showDateTime(&myRtc);
}

// Take a pointer to an rtc_t
// structure and show the data
```



```

void showDateTime(struct rtc_t *myRtc)
{
    printf("Month: %s\nDay: %s\nYear: %d\n\n",
        myRtc->myDate.month_text,
        myRtc->myDate.day_text,
        myRtc->myDate.year);

    printf("%d\\%d\\%d\n\n",
        myRtc->myDate.month,
        myRtc->myDate.day,
        myRtc->myDate.year);

    printf("%d:%d:%d\n\n",
        myRtc->myTime.hour,
        myRtc->myTime.minute,
        myRtc->myTime.second);
}

```

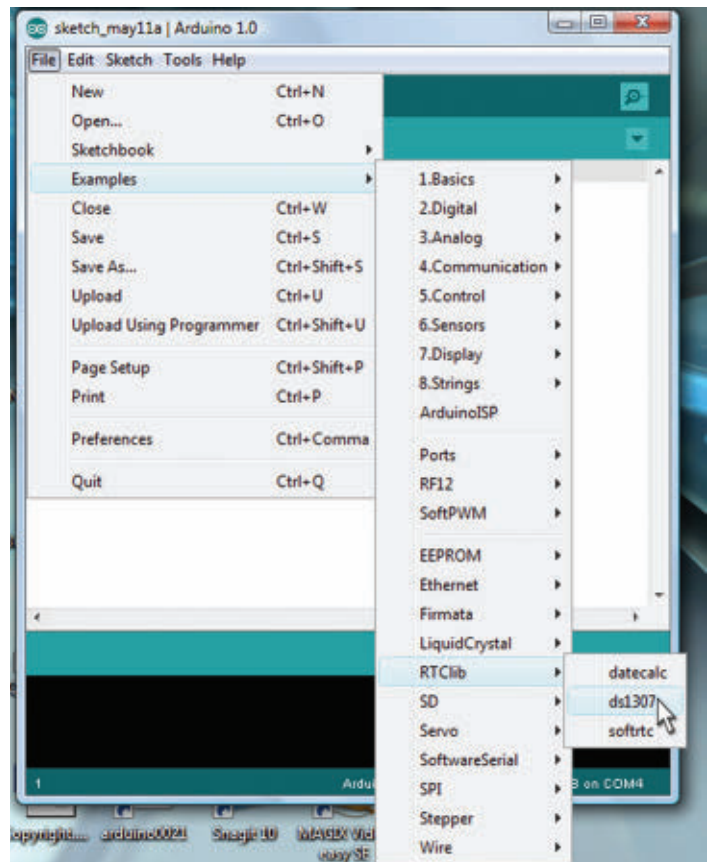
Take a moment to review that code and think about the two methods for accessing the data in a structure. When you are dealing directly with the structure, you use the dot '.' operator. When you are dealing with a pointer to the structure, you use the arrow '->' operator. When you are dealing with structures within structures as shown in our example, you use the '->' for the outer structure which was passed as a pointer and the '.' for the inner structures that got passed along with it. You have to use this a bit to get comfortable with it.

Lab

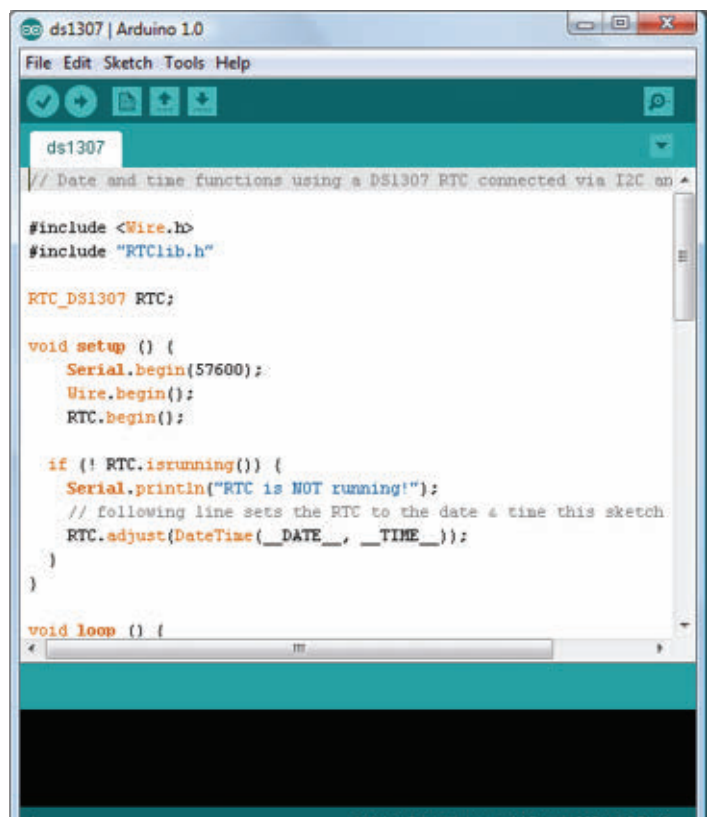
The PC has a real time clock (RTC) that has its own battery so that it can keep running — even when the PC is unplugged. With microcontrollers, we have to add hardware to make an RTC. In the AVR Butterfly, a 32.768 kHz watch crystal is attached to an internal AVR timer/counter peripheral so that an interrupt can be generated every second to keep count of seconds. Another way to do this is to have an external IC to keep time for us; we can then ask that device for the time. One common device used for this is the DS1307 that requires one of those 32.768 kHz crystals. It can communicate with a microcontroller via an I²C bus. This month, we will build an RTC on a breadboard for use with an Arduino that conveniently has an RTC library already written for us. We will then add a PCB to this kit (DS1307RTC kit) that you can purchase from the *Nuts & Volts* Webstore. In a later Workshop, we will take a deeper look at computer time-keeping that will lead us to writing a C based time-keeping library and to learning about the AVR timer/counter peripherals.

How the DS1307 Stores Date and Time Data

The DS1307 has 64 registers in SRAM — the first eight bytes are used to store the time data; the next 56 are available for your use (more on that later). Take a look at the first byte 00h that is used to store seconds. You see that the four lower bits store seconds, while the next higher three bits store '10 seconds.' You might wonder what that is all about since you can, in fact, store all the



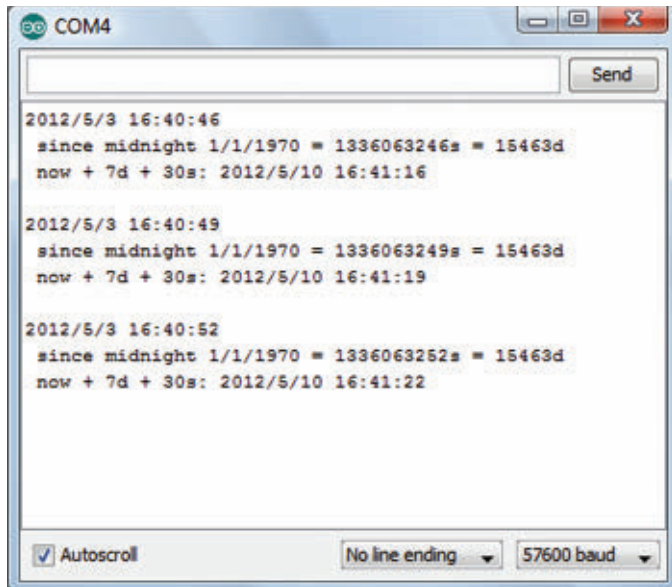
■ FIGURE 8. Arduino select RTClib DS1307 sketch.



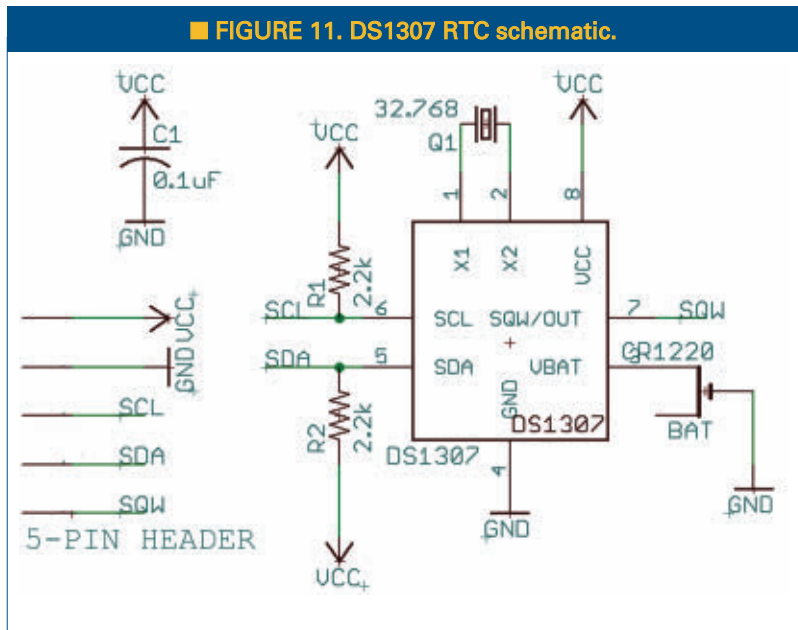
■ FIGURE 9. Arduino DS1307 sketch.

Qty	Name	MOUSER PART NUMBER
1	DS1307	700-DS1307
1	32.768 watch crystal	815-AB38T-32.768KHZ
1	Battery holder 12 mm coin	534-3001
1	Battery CR1220	614-CR1220
1	Capacitor 0.1 μ F	21RZ310-RC
2	Resistor 2.2K ohm	660-MF1/4DCT52R2201F

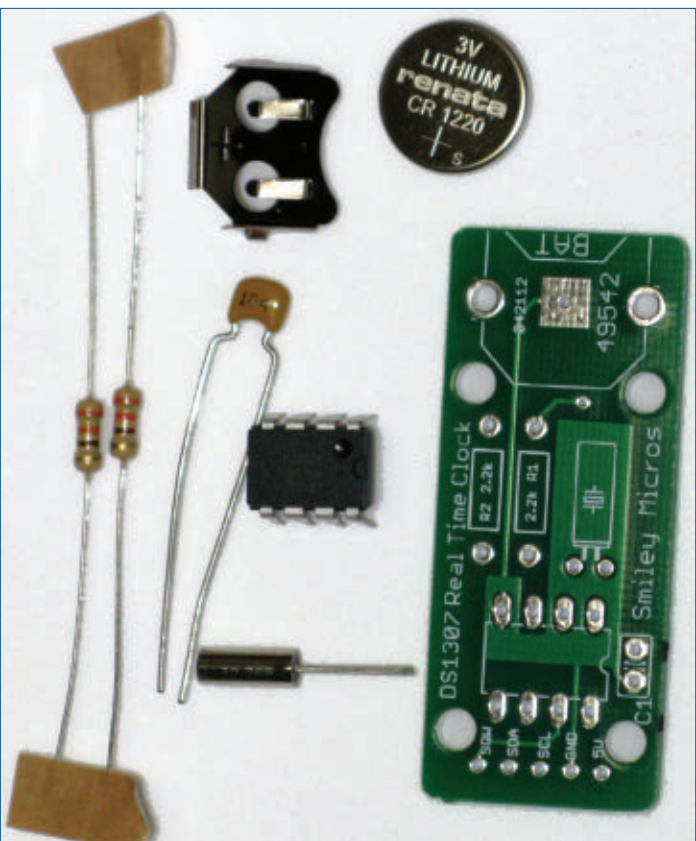
Table 1. Bill of Materials.



■ FIGURE 10. Arduino DS1307 sketch output in a serial monitor.



seconds in a minute – all 60 of them in five bits (stores up to 64 unique values). What you are seeing is BCD (Binary Coded Decimal) storage. This allows the binary numbers



■ FIGURE 12. DS1307-RTC parts kit.

to be directly used to express human readable numbers without translating them. In a later Workshop, we will see how to use what we have learned about data structures to manipulate the DS1307 data in software. Since we are limited in space, let's build our real time clock now and learn about the code later.

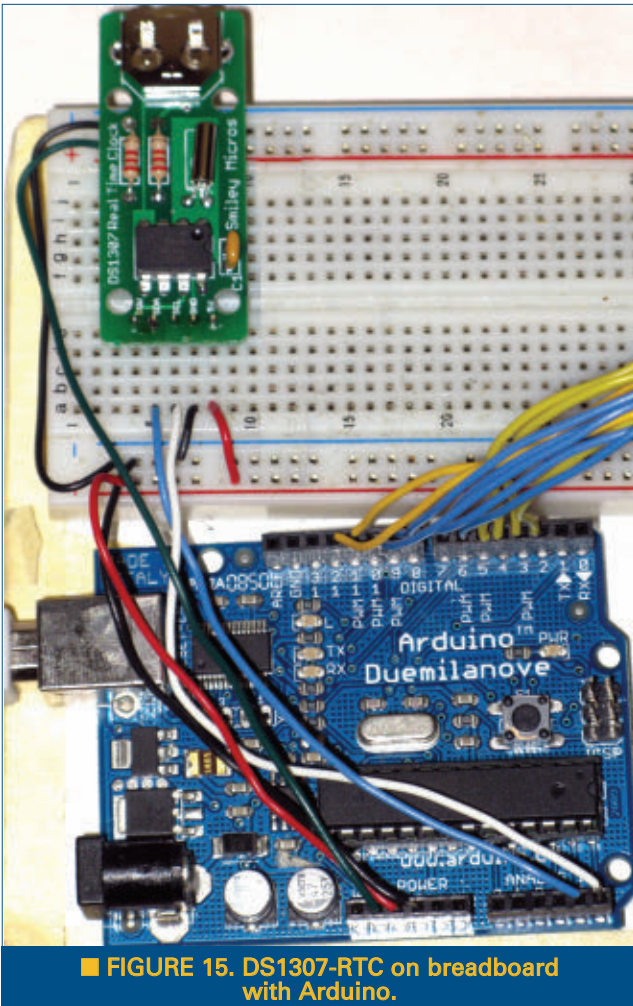
Build a DS1307 Circuit on a Breadboard

We see an illustration for a DS1307 circuit on a breadboard in **Figure 4**. This illustration was generated in Fritzing – a very interesting open source application that hopes to be for Electronic Computer Aided Design (ECAD) what the Arduino is for microcontrollers. We will get into the details of Fritzing next time, but for now let's build our real time clock and test it with an Arduino.

We see a close-up of the breadboard in **Figure 5** that has labels added to help us with our wiring. **Figure 6** shows how this looks on a real breadboard.

With those great images in **Figures 4** and **5**, you'd think I'd wire it up like that, but I didn't. I had wired it up and tested it before I came across

Fritzing which I used to make **Figures 4** and **5**. Showing the alternate wiring doesn't cause any real problems. You can wire it up either way, as long as you make sure you



■ FIGURE 15. DS1307-RTC on breadboard with Arduino.

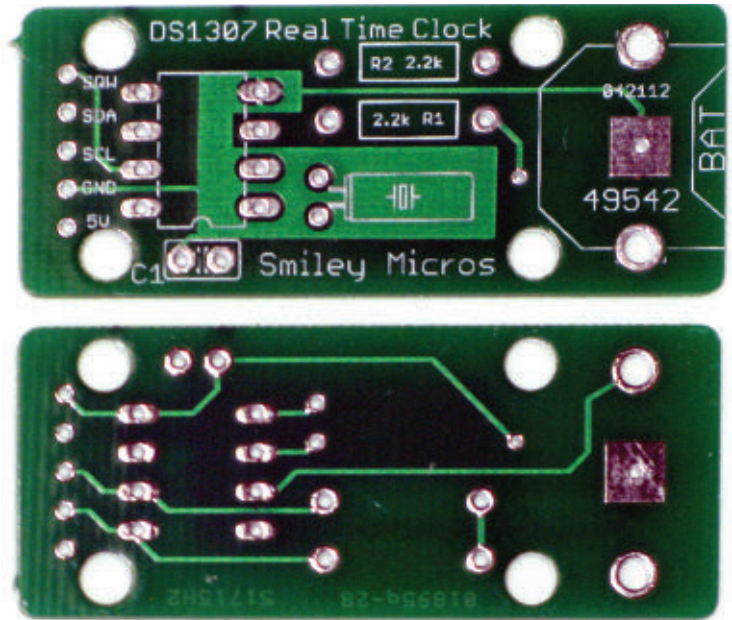
get the power and ground correct. **Figures 6 and 7** show the DS1307 wired up on a breadboard for use with the Arduino. It also has the LCDNAV wired up (perhaps for a breadboard alarm clock that we might see in a later Workshop).

Bill of Materials

Table 1 lists the parts you can get from www.mouser.com. (Or, as mentioned before, you can check the *Nuts & Volts* Webstore where you can get these parts and a PCB to mount them on.)

Using the DS1307 With the Arduino

There is an excellent library for the Arduino at www.arduino.cc/playground/Code/Time that lets you use a DS1307. Follow the Arduino directions for including a library. Then, click on the library and the DS1307 examples as shown in **Figure 8**. The files shown in **Figure 9** calculate the seconds from the Unix Epoch which began 1/1/1970, convert that to days and then to now (today's date/time) plus seven days and 30 seconds as shown in **Figure 10**.



■ FIGURE 13. Arduino DS1307 printed circuit board.



■ FIGURE 14. DS1307 RTC PCB with components.

DS1307-RTC Kit

There is certainly nothing wrong with purchasing all the parts and then building this circuit on a breadboard as discussed above. It is easier and more reliable, however, to build it on a printed circuit board. **Figure 11** shows the schematic; **Figure 12** shows the components. **Figure 13** shows the PCB; **Figure 14** shows the PCB with the parts mounted; and **Figure 15** shows it on a breadboard hooked up to an Arduino. The DS1307 uses the I²C bus where pin 6 goes to SDA and pin 7 goes to SCL. On the Arduino, we connect the SDA to the analog pin 4 and SCL to analog pin 5. These Arduino pins are, of course, not used in the analog mode, but are set up in software for the I²C bus. You can use the same software as discussed above for the breadboard version of the design.

So, now we have a tool to provide a real time clock on a breadboard. We see that we can use this tool with an open source Arduino library. My goal in building the breadboard RTC was to provide a design that can be

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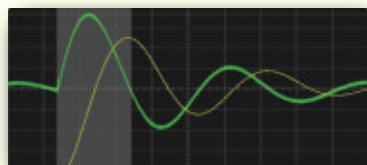
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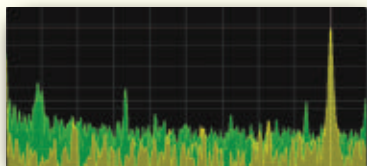
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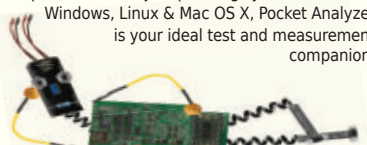
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ported to a PCB break-out board for ease of use, and then use the data from this board to look in more detail at how C handles dates and times.

Along the way, I ran into Fritzing which gives us **Figures 4 and 5**. Fritzing is a free open source program that hopes to do for

hardware design what the Arduino has done for software. Amazingly, they have somewhat succeeded.

Anyway, Fritzing is so compelling that I've decided to delay the C time discussion. So next time, we will begin a two-part series on Fritzing and then resume our C time discussion after that. **NV**



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READER FEEDBACK

Continued from page 53

one has to navigate these days to get a ham license. The process is not well described and may be more complex than the technical exam to get the license. Whose job is it to make the method more well known and understood? Anyway, we appreciate you clearing this up.

Lou Frenzel W5LEF

Hmmmm ...

On page 10 of the June '12 issue, "Spotlight on Bacteria" claims the light goes through 25 m. (Was an "m" missing? Perhaps 25 mm ~ 1"? Otherwise, that would be 25 m or approx. 75 ft!)

Phil Karras KE3FL

Good catch, Phil! It should have been micrometers (µm.) Looks like the µ was dropped.

Unlocking Phones (Not!)

After reading Louis Frenzel's article, "What is 4G Wireless" – which was pretty helpful and timely since I'm researching smartphones to buy for the first time (I currently use a feature phone) – I have a question. Can unlocked phones from Europe and Asia be used just as well in the US? Especially re: Internet service? Would the Internet service be at high speeds (3G or 4G)?

I was told by a TMobile in-store sales rep (I subscribe to TMobile) that even if I get an unlocked phone intended for the markets in those continents, I wouldn't be able to use the Internet very well in the US, because Europe and Asia use different channels within the same bandwidth. Or something like that. I may not be using the right terminology. Conceptually, what I understood it as is the phones in Europe and Asia are within the same range of frequencies as the US for Internet, but within that range, the European and Asian phones use a different frequency than the US, so I wouldn't get any "reception," so to speak, for the Internet, or very little.

He said that Samsung specifically sets phones for TMobile at a certain channel so that they work within its network. I asked if those channels could be changed, and he said no, it would be very difficult; they're preset. What are your thoughts? Thank you for any feedback!

Christina Hur

The T-Mobile rep is right. The smartphones used in Europe and Asia use different bands and frequencies so generally do not work in the US. There is no way to change the frequency. They are fixed. In general, unlocking a phone is a nightmare. It causes more wasted time and grief unless you are a super guru hacker type. You will not save money this way. Bite the bullet and get a US phone.

Lou

A Matter of Degrees

This note was prompted by Ron Hackett's article "Interfacing the DS18B20 Digital Thermometer" and the necessary code decision needed to account for below zero temperatures (page 18 in the June '12 issue).

A clean way to convert degrees C to degrees F is: $F = (C + 40) * 9 / 5 - 40$. This way, no decision needs to be made in code for less than zero degrees.

To change from degrees F to degrees C, one need only exchange the 9 and 5: $C = (F + 40) * 5 / 9 - 40$.

The reason this works is because a graph of F and C temperatures cross at -40.

Sheridan George

Thank you for your suggestion for avoiding making a decision in code for less than zero degrees C.

I assume your formulas would work in a programming system that is able to handle negative numbers. However, the PICAXE BASIC compiler is limited to computations involving positive integers. In the example on page 18, if the temperature is -5 degrees C, PICAXE BASIC is not able to compute the value of $(-5 + 40)$ in your formula; in fact, we can't even assign a value of -5 to a variable. As a result, it's necessary to do separate calculations in code for positive or negative values (adding or subtracting magnitudes accordingly), and then assign the appropriate sign ("+" or "-") to the result. I hope this clarifies the issue.

Ron



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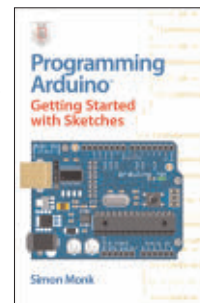
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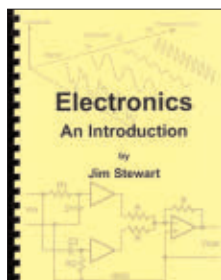


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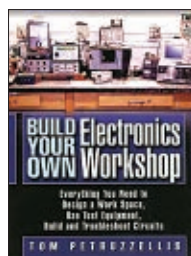
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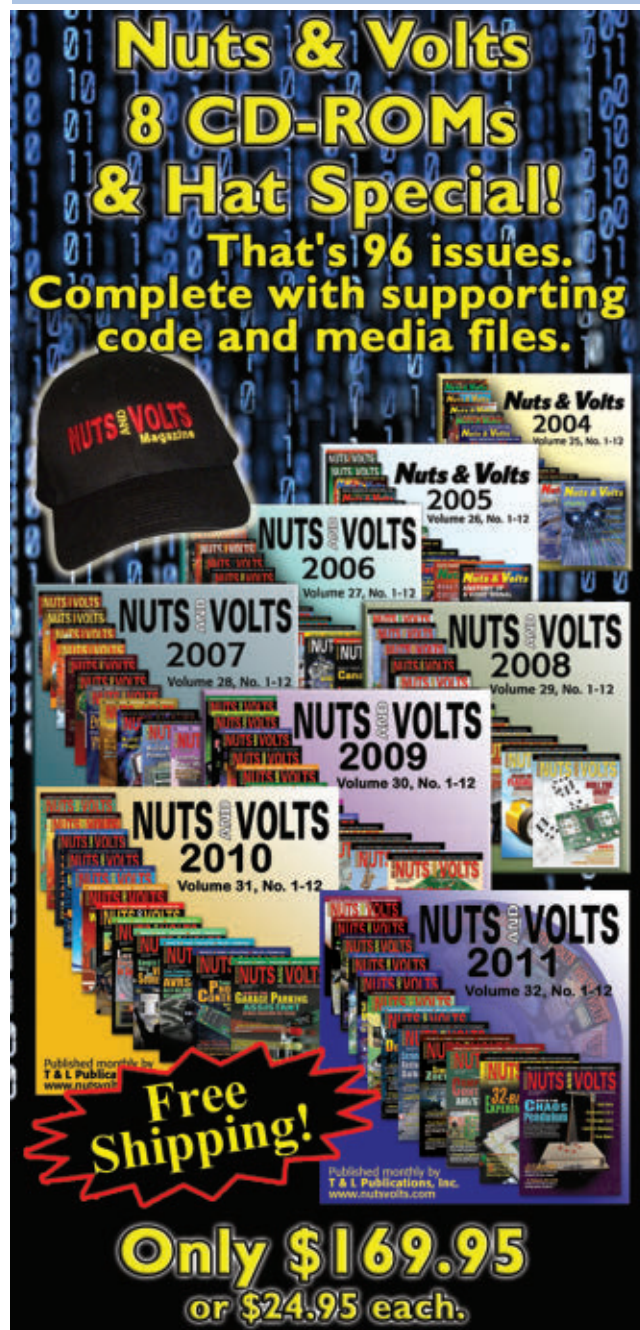
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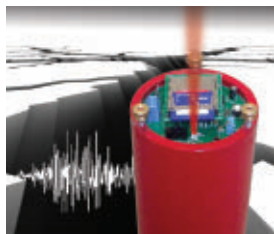
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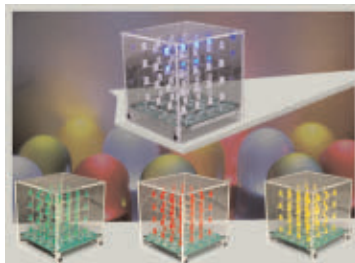
As seen in the May 2012 issue.

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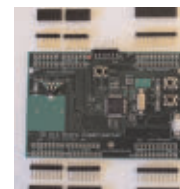
As seen in the July 2011 issue.

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.

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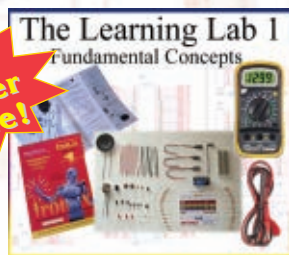
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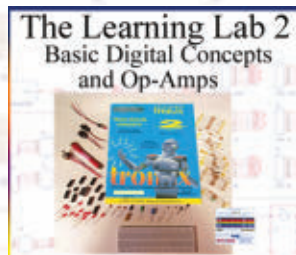
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A NEW BALLOONSAT AIRFRAME DESIGN

When teaching students to make BalloonSats, I give them six sheets of Styrofoam and ask them to cut and glue them together to form a hollow box. During their construction, students also must cut channels for tubing and determine where to mount the electronics and sensors. However, if you look at a CubeSat, you'll notice that they are assembled by stacking planes. So I asked myself, why not attempt something like that for BalloonSats?



Since starting my dissertation on the effects of BalloonSats on student attitude toward science, I've been giving some thought to the design of the BalloonSat airframe. This is partly because I already have a good BalloonSat flight computer design and would like an airframe design to match. Somehow, just giving students six sheets of Styrofoam and asking them to make an airframe seems crude and undeveloped in comparison.

For readers not familiar with CubeSats, they are small satellites that follow a simple design standard. CubeSats are 10 centimeter cubes containing a flight computer, sensors, batteries, and solar cells. All the components are stacked together like the shields of an Arduino. Then, solar panels are clipped to the outside faces of the stack. Many universities have purchased a kit for their aerospace students to build. After students have finished their CubeSat, it can be launched into earth orbit.

So, why not try something similar for BalloonSats? Now, I'm not claiming to have the perfect solution to BalloonSat design, but I did test the following design and I am very happy with the results. Therefore, this month let me share the design and let's see how far it can evolve.

CELLFOAM 88 AND PLASTIC TUBES

The traditional Styrofoam used in the construction of

■ **FIGURE 1.** University of Kansas AE360 class BalloonSats on their way to near space.

BalloonSat airframes has a soft face; you can easily mar the surface. I therefore opted to use Cellfoam 88 for the airframe material. Cellfoam 88 is traditional Styrofoam, but the faces of it are pressed between two hot rollers. This gives the face a hard and smooth surface. This hardness and smoothness of Cellfoam 88 is somewhere between a soft Styrofoam and a solid sheet of polystyrene.

I discovered this allows you to glue a solid sheet of Styrene to the face of Cellfoam 88 (if liquid polystyrene glue is used). If, on the other hand, you try gluing Styrene to traditional foam, the glue will melt the foam.

A weather balloon will carry many BalloonSats into near space by attaching them together with one or more cords. BalloonSats must have some type of tube through the airframe. The tube forms a channel for the cords that protects the Styrofoam airframe from abrasion. In my traditional (that is, until now) airframe, students cut channels into the walls of the airframe and glued the tubes into them. That way, the tube does not reduce the useable volume of the airframe.

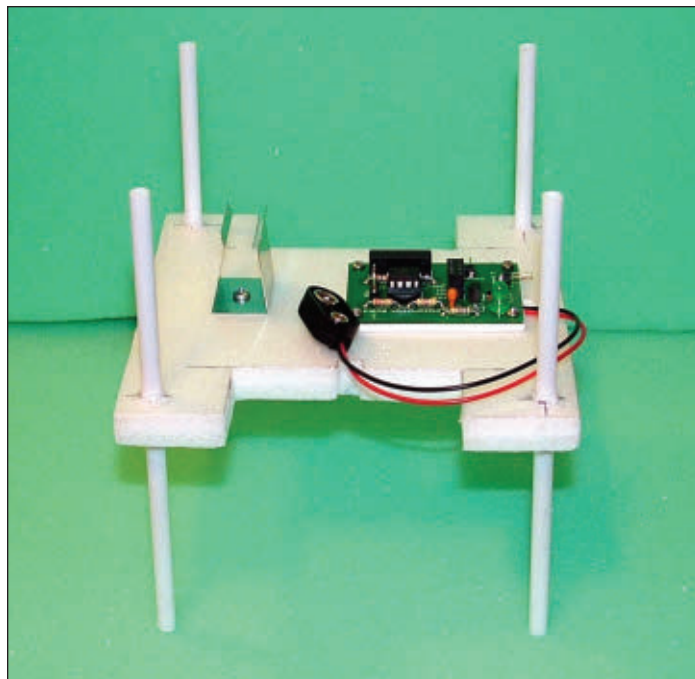
So, Cellfoam 88 and plastic tubes are the core of the airframe design in this article. To replicate the CubeSat concept, I stacked layers of uniformly cut Cellfoam 88 sheets on four plastic tubes. These form decks that slide up and down the four tubes. The holes for the tubes are drilled near the corners of the decks where they create the least impact to useable volume. Since the BalloonSat is a small cube, the number of decks is very limited.

I settled for three in my first test: a top, bottom, and middle deck. This created two bays: an upper and a lower. I placed the camera in the lower bay and the electronics and battery in the upper bay.

CONSTRUCTING THE AIRFRAME

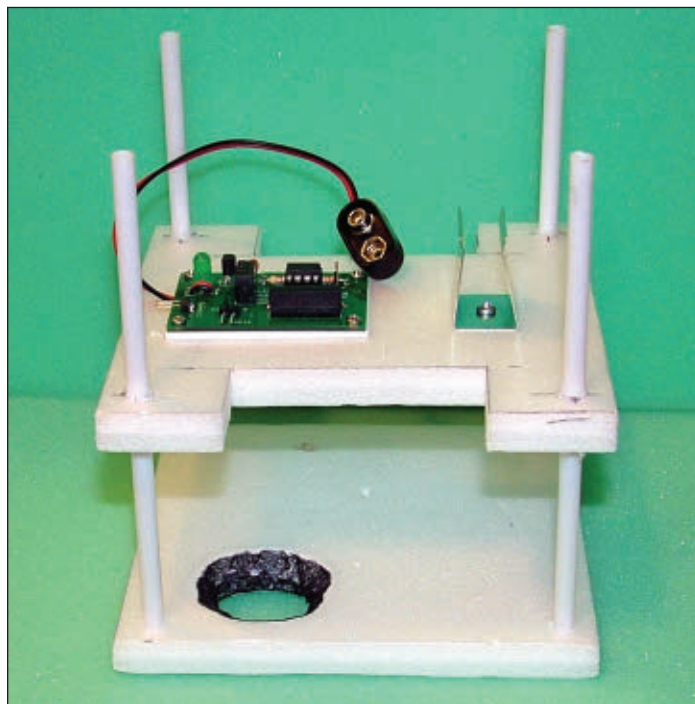
I began cutting out four sheets of Cellfoam 88. I used the 10 mm thick sheets and cut them into squares measuring five inches on a side. The design only needed three sheets, but I cut an additional sheet as a backup. I then stacked the sheets and drilled four holes near their corners. The holes were 3/16 inches in diameter — just large enough for the plastic tubes. By drilling the sheets while they were stacked together, the tubes passed through the same positions on all four decks.

Bolting stuff to Cellfoam requires care because a tight nut and bolt will crush the foam. Therefore, I glued a thin sheet of polystyrene plastic to the underside of the Styrofoam. I mounted the electronics to the top of the Styrofoam with a foamed neoprene sheet beneath it. Neoprene foam is available in colorful sheets at many craft stores where it is sold under names like Fun Foam, Funky Foam, and Foamies. Finally, I used a nylock (nylon insert nut) in place of a hex nut. Using a plastic sheet, slightly compressed neoprene foam, and nylocks seems to be a very secure way to attach the electronics to Styrofoam.

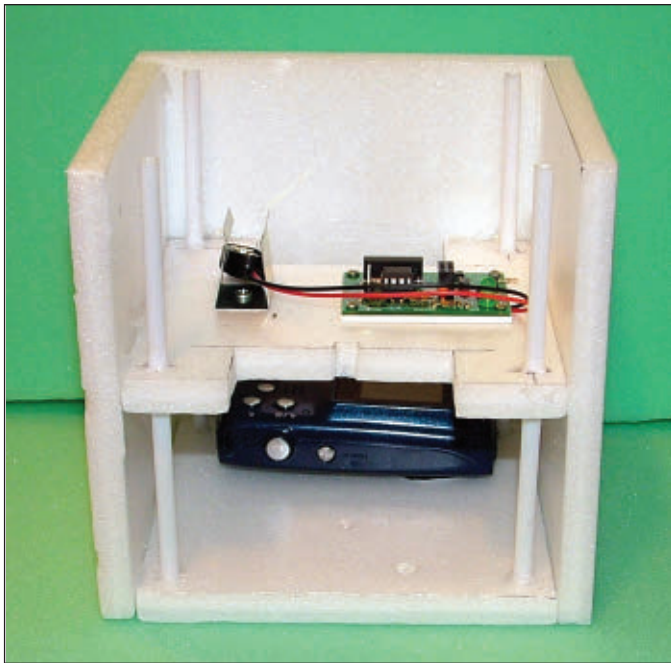


■ **FIGURE 2.** In the initial test-fitting, I bolted the flight computer to the middle deck and mounted the middle deck on the four corner tubes. At this point of the construction, the middle deck was glued to the tubes. The middle deck would divide the BalloonSat into two equally tall bays.

As you can see in **Figure 2**, there are two notches cut into the middle deck. I initially cut them so I could route

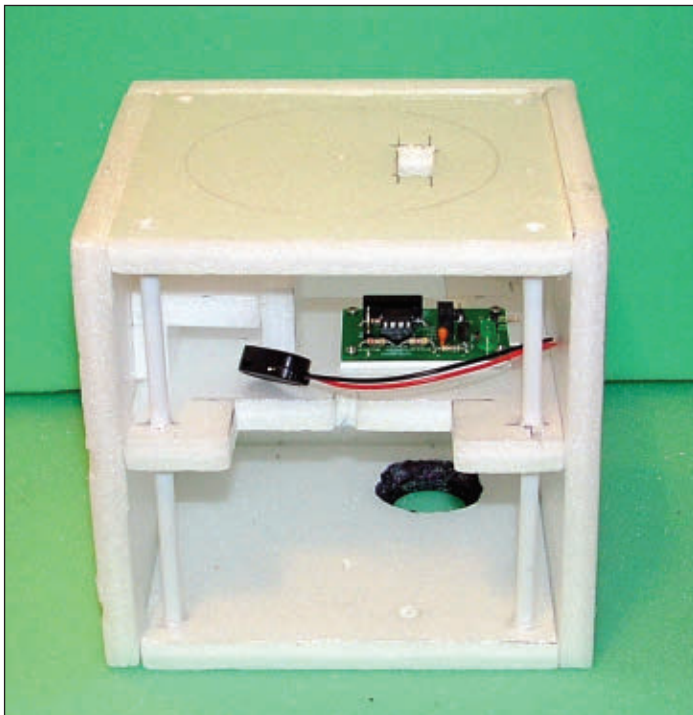


■ **FIGURE 3.** Next up, test-fitting the bottom deck of the airframe. This is where the digital camera will reside. I cut a hole in the Styrofoam for the camera lens and darkened it with a permanent black marker.

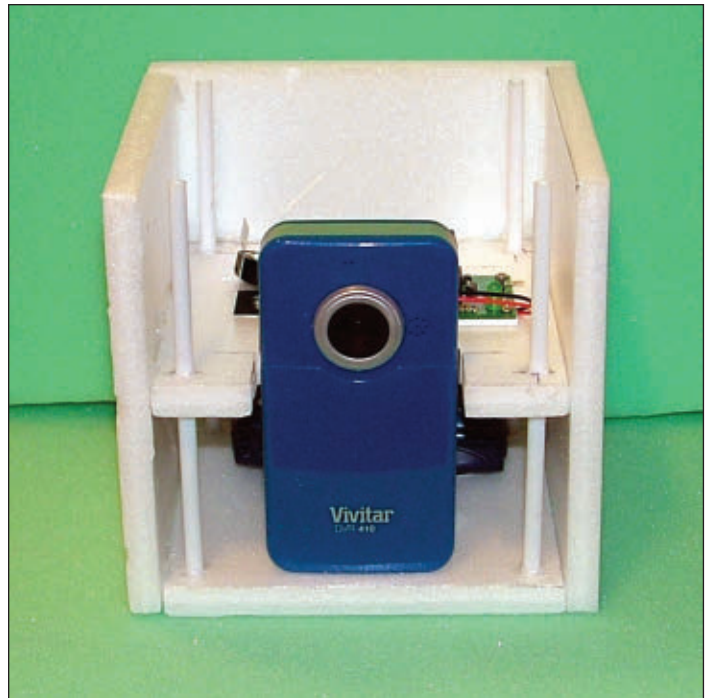


■ **FIGURE 4.** At this point, the sides have been glued to the bottom and middle decks.

wires between the upper and lower bays. Later, I decided to attach a small digital video recorder to one face of the BalloonSat. However, I didn't know which face at the time as the design could support a hatch on one face or on two opposite faces. Therefore, I cut both notches large



■ **FIGURE 7.** The airframe now has a top. The four holes drilled for the tubes are now visible. They are near the corners of the top deck.



■ **FIGURE 5.** Test-fit of the video camera.

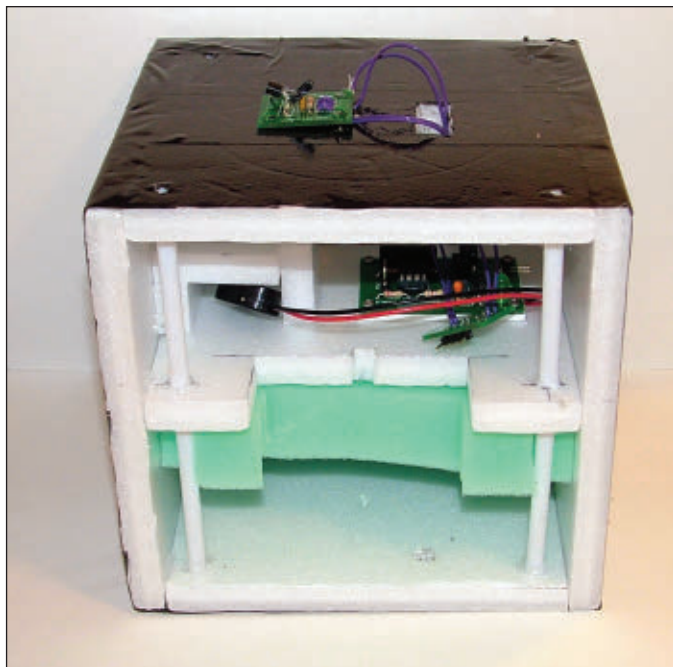
enough for the camera. That let me put off deciding which face gets the video camera until later.

I then stacked the middle deck and tubes on the bottom deck of the airframe. The digital camera looks out the bottom of the BalloonSat and so has to be mounted into the lower bay. Like most cameras, this one is designed to be mounted to a tripod using a 1/4-20 bolt. I placed the camera on the bottom deck so its base would be up against the future wall of the airframe. Then, knowing where the camera will lay, I cut out a hole in the bottom deck for the camera's lens. To prevent sunlight from causing glare, I then blackened the edges of the camera lens hole.

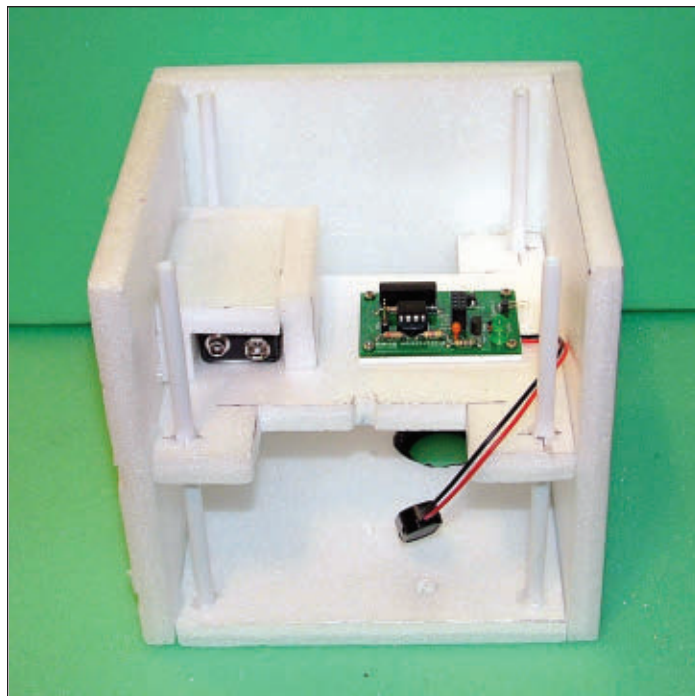
Next, I used hot glue to attach three of the airframe sides to the decks. I only attached three, since the fourth side will be the hatch of the BalloonSat. The camera was checked one more time to make sure that it still slid into the lower bay. I also measured the location for the camera's 1/4-20 threaded hole. Before drilling the 1/4 inch hole, I first drilled a small test hole in the airframe to double-check that my placement was accurate. After verifying the hole was properly placed, I finished drilling the larger hole for the bolt.

Before gluing the top to the airframe, I test-fitted the video camera. As you can see in **Figure 5**, it fits into the airframe and looks out the hatch. It was also at this point that testing showed that trying to snap the 9V battery into the holder would be a bad idea.

The stress and strain created by snapping the battery into the metal holder would eventually break the Cellfoam 88 of the middle deck. Therefore, I replaced the metal battery clip with a Styrofoam box made with 10 millimeter



■ **FIGURE 8.** The airframe has been wrapped in black tape. The holes in the tape are cut with an Exacto knife. However, I find that a hot soldering iron or hot Styrofoam knife is better for melting clean, small holes in the tape. The sensor array is hot-glued to the top of the airframe.



■ **FIGURE 6.** The battery box. By sliding the battery into this opened box, it's kept from bouncing all around inside the airframe.

thick foam. The battery box was placed far enough from the front that it wouldn't interfere with attaching the video camera.

As you might begin to see, in this BalloonSat design I will connect the flight computer to the nine volt battery and then turn on the digital camera. Afterwards, I can start up the camcorder and close the hatch.

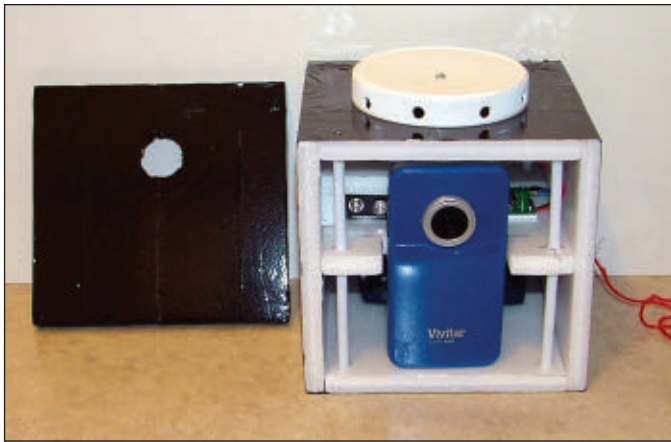
Now, it was time to attach the top deck. The weather sensors would be placed on the top, where their orientation (with respect to the sun) doesn't change significantly. If they are attached to the side of the airframe, the balloon's rotation would carry them in and out of the sun — perhaps affect their readings. The sensors I selected were an LM335 temperature sensor and a Honeywell HIH-4000 relative humidity sensor. Since both react to sunlight shining on them, I placed a white plastic lid over the sensors. The lid's rim was drilled with a series of holes that are designed to let the air flow in. However, the holes are small enough that no significant amount of sunlight can shine on the sensors inside. After gluing the top to the airframe, I marked the location of the plastic lid and cut a slot to allow the sensor's cable to pass into the airframe.

The results of a near space experiment that I performed years ago led me to believe that the interior of a BalloonSat airframe remains warmer if its exterior is colored black. Since the airframe material is Styrofoam, I use colored packing tape to add color to the BalloonSat. This tape is popular for covering Styrofoam gliders (in place of painting them). The tape is also used to seal and

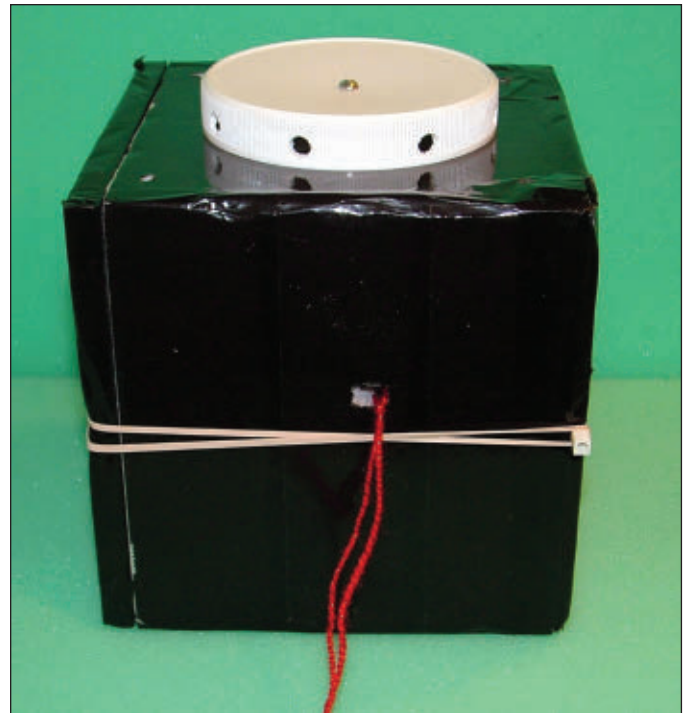
label packages in preparation for mailing. You can find it at Uline (www.uline.com) as item S-700. Another benefit of using the tape is that by wrapping it around the outside of the airframe, it creates compression that helps hold it together.



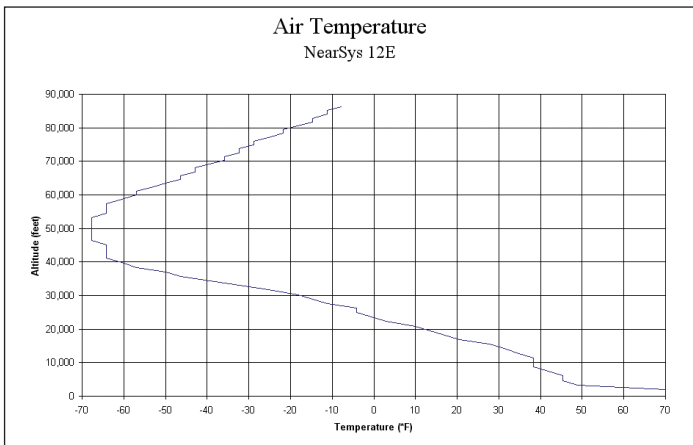
■ **FIGURE 9.** Everything but the hatch is ready. The cameras are bolted into the airframe as is the white plastic lid on top.



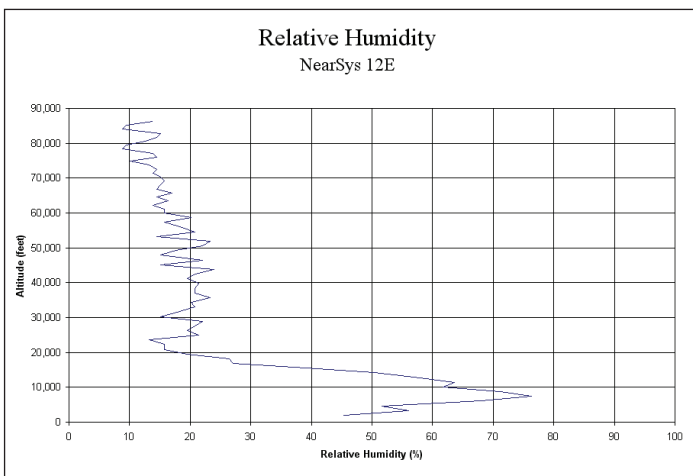
■ **FIGURE 11.** The red string on the right side of the BalloonSat is the flight computer's commit pin. It permits me to connect the battery to the flight computer ahead of time, but won't let it begin recording data. That is, until I pull out the pin.



■ **FIGURE 12.** A side view of the BalloonSat airframe. The hatch is on the left side. You can see there's a small opening in the airframe for the commit pin cable to hang out of.



■ **FIGURE 13.** The air temperature as a function of altitude. The increasing temperature above 50,000 feet indicates that this is the altitude where the stratosphere begins.



■ **FIGURE 14.** You can see we passed through a cloud layer at about 8,000 feet. The rest of the flight is very dry.

The downward-looking camera only bolts to the airframe at one point. This turned out to be a problem, since I left clear space around the camera so it could easily slide in and out of the lower bay. Without a tighter fit, the camera is liable to twist against the airframe during the chaotic descent and crack the foam airframe. Just in case, I took up the slack and added gentle pressure to the camera by sliding a sheet of thick foam latex to the top of the bottom bay.

The next step was the construction of the BalloonSat hatch. The hatch is a 10 millimeter thick sheet of Cellfoam 88 that sits on the surface of the opened airframe. However, I wanted to keep the hatch from sliding around. So, I cut rectangles out of five millimeter thick Cellfoam 88 that fit between the decks of the BalloonSat. These were then strategically hot-glued to the inside of the hatch. Now, the hatch snaps into place on the airframe, but the rectangles keep it from twisting or sliding around. The position of the video camera's lens was measured and I cut a hole in the hatch to match. Finally, the hatch was given a coat of black tape.

I made one change to the airframe after its assembly. I wanted a simple way to hold the hatch closed, so I cut a channel in the back of the airframe and glued a square tube into it. The tube was about seven inches long, so it extends a 1/2 inch beyond both sides of the airframe. That square tube stands out like a sore thumb in the back of the airframe, therefore, I covered the construction site over with a strip of black sealing tape. To lock the hatch, I

■ **FIGURE 15.** This is Great Bend and its airport as seen from 59,000 feet. I had been experimenting with using this camera for near infrared photography and forgot to change its settings back to color.

wrap a rubber band around one end of the tube, across the hatch, and then wrap it around the other end of the tube.

SUCCESS, MOSTLY

I had a chance to fly my new BalloonSat on April 22, 2012. The launch took place at the Physics department of Ft. Hays State University (thanks Dr. Adams and Dr. Maseburg). My BalloonSat was tracked using the Ft. Hays APRS tracker and one of mine.

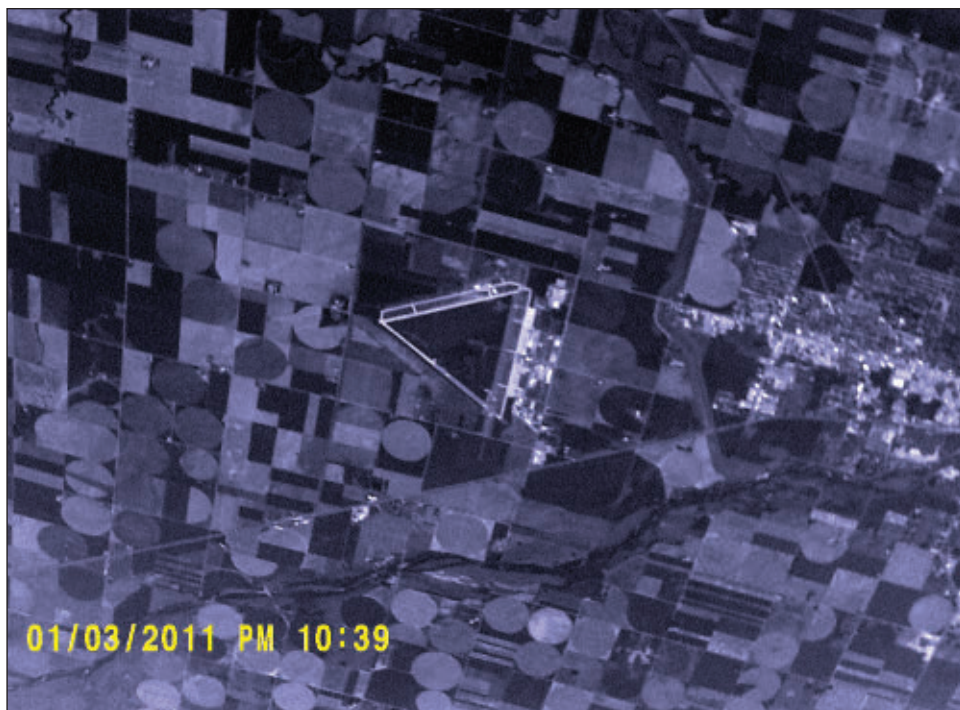
I was glad for the Ft. Hays tracker, as I was recently having trouble with my trackers quitting during flight. (The problem was eventually traced to old batteries, but I digress.) The flight reached just under 87,000 feet and landed south of Great Bend, KS. I recorded the information in **Figures 13, 14, and 15** concerning the air temperature and relative humidity with this BalloonSat.

LESSONS LEARNED

The BalloonSat worked well, overall. However, I learned several things on this mission. First, check the size of the SD memory card in the video camera and make sure it can record an entire mission (over two hours). I also discovered that if the BalloonSat gets shaken too much, the camera's power button and SD memory card can bang into the Styrofoam airframe. Pushing on the camera's power button will shut it off and pushing the SD memory card will eject it from the camera.

That's a pity because there's no one onboard to restart the recording or reinsert the camera's SD card. So, I've now learned to cut small notches into the Styrofoam where it could make dangerous contact with the camera. I later discovered that depending on the camera, a small nylon bolt can be inserted into the AV jack to push the camera power switch away from the Styrofoam airframe. Finally, if you or someone else messes around with a camera, be sure to reset it when you're done.

Onwards and Upwards,
Your near space guide **NV**
(Making mistakes so you don't have to)



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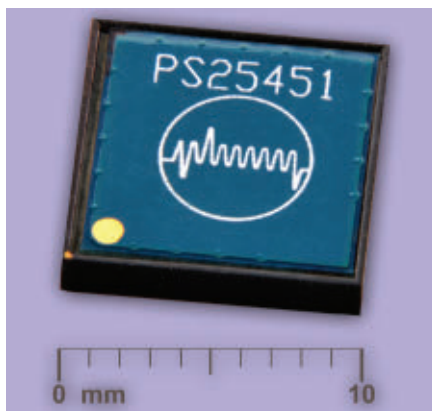
focus on finding problems by monitoring real time readings on a laptop or computer screen from safe distances — up to 30 feet away.

The meter comes complete with a remote USB receiver, Windows® compatible software, test leads with alligator clips, Type K bead wire temperature probe with adapter, carrying case, and six AA batteries. The MG300 is available with NIST-traceable certification (model MG300-NIST). For users outside North America, the MG302 which transmits data at 433 MHz instead of 915 MHz is also available.

For more information, contact:
Extech
Web: www.extech.com

LOW COST EPIC SENSOR FOR REMOTE CONSUMER APPS

Saelig Co., Inc., announces the PS25451 — an ultra-low cost version of Plessey's award winning EPIC sensor that provides remote sensing for high volume consumer markets. The PS25451's economical



electrode design eliminates the more expensive titanium dioxide electrodes. The EPIC sensor (Electric Potential Integrated Circuit) measures electric field changes without physical or resistive contact. EPIC is an award winning, patent-protected technology for rapidly measuring spatial electric fields.

The PS25451 is an ultra-high impedance, non-contact, solid-state electric potential sensor that is suited for a variety of consumer devices such as proximity switching of lighting, gesture-based remote control of interactive toys, computer games, TVs, monitors, other appliances, and presence detection (even through walls) for security/alarm systems. The EPIC sensor works by measuring tiny changes in an electric field in a similar way to a magnetometer

detecting changes in a magnetic field. This enables it to be used for security motion sensors and non-contact electrical switches, as well as medical applications detecting heart beats, nerve, and muscle activity either by dry contact (i.e., no gels required) or contactless.

The PS25451 is housed in a proprietary 3D package with exposed pins for surface-mount assembly, and measures 10 mm x 10 mm x 2 mm. By adjusting the gain and bandwidth of the associated amplification circuitry, the sensors can be tuned for detection at a distance as required.

EPIC technology functions at normal room temperatures as an ultra-high input impedance sensor that forms a highly stable, extremely sensitive, contactless digital voltmeter to measure millivolt electric field changes.

For more information, contact:
Saelig
Web: www.saelig.com

RADIOTRONIX PRODUCT LINES

Linx Technologies has started shipping the product lines it

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) \$135⁰⁰ MODEL FG-32 (5 Digit Display) \$195⁰⁰		INSTEK CORP. OSCILLOSCOPE MODEL GOS-620 Dual Channel - 20MHZ (INCLUDES PROBES) \$305⁰⁰		DC POWER SUPPLIES MODEL HY3003 - DIGITAL DISPLAY Variable output, 0-30 VDC, 0-3 Amp \$95⁰⁰ MODEL HY3003-3 - TRIPLE OUTPUT Two 0-30 VDC, 0-3 Amp variable outputs plus 5V 3A fixed. Digital Display. \$184⁰⁰	
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. \$139⁹⁵		DIGITAL MULTIMETER 32 Ranges - 3 1/2 Digit MODEL MY-64 \$33⁹⁵ AC/DC Volt/Current, Res. Cap., Frequency. Rubber Holster Included		Weller® SOLDERING STATION #1 BEST SELLING \$39⁹⁹ STATION MODEL WLC 100 0603WLC100	
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acquired from Radiotronics. The first products shipped in limited quantities are the TRM-915-DTS (formerly the Wi.232DTS-R), TRM-868-EUR (formerly the Wi.232EUR-R), and the TRM-915-R250 (formerly the Wi.232FHSS-250-R). Linx has also started shipping the DP1203 modules, as well as recertified versions of the DTS, EUR, and R250 modules.

Radiotronics was acquired by Linx in March 2012. Linx will support, manufacture, and continue development of the Wi.232DTS, Wi.232EUR, Wi.232FHSS, Wi.DP1203, and Wi.DP1205 product lines.

For more information, contact:
Linx Technologies
 Web: www.linxtechnologies.com

POLAR HEART RATE RECEIVER

The Polar heart rate receiver from Parallax is a Polar WearLink compatible receiver capable of wirelessly receiving coded heart beat transmissions from the Polar WearLink+ heart rate sensor. With its standard servo interface pinout (Vss, Vdd, Sig), interfacing with this receiver is very simple. Upon receipt of a heart beat signal, a 15 ms pulse is sent on

the signal pin. This receiver also features a longer reception distance, giving you added flexibility in your application.

Key features include:

- Receives coded or non-coded signals from Polar heart rate transmitters.
- 100 cm to 125 cm reception distance gives a greater range from the transmitting heart rate sensor.
- Long 15 ms pulse on received heart beat gives the processor ample time to sample a pulse.
- Interface connector is not preinstalled to give prototyping flexibility.
- Standard servo connector compliant for easy interfacing.

Price is \$29.99.

POLAR WEARLINK + CODED HEART RATE SENSOR

Also available from Parallax is the Polar WearLink+ coded heart rate transmitter which monitors and



then wirelessly transmits heart rate data from the chest strap to a Polar WearLink compliant receiver. This allows the wearer to monitor their heart rate and related bio-metric statistics. This transmitter can be paired with local gym exercise equipment if it is Polar WearLink compatible.

Key features include:

- Heart rate sensor wirelessly transmits heart rate without the need for conductive gel.
- Water-resistant up to 30 meters for use in extreme environments.

Continued on page 77



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Build a Screaming Box

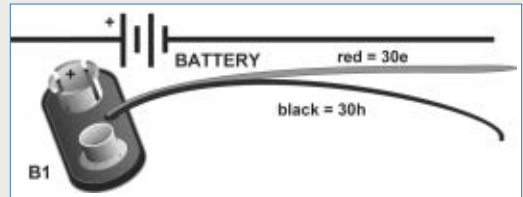
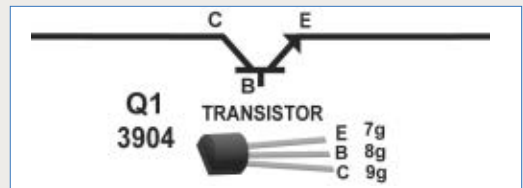
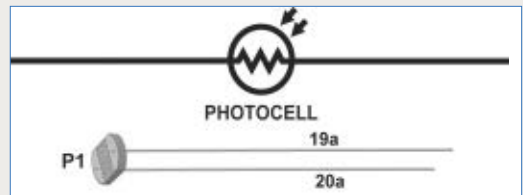
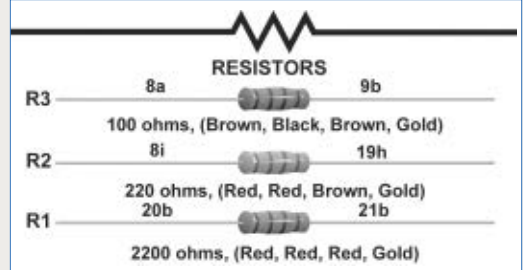
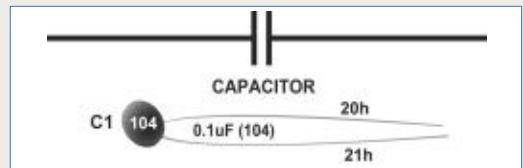
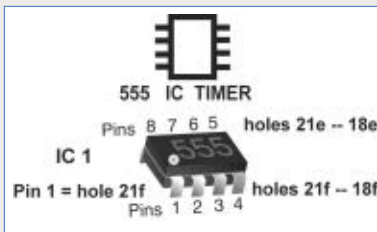
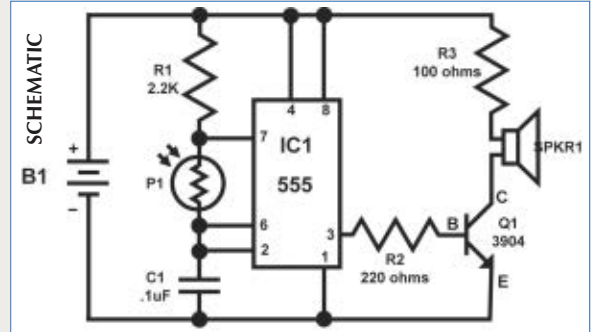
A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at www.nutsvolts.com or call us at 800-783-4624.

Use this simple light detector circuit to make a Screaming Box to use as a gag or to catch late-night snackers in the act!

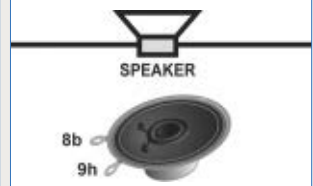
Build the Circuit. Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct. **Do the Experiment.**

Theory: This project uses the 555 timer circuit as an astable multivibrator. The voltage across the photocell controls the frequency of the pulses coming from pin 3 of the 555. Transistor Q1 amplifies the pulses and sends them to the speaker. The more light that hits the photocell, the lower the resistance and therefore the higher the frequency of the tone emitted from the speaker.

Procedure: Connect a nine volt battery to the battery snap. You should hear an approx. 500 Hz tone coming from the speaker. If you decide to place the circuit in an enclosure of some type (or hide it in a cookie jar), remember to detach the circuit from the battery when not in use because it will drain the battery. (When using the circuit in an enclosure, you may still hear a small buzz sound even when you have the photocell completely covered.)



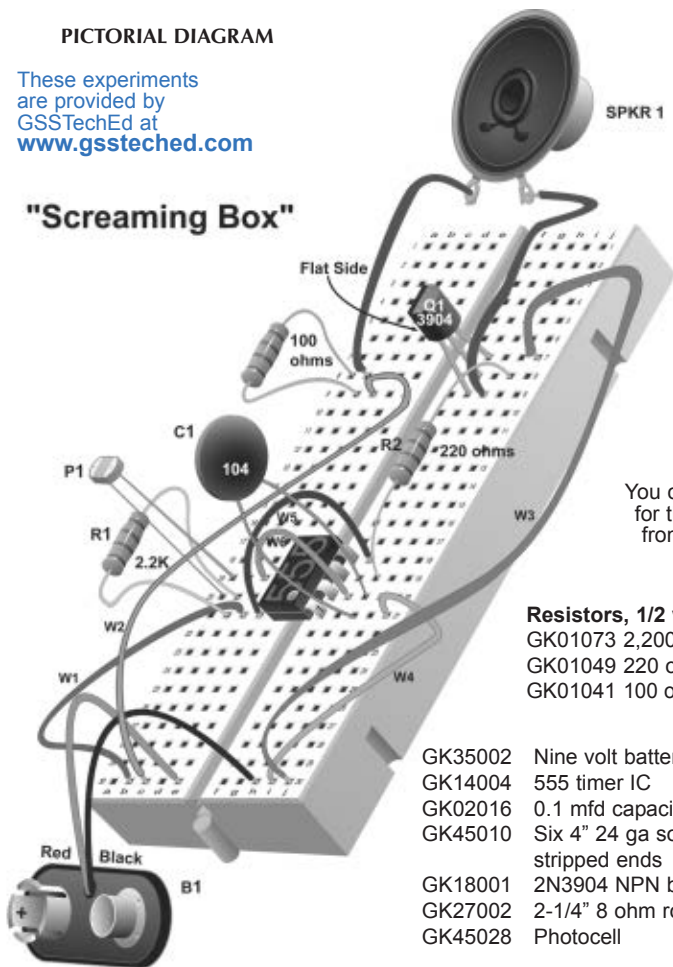
WIRES
W1 = 21c and 30b
W2 = 9c and 30c
W3 = 7j and 30j
W4 = 21j and 30i
W5 = 21d and 18g
W6 = 19d and 20g



PICTORIAL DIAGRAM

These experiments are provided by GSSTechEd at www.gssted.com

"Screaming Box"



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

Resistors, 1/2 watt 5%
GK01073 2,200 ohms (R1)
GK01049 220 ohms (R2)
GK01041 100 ohms (R3)

GK35002 Nine volt battery snap
GK14004 555 timer IC
GK02016 0.1 mfd capacitor
GK45010 Six 4" 24 ga solid wires, stripped ends
GK18001 2N3904 NPN bipolar transistor
GK27002 2-1/4" 8 ohm round speaker
GK45028 Photocell

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Continued from page 75

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>>> QUESTIONS

Modify Scott 340A Tube Receiver

I live very close to a huge water tank that affects stereo reception. I would like to connect a scope to measure FM multipath distortion. I have had no luck getting help from user groups, etc., so far! Does anyone know exactly how to do this? I can't afford the McIntosh tuners. I can do the construction if I had a schematic. Is this possible?

#7121

Nick Oshana
Bristol, CT

Timer Needed

I need a 2-3 second timer to operate a 24 volt relay, to open and close a garage door using a Desa Int'l wireless doorbell.

#7122

James Moore
via email

Fiber Optic Fusion Splicer

I am looking for some technical information for repairing various fusion splicers on the market such as Fitel, Sumitomo, and Fujikura. Anybody have any information they are willing to share?

#7123

Walter
Glendale, AZ

Garage Door Sensor

What's the best way to hack the garage door sensor so that when the garage door is open, anything breaking the light beam will trip a relay?

#7124

Kenneth Lysek
Henderson, CO

CCD/CMOS Camera Back

One of my deepest desires has been to "resurrect" my film cameras as digital. Is it at all feasible to construct some sort of relatively compact and usable CMOS or CCD device which can be attached to an existing camera that would yield high resolution images to be stored on a standard

memory card? If so, could a diagram and list of materials be provided? I would prefer a full format sensor for use on a full format 35 mm camera, but a smaller format sensor would be acceptable for attachment to microscopes or telescopes.

#7125

Greg Bargis
Baltimore, MD

Schematics and Components

I don't know that much about reading circuit diagrams, but in theory, if I bought all the components in a given diagram, could I simply connect each component to the others as shown in the schematic? I have seen reference to using a breadboard but from what little I've read, they are configured in various ways and I wouldn't know what configuration a given project might require.

I understand that soldering component leads together with no substructure or framework might look like a piece of modern art, but could I do that and expect it to do what it is supposed to — whatever that is?

#7126

M. D. Calvert
Oak Ridge, TN

RF Chip for Fuel Tank

Has anyone heard of a RF chip which attaches to the fuel tank of a vehicle and supposedly provides high frequency output which increases fuel mileage?

#7127

CWS
via email

>>> ANSWERS

[#5125 - March 2012] Looking For Datasheets

I have a collection of one and two Meg memory strips from early PCs, with which I would like to make delay lines for digitized audio. I can find no application or pin-out data for the chips; the markings seem inconsistent from strip to strip, and have no manufacturer's name or logo. (I have one set of what I believe to be four Meg strips designated as MT4C4ME8DJ.) I've done Google searches for this style of memory chip to no avail. Can anyone help?

This is an old EDO SIMM.

Knowing that — and knowing that MT meant Micron — I did a Google search for "micron edo memory datasheet" and found: www.pjrc.com/mp3/simm/datasheet.html which says (among other things):

4, 8 MEG x 32 DRAM SIMMs
(OBSOLETE)
DRAM MODULE
MT8D432(X)
MT16D832(X)

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- High performance CMOS silicon-gate process
- Single 5V $\pm 10\%$ power supply
- All inputs, outputs, and clocks are TTL-compatible
- Refresh modes: RAS#-ONLY, CAS#-BEFORE-RAS# (CBR), and HIDDEN
- 2,048 cycle refresh distributed across 32 ms
- Fast Page Mode (FPM) access or Extended Data-Out (EDO) Page Mode access

OPTIONS

Options	Marking
Timing	
50 ns access	-5*
60 ns access	-6
Packages	
72-pin SIMM	M
72-pin SIMM (Gold)	G
Operating Modes	
FAST PAGE MODE	None
EDO PAGE MODE	X

*EDO version only

Part Numbers

EDO Operating Mode

Part Number	Configuration	Plating
MT8D432G- x X	4 Meg x 32	Gold
MT8D432M- x X	4 Meg x 32	Tin/Lead
MT16D832G-x X	8 Meg x 32	Gold
MT16D832M-x X	8 Meg x 32	Tin/Lead

FPM Operating Mode

Part Number	Configuration	Plating
MT8D432G-x	4 Meg x 32	Gold
MT8D432M-x	4 Meg x 32	Tin/Lead
MT16D832G-x	8 Meg x 32	Gold
MT16D832M-x	8 Meg x 32	Tin/Lead

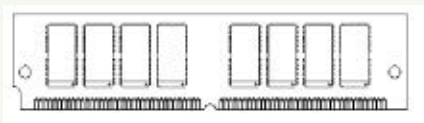
For the latest datasheet revisions, please refer to the Micron website: www.micron.com/mti/msp/html/datasheet.html.

If this isn't the right part, then try www.alldatasheet.com/view.jsp?Searchword=MT4C4ME8.

Rusty Carruth
via email

Pin Assignment (Front View)

72-Pin SIMM
4 Meg x 32
8 Meg x 32



PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL
1	Vss	19	A10	37	NC	55	DQ12
2	DQ1	20	DQ5	38	NC	56	DQ28
3	DQ17	21	DQ21	39	Vss	57	DQ13
4	DQ2	22	DQ6	40	CAS0#	58	DQ29
5	DQ18	23	DQ22	41	CAS2#	59	Vdd
6	DQ3	24	DQ7	42	CAS3#	60	DQ30
7	DQ19	25	DQ23	43	CAS1#	61	DQ14
8	DQ4	26	DQ8	44	RAS0#	62	DQ31
9	DQ20	27	DQ24	45	NC/RAS1#*	63	DQ15
10	VDD	28	A7	46	NC	64	DQ32
11	NC	29	NC (A11)	47	WE#	65	DQ16
12	A0	30	VDD	48	NC	66	NC
13	A1	31	A8	49	DQ9	67	PRD1
14	A2	32	A9	50	DQ25	68	PRD2
15	A3	33	NC/RAS3#*	51	DQ10	69	PRD3
16	A4	34	RAS2#	52	DQ26	70	PRD4
17	A5	35	NC	53	DQ11	71	NC
18	A6	36	NC	54	DQ27	72	Vss

*32 MB version only

[#6122 - June 2012] VHF Receiver

#1 Does anyone know of a VHF receiver that will tune in AM/SW signals after they've been frequency shifted up to the 216-302 MHz range? I would like to isolate the 500 kHz - 22 MHz band from a directional AM/SW antenna and use a local oscillator to raise them to 216-237.5 MHz. Then, I'd like to do the same for three other directional antennas to end up with four intermediate frequencies ranging from 216-302 MHz. I'm worried that a typical VHF tuner will only look for FM signals – of the wrong channel width – within the VHF band. These four new intermediate frequencies will now be high enough to make it through amplifiers (usually limited to 54-894 MHz) on our local cable system. I know that a local oscillator could be used at the receiver to bring them back down to their original range for use with a regular AM/SW radio, but I'm looking for an off-the-shelf solution without a hardware modified receiver. Can the "Uniden Home Patrol" or "GRC PSR-800" receivers have their Flash memory store software modified to do this? The four separate intermediate frequencies will give the end user access to their choice of signals from four different directions. Something low cost, with an internal power supply (no wall warts), and include digital or SSB would be ideal. Thanks.

Your shortwave distribution via cable TV sounds most interesting!

I have reviewed the specs for the PSR-800 and Uniden Home Patrol receivers and find them to be less than ideal for your purpose.

1) The channel step size for these receivers is 6.25 kHz for the PSR-800 and 5 kHz for the Uniden. Many longwave and shortwave stations are best resolved on 1 kHz or 9 kHz channel steps or smaller. Your listeners will not be able to tune in all stations.

2) The AM channel bandwidth for these types of receivers is in the order of 12 to 15 kHz which means that several stations may be heard at once.

Most shortwave receivers offer a 3 or 6 kHz filter bandwidth to better resolve shortwave stations.

A receiver such as the AOR8200 MK3 or one of its desktop equivalents, or one of the ICOM professional receivers such as the ICR-8500 (now obsolete) would be a suitable receiver and will permit CW, USB, and LSB reception.

You mentioned the use of a local oscillator as a down converter at the receiving end to facilitate use of a standard shortwave receiver. This would be an excellent option as you could use the frequency selector knob of the LO to directly steer your directional antenna selection (N,E,W,S) without having to retune the receiver. This would be functionally a superior method. Secondly, the use of a down converter frees the listener from having to calculate the LO offset used for each frequency and directional antenna.

The selection of shortwave receiver should be models which permit direct connection of an external antenna (the down converter output). In this way, interference from over the air signal to the cable provided signal can be minimized. There will be a delay, and resulting tone difference between signals leaking in from over the air and those of the cable system, so use of well shielded coax is recommended.

Something you should consider is that the TV channels on the cable system are generally adjusted so that their amplitude is equal on each channel to minimize reception of inter-modulation (IM - channel mixing) artifacts on television channels. Your shortwave channel will demand a larger dynamic range to receive weaker shortwave stations, so it is possible that IM products from the TV channels will be heard within the shortwave pass band. Likewise, the shortwave signals presented to the

head end will have to be adjusted so that the aggregate power (in a 6 MHz channel bandwidth) does not exceed that of the channel power of the TV channels, or TV reception may be bothered.

You might also consider use of an FM modulated up converter and FM demodulator/down converter method where the 500 kHz to 22 MHz "base band" is directly applied to an FM modulator and recovered from a demodulator at the receiver. You may be able to find some suitable commercially available CATV FM video modulators and demodulators that will interface directly at the head end.

I experimented with this technique over an FM microwave link and it worked well, and because the base band is faithfully demodulated, there was no frequency translation error in the recovered signal.

Good luck on this project. I would be interested in hearing how it works out.

Joe Leikhim
Communications Consultant
Oviedo, FL

#2 My Realistic PRO 2004 allows the selection of AM detection at any time, and those receivers can be found on eBay for a pretty low price these days. You would be stuck with a fixed frequency step and no BFO, but that's probably fine for listening to foreign broadcasts. Another approach is a software-defined radio like the Funcube Dongle. That will require a computer, but it is really flexible and there's amazing free software, too. I'm surprised that you have that kind of directionality for such a wide frequency range; I would think that two antennas would be about as good as you can do.

Charles Wenzel
Austin, TX

[#6123 - June 2012] Digital Technology?

I am a senior citizen plagued with hearing loss. I have been using hearing

aids for about 30 years!! The vendors keep touting "digital" technology although none of them can explain how "digital" amplifiers work. I am familiar with analog amplifiers. Can someone give an explanation of this "digital" technology?

A digital hearing aid still has an analog microphone, mic pre-amp, audio power amp and speaker (ear-piece). It's what's in the middle that's digital: a programmable digital signal processor. The DSP takes the mic input and converts it to bits of data (digital). The DSP can analyze the data and make adjustments depending on the programming. For example, if you have a hearing loss at 2,000 Hz the audiologist can program a boost in your hearing aid at 2,000 Hz. If after some time your hearing becomes diminished overall, the audiologist can program a general boost of all the frequencies if needed. The DSP can make smart decisions to automatically reduce or eliminate feedback and background noise. The latter can help you understand conversations in a noisy room. The DSP can automatically adjust the volume too. After the DSP does all this processing, it converts the bits of data back to analog and sends it to the audio amp. The beauty of a digital hearing aid is that a single design can be programmed to be used by many people without changing the electronics. All you need to have customized is the ear mold to fit your ear. An audiologist connects the hearing aid to a laptop computer to program its many parameters. Take a look at www.hearsource.com to see an example of how you can program your own digital hearing aid. As always, don't underestimate the value provided by your audiologist. Consider self-programming as fine-tuning and let the audiologist determine your baseline. (I am not a hearing professional. Consult with your doctor and audiologist for expert advice.)

Rick Swenton
Bristol, CT

AMATEUR RADIO AND TV

NightFire Electronics.....35
Ramsey Electronics, Inc. ...20-21

BATTERIES/CHARGERS

Cunard Associates30

BUYING ELECTRONIC SURPLUS

Jaycar Electronics.....41
Weirdstuff Warehouse30

CCD CAMERAS/VIDEO

Circuit Specialists, Inc.82-83
Ramsey Electronics, Inc. ...20-21

CIRCUIT BOARDS

AP Circuits27
Cunard Associates30
Dimension Engineering.....8
ExpressPCB40
Front Panel Express LLC18
Futurlec13
PCB Pool63
R.E. Smith Inc.26
Saelig Company Inc.26

COMPONENTS

Can Kit Corp.62
Chaney Electronics4
Electronix Express74
Fun Gizmos30
Futurlec13
NightFire Electronics.....35
Noritake13
SDP/SI30

COMPUTER

Hardware

Noritake13
Weirdstuff Warehouse30

Microcontrollers / I/O Boards

Abacom Technologies18
Bitscope62
Fun Gizmos30
microEngineering Labs.....75
MikroElektronika3
Parallax, Inc.Back Cover

Pololu Robotics & Electronics....5

DESIGN/ENGINEERING/ REPAIR SERVICES

Can Kit Corp.62
ExpressPCB40
Front Panel Express LLC18
PCB Pool63

DIGITAL

OSCILLOSCOPES

Rigol Technologies.....30

DRIVE COMPONENT CATALOGS

SDP/SI30

EDUCATION

Bitscope62
Command Productions29
Elkins Training.....13
Global Specialties7
GSS Tech Ed73
NKC Electronics30
Poscope53

EMBEDDED TOOLS

NetBurner2

ENCLOSURES

Front Panel Express LLC18

EVENTS

AUVSI52

KITS & PLANS

Can Kit Corp.62
Chaney Electronics4
GSS Tech Ed73
Jaycar Electronics.....41
NetBurner2
NightFire Electronics.....35
NKC Electronics30
QKITS30
Ramsey Electronics, Inc. ...20-21

MISC./SURPLUS

All Electronics Corp.19
Chaney Electronics4
Front Panel Express LLC18

Weirdstuff Warehouse30

OPTICS

Noritake13

PROTOTYPING AND TRAINERS

Global Specialties7

PROGRAMMERS

Futurlec13
microEngineering Labs75
MikroElektronika3

RF TRANSMITTERS/ RECEIVERS

Abacom Technologies18

ROBOTICS

Fun Gizmos30
GSS Tech Ed73
Lemos International Co., Inc. ..30
Pololu Robotics & Electronics....5
Robot Power30
SDP/SI30

SATELLITE

Lemos International Co., Inc. ..30

TEST EQUIPMENT

Bitscope62
Circuit Specialists, Inc.82-83
Dimension Engineering.....8
Electronic Design Specialists....9
Global Specialties7
Jaycar Electronics.....41
NKC Electronics30
Poscope53
Rigol Technologies.....30
Saelig Company Inc.26

TOOLS

MikroElektronika3
NetBurner2
PanaVise27
Poscope53

WAVEFORM GENERATORS

Rigol Technologies.....30

Abacom Technologies	18
All Electronics Corp.	19
AP Circuits	27
AUVSI	52
Bitscope	62
Can Kit Corp.	62
Chaney Electronics	4
Circuit Specialists, Inc.	82-83
Command Productions	29
Cunard Associates	30
Dimension Engineering	8
Electronic Design Specialists	9
Electronix Express	74
Elkins Training	13
ExpressPCB	40
Front Panel Express LLC	18
Fun Gizmos	30
Futurlec	13
Global Specialties	7
GSS Tech Ed	73
Jaycar Electronics	41
Lemos International Co., Inc.	30
microEngineering Labs	75
MikroElektronika	3
NetBurner	2
NightFire Electronics	35
NKC Electronics	30
Noritake	13
PanaVise	27
Parallax, Inc.	Back Cover
PCB Pool	63
Pololu Robotics & Electronics	5
Poscope	53
QKITS	30
Ramsey Electronics, Inc.	20-21
R.E. Smith Inc.	26
Rigol Technologies	30
Robot Power	30
Saelig Company Inc.	26
SDP/SI	30
Weirdstuff Warehouse	30



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



These 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 Station

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 & automatically returns to that setting the next time the user turns the system on. Also included is a separate 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.
- Automatically 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

SMD Hot Air Rework Station with Suction Pick-Up Wand



What every shop or lab needs to deal with today's SMT designed circuit boards. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! A multi-technology assembly and repair station. The heater and air control system is built-in and adjusted by the simple touch of the front keypad for precise settings.

Temperature range is from 100°C to 480°C / 212°F to 896°F, and the entire unit will enter a temperature drop state after 15 minutes of non-use for safety and to eliminate excessive wear.

Item#
CSI825A **\$109.00**

www.CircuitSpecialists.com/CSI825A

SMD Hot Air Rework Station with Soldering Iron



An SMT rework station & soldering station in one handy unit! Perfect for shops & labs dealing with today's SMT board designs. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! This multi-purpose station is perfect for all your surface mount and thru-hole requirements.

The soldering iron has a grounded tip for static sensitive parts and uses a ceramic heating element for fast heat up and stable temperature control. A separate aluminum constructed soldering iron holder is included.

Item#
CSI906 **\$109.00**

www.CircuitSpecialists.com/CSI906

Heavy Duty PCB Cutting Shear



This PCB cutter is a terrific cutting tool for printed circuit boards, thin aluminum, plastic or copper. Cut fiberglass or paper phenolic pcbs up to 2mm thick. The powerful E-Z pull handle provides extreme leveredge through its unique design. A plastic safety guard is implemented to avoid cutting accidents. The upper and lower blades are manufactured from hardened alloyed tool grade steel and provide a precise well finished cut every time. A ruler affixed to the cutting platform ensures accurate cutting. This is a heavy duty, rugged shop grade pcb cutter.

PCB Cutter Technical Data:

Board size : up to 320mm (about 12 ")
Cutting thickness: up to 2mm
Panel size: 51×31.5mm²
Machine size: 53×33×30mm³
Net weight: 17.5Kg
Gross weight: 21Kg

Item#
PCB Cutter **\$399.00**

www.CircuitSpecialists.com/pcb-cutter

Data Logging True RMS Digital Multimeter



The DM620 data-logging meter features auto ranging and has an auto shut down feature that extends battery life when the unit is left powered up. It also features Range Hold, Data Hold, and an audible continuity function. Besides the True-RMS AC and DC measurement modes for both voltage and current, it also features Resistance, Capacitance, and temperature measurements, along with a diode test function and the ability to measure the Frequency, Period, and Duty cycle of signals up to 10 Mhz.

- Data Logging: 18,000 Points & 50,000 Counts without attaching to a PC
- USB Interface (USB Cable & USB AC Charger Included)
- Basic Accuracy: 0.05% DC V
- True RMS
- Auto Calibration
- Trend Plot
- Real Time Clock
- 10 Mhz Frequency Counter
- Record, Relative, Compare & Period Modes

Item#
DM620 **\$139.00**

www.CircuitSpecialists.com/DM620





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:

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Step Up/Down Transformers

2 outlets: 1 for 110/120VAC
1 for 220/240VAC

Provides:
110/120VAC to 220/240VAC
or 220/240VAC to 110/120VAC

Heavy duty transformer design
for safety & reliability

With either 110VAC or 220VAC input

300 Watt Step Up/Step Down Transformer

Item # **ST-300** \$17.95

www.circuitspecialists.com/ST-300

1500 Watt Step Up/Step Down Transformer

Item # **ST-1500** \$53.00

www.circuitspecialists.com/ST-1500



Step Up transformers

Allows users to acquire 220 VAC
output with 110 VAC input.

Reliable heavy duty linear
transformer design.

Universal 3 pronged style 220
VAC receptacles.

Integrated wire carry handles
for added convenience.

200 Watt Step Up Transformer

Item # **TS-200** \$9.95

www.circuitspecialists.com/TS-200

1000 Watt Step Up Transformer

Item # **TS-1000** \$29.95

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Digital Multimeter with Mechanically Protected Inputs



This is a terrific low cost digital multimeter from Circuit Specialists. IDEAL for students and technicians with a broad selection of measurement ranges and features. The inputs are mechanically protected to PREVENT incorrect test lead placement (the leading cause of damage to digital multimeters). As the user moves the range selector, the inputs that are not appropriate to the set range are blocked while the appropriate inputs are opened. This makes it impossible to mis apply the test lead settings and makes using this digital multimeter easier and safer.

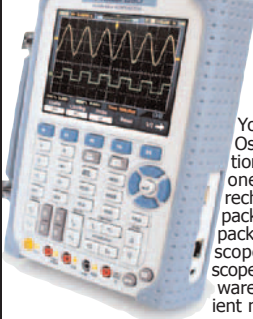
- 3 1/2 LCD display
- Overload protected
- Auto power off function
- data hold function
- Shock Resistant Case
- mechanically protected inputs
- 2000uF test function
- Transistor test

Item #
CSI2012L

\$18.95

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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 leads, two scope probes, charger, PC software, USB cable and a convenient nylon carrying case.

- 200MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
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- 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

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- 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**

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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**

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Programmable DC Power Supplies

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

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

www.circuitspecialists.com/csi-power-supplies

Hantek 5000B Series Digital Storage Oscilloscopes

Introducing the Hantek 5000B Series Digital Storage Oscilloscopes. Available in 60MHz, 100MHz and 200MHz Bandwidths. Each one provides a 1GSa/s real-time sample rate. In addition, they have a 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 probe compensation 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:

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- 25GSa/s Equivalent sample rate
- Large (7.0-inch) color display, WVGA(800x480)
- Record length 1M
- Trigger modes: edge/pulse width/line selectable video/slop/overtime etc.
- USB host and device connectivity, standard
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- Four math functions, including FFTs standard
- Provides software for PC real-time analysis

3 Models to choose from



DSO5062B
60MHz
Digital
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\$369.00* ~~\$385.00~~

www.circuitspecialists.com/dso5062b.html



DSO5102B
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Digital
Storage
Oscilloscope

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www.circuitspecialists.com/dso5102b.html



DSO5202B
200MHz
Digital
Storage
Oscilloscope

\$499.00* ~~\$599.00~~

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* Discount does not apply to prior sales.



Microcontroller Education & Events!



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DATE	EVENT TYPE	EVENT NAME	CITY & STATE
06/23/12	Public Event	Unofficial Propeller Expo Chicago (UPEC)	Lombard, IL
07/09 - 07/12/12	Teachers Only	ARRL Teachers Institute on Wireless Technology	Rocklin, CA
08/01 - 08/02/12	Teachers Only	FREE BASIC Stamp Educator's Course	Rocklin, CA
08/03/12	Teachers Only	FREE Propeller Educator's Course	Rocklin, CA
08/11/12	Public Event	Robot Weekend @ Sacramento Discovery Museum	Sacramento, CA
09/29/12	Scouting Event	Boy Scouts Expo	Beale Air Force Base, CA
09/29/12	Public Event	World Maker Faire New York	Queens, NY

Parallax Educator's Courses

Tech Lit is our favorite subject! Our microcontroller immersion workshops equip teachers with electronics, programming, and robotics experience to enhance any STEM (science, technology, education, mathematics) program. The BASIC Stamp course covers the elements of inventing and robotics with simple electronic components. The Propeller course shows how quickly and easily complex projects can be built with this multicore microcontroller.

Note: Open to high school, community college, university, and vocational-technical school instructors only.

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