■ BY VERN GRANER

ROBOTICS ON A BUDGET: BUILDING BOTS THAT DON'T BREAK THE BANK

WITH THE RECENT HEADLINES ABOUT bailouts, layoffs, and global recession, it's pretty obvious there's going to be some belt-tightening in the average household. For many of us, hobbies are one of the first things to get cut out when there are bills to pay. At the very least, we want to look a bit harder at our purchases and see if we can draw a firm line between our "wants" and our "needs." Of course, all work and no play can result in the axe-chopping of a hotel door in the wilderness (REDRUM!), so we need to find *some* way to keep "play" in the game! That means it's time to go hunting for some low-cost (maybe no cost?) robotic fun!

THE THRILL OF THE CHASE

Most towns have a thrift store or other shops that recycle and resell clothes, toys, household wares, and the like. In many cases, you'll find these stores carry lots of useful electronics that can be picked up for a song. Typically, they are camouflaged as broken electronic toys, answering machines, computers from previous decades, telephones, boom-boxes, and other consumer electronics. It can be fun (and frugal) to go hunting through the shelves for these hidden parts caches. You may be surprised how many parts you can scrounge up with as little as $10 (Figure 1).

For example, many thrift stores have old ink-jet (and sometimes dot matrix) printers. These are a great resource for harvesting parts! Gears, motors, belts, sensors, buttons, LCD displays, and all kinds of electronic components can be extracted with a bit of time, some hand tools, and a soldering iron. The same thing can be said for electronic "action" toys. These have been known to contain sound generators, LEDs, speakers, battery holders, and even infrared transceivers (Figure 2). Also, many of the thrift stores I've visited really have no idea how to price the electronics and so you may be able to fill an entire shopping cart for as little as $20!

■ FIGURES 1A, 1B, and 1C. Examples of some thrift shop finds including switches in an old joypad, a human hand analog that seems to be crying out to be upgraded with a servo, and the "gripper" used in last month's column on pneumatics.
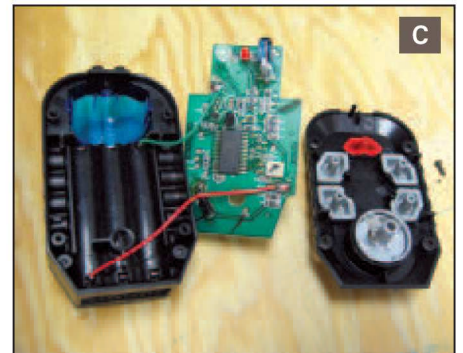
■ FIGURES 2A, 2B, and 2C. The LEGO Spybotics remote control module sports a nice AAA battery box, IR transmitter, pushbuttons, and an LED.

HARD DRIVE HARVEST

One item that is almost always able to yield some useful parts after being opened up is the venerable computer hard drive. Some older drives (especially older 5-1/4" MFM/ST-506 type drives, and some 5-1/4" floppy drives) contain very nice stepper motors (Figure 3), gear trains (Figure 4), sensors (Figure 5), and other useful bits for the hobbyist. If you can't find this vintage of hard drive, don't despair! Similar parts can be found in most CD/DVD ROM drives.

Most all modern 3.5" hard drives (Figure 6) contain recyclable and useful parts including very powerful neodymium magnets, .100" jumpers, precision screws, bearings, and other hardware (Figure 7), as well as the shiny data platters. Disassembly is simple, quick, and fun and the parts yielded are usually useful and worth your time to harvest.

Another item I hunt for at thrift stores is the oft-maligned wall wart (given its name due to its appearance as an unsightly growth on the wall). It always seems I need a specific voltage, amperage, plug type/size, or gender that I don't have on hand. I've been known to walk out of a thrift store with 10 or more of these babies (Figure 8). This way, I can always dig out an acceptable, portable power supply for a small experiment.

In the Austin, TX area, wall warts at thrift stores typically go for between $0.50 and $2.00. You can also often discover orphaned "brick style" power supplies commonly used to power laptop computers. These tend to be higher voltage/amperage and can sometimes produce multiple supply voltages so they have the potential of replacing a couple of wall warts. Keep your eyes peeled (and possibly take a magnifying glass with you) as the writing on these can be very small.

KEEP IT ON THE DOWN-LOW!

In most cases, my idea of "low cost" is below $100. I know this will probably be different for each person, but I stay with this number for two reasons. One: sub $100 purchases are less likely to be picked up on the radar by a "significant other." Two: if you are discovered, it's easier to recover from because it's about the same cost as a nice dinner out for two.

So, with $100 as the benchmark, can we really buy much in the way of "new" robotics parts or projects? The answer is a resounding YES!

Compared to a couple decades ago when a useful robotic training system cost thousands of dollars (think HERO-1), today's robotics offerings are immensely powerful with exceptional price/value ratios. For example, Parallax offers a complete two-wheel robot kit with their ever-popular BASIC Stamp II at its heart that retails for $99.99 (careful online shopping can nab one for $75 or less!).

The "Scribbler" (Figure 9) is a real programmable robot with the ability to move, use sensors, evaluate inputs, make sounds, and even draw pictures (hence the name). It also includes a
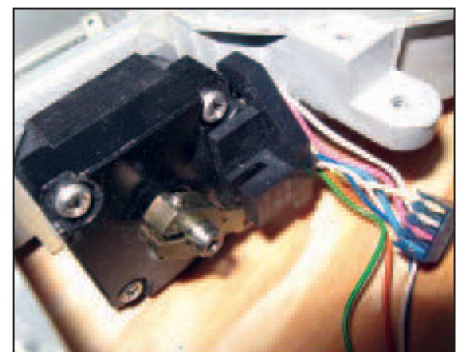
■ FIGURE 3. This is what's left after removing the platters, platter drive motor and circuit board from a dead ST-506 hard drive.

■ FIGURE 4. The stepper motor drives this nice metal platform that used to position the hard drive's magnetic heads.
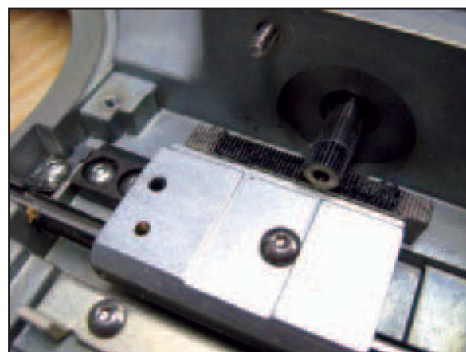
■ FIGURE 5. On the other side of the platform, an optical sensor with an adjustable interrupter is affixed to the stepper motor's shaft.

■ FIGURE 6. A typical "modern" IDE hard drive ready for disassembly.

■ FIGURE 7. The parts of a 3.5 inch hard drive after disassembly. (Time to complete this was only about 30 minutes).

free graphical programming interface, as well as a comprehensive teaching curriculum to help newcomers learn robotic principles. Of course, since it is powered by the venerable BASIC Stamp II microprocessor, it's possible to skip the entry level stuff and program the unit directly using the free IDE.

There are similar offerings from a variety of companies with some more "focused" kits that are in the sub $20 range. These usually explore a facet of basic robotics such as sensors or motors (see Resources for a list of low cost robotics kits). A good example of this is the Light Spider Robot Kit that sells for $12.25 (Figure 10) or the Aqualocator Robot Kit that sells for $24.95 (Figure 11). These "single purpose" robots are a good place to learn and experiment with facets of robotics without breaking the bank.

ULTRA LOW COST MICROCONTROLLERS

Though I am (and continue to be) a big fan of Parallax parts and their incredible support, there are some very interesting offerings from other companies that have been in the microcontroller game for quite a while. For example, the UK company Revolution Education Ltd. markets the PICAXE series of microcontrollers. Their PICAXE-08M is an eight-pin chip that sports five I/Os, three analog inputs, and is programmed in a dialect of Basic. I found this chip being offered on the SparkFun website for $3.95 (Figure 12). In fact, a complete kit that has a socket for the PICAXE-08M microcontroller chip, programming jack, and prototyping area was selling for $4.95 (Figure 13).

A 3.5" stereo (i.e., Tip-Ring-

Sleeve) jack is required to connect to the programming port and you can buy the DB-9 to 3.5" cable pre-made from SparkFun for about $7. However, to keep things cheap I was able to make one from a recycled serial mouse (removed the cable with the correct gender DB-9 connector) and a broken pair of portable headphones (I clipped the cable and used the 3.5" stereo plug). So all tolled, that's a fully functional prototyping kit for a microcontroller chip programmed in Basic for less than $10. To me, it's astounding that so much power and versatility now resides in the same footprint as a classic 555 timer!

OKAY, SO HOW ABOUT SOME NO-COST IDEAS?

So, the pennies have been pinched, the numbers have been crunched, and it turns out that unless you want to be programming your projects by candlelight, you may sadly have to forgo any more expenditures in the electronics/robotics department for a while. With a budget of effectively zero, is there any way to continue in your hobby?
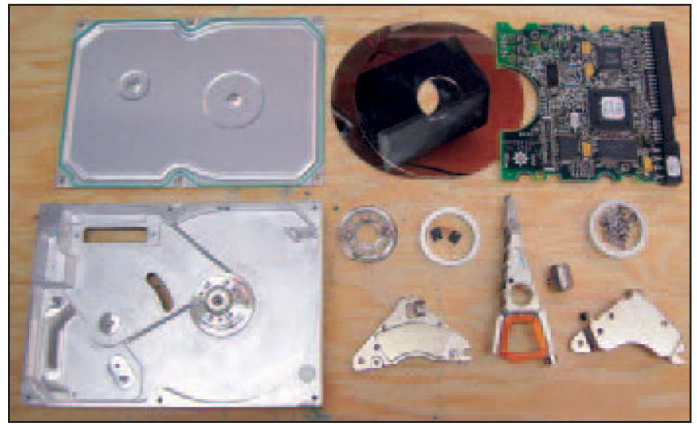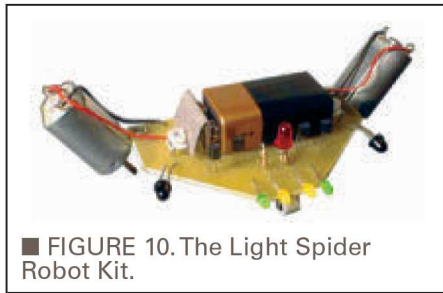
Past experience shows that it is possible to continue to experiment (and even build projects) if we apply a bit of imagination. Let's start by exploring some no-cost strategies for electronics and robotics projects.

GET RE-EXCITED!

Quite a few years ago (I shudder to think), I was a typical "starving artist" singer/songwriter with big dreams of rock and roll stardom. At loose ends during the day and between gigs, I would head on down to the local music shops and wander the isles examining the newest breakthroughs in musical equipment. I would often find myself salivating over some hot new MIDI instrument, effect processor, recording system, sound processor, or PA system gadget. It was particularly depressing when I would return home emptyhanded as times were tough and I couldn't afford to buy any of these
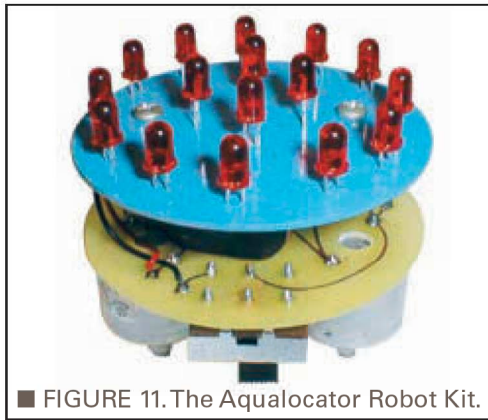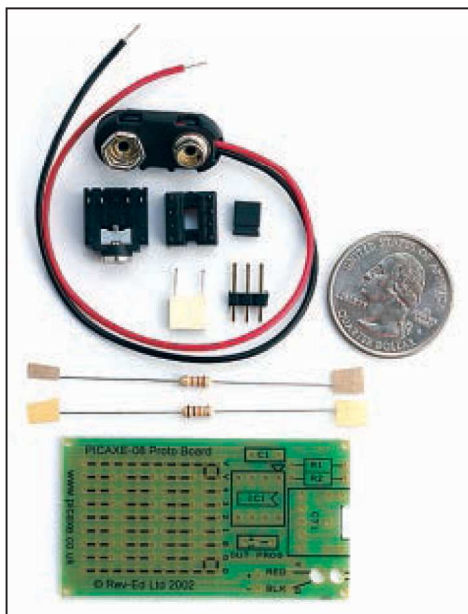

■ FIGURE 8. A collection of wall wart and "brick" style power supplies picked up on shopping trips to the thrift store.

■ FIGURE 9. The Parallax Scribbler robot.

■ FIGURE 10. The Light Spider Robot Kit.

■ FIGURE 11. The Aqualocator Robot Kit.

■ FIGURE 12. The PICAXE-08M — an eight-pin chip that sports five I/Os, three analog inputs and is programmed in Basic.

cool toys. It was in those days that I discovered a cure for the "new gear blues" that continues to work for me to this day.

Here's the trick: I would go back and re-read the advertising literature for the equipment that *I already owned*. Reading through the lists of capabilities, the marketing hype, and the typical configurations of the stuff I already had would in many cases rekindle the excitement I felt when I first opened the box!

Now with the Internet, it's possible to pull up information, specifications, and marketing literature for just about *any* part or device you have lying around. A good place to start "prospecting" for the gold you may already own (but may have forgotten about) is one of those junk boxes in the closet or even hiding in plain view collecting dust on a shelf (Figure 14). Punch a few model numbers into Google and see if you can remember why you

■ FIGURE 13. The PICAXE eight-pin proto kit from SparkFun Electronics.


bought these things in the first place. Sometimes we forget the excitement that drove the original purchase, but it can come back to you with a little bit of reading.

NOW, WHY DIDN'T I THINK OF THAT!?

You may find your searches lead to websites with pictures and videos of some new and interesting way to combine or use the very devices you already have. A couple of months back, I was wanting to bring a project to the Robot Group's weekly meeting "Show and Tell" event. I did a few searches on Google and found a cool video blog where the Parallax GPS and a BASIC Stamp II were combined to make a rudimentary GPS system (see Resources). I had purchased a Parallax GPS unit a while back for a Magellan robot I was contemplating, and a quick search through my microprocessor box turned it up in its anti-static bag, never used. A bit more digging turned up a BASIC Stamp II, a Board
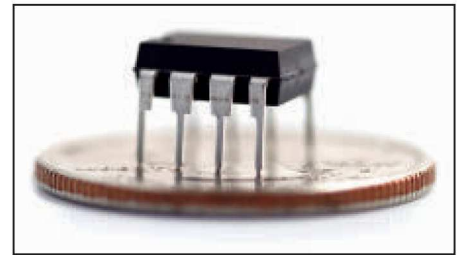

of Education, and a two line serial LCD display (among other parts) just sitting in a box. Inspired by the video, I combined my pieces in a similar way to recreate this unit. By the next day, I had a simple GPS display sitting on the dashboard of my car as I headed to the meeting. Total equipment cost: zero dollars.

After this success, I remembered watching an episode of "Prototype This!" on The Discovery Channel where Joe Grand from Grand Design Studios used a Stamp to join an RFID reader to a speech synthesizer to create a neat "restricted access" system. After a bit of digging in my junk boxes, I discovered I had all the parts he used in that design. So, I was able to make another complete project using existing parts I already owned, just combined in a way I hadn't done before (Figure 15).

VIRTUAL ROBOTICS

Another idea for zero cost involves *virtual* robotics projects. I went over this in-depth in the March 2008 issue of *Nuts & Volts*. It has quite a bit of information about how to experiment with robotic simulations that cost nothing to download and run on your computer. As a subscriber to *Nuts & Volts*, you are able to use the on-line service to read back issues for *Nuts & Volts* for free! See the Resources section for a link to the on-line edition of the magazine.
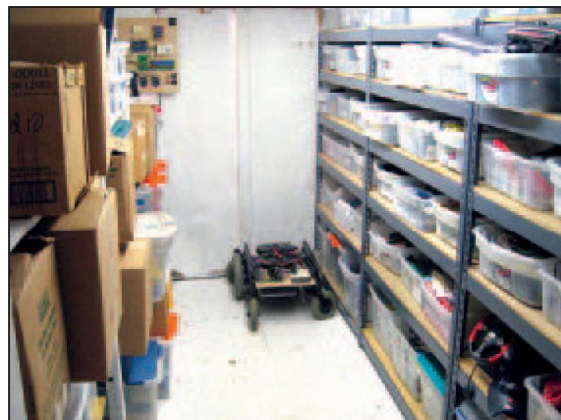
■ FIGURE 14. The junk bins in my shop that contain the bits and pieces collected over three and a half decades of electronics and robotics fun.

PLANNING IS FREE!

While you're perusing the Internet, I think it's important to remember that research and planning cost you nothing. All you need to do is bookmark the interesting pages and/or spend some time drawing up your ideas — either in a CAD program or with something as humble as a notebook and pencil. I spend lots of time doodling drawings of devices that sometimes don't come to fruition (yet) and others that do (check out the December 2007 issue of *Nuts & Volts* to see how one of my sketches became a 20 foot tall ping-pong ball shooting robot). I've placed a couple of useful links in Resources that you can use to get inspired to start planning your next project (don't miss the "Let's Make Robots" site where members share their latest creations!).

KEEP YOUR CHIN UP!

I hope this article helps to inspire you to not let economics defeat your interest in electronics and robotics. As Theodore Roosevelt once said, "Do what you can, with what you have, where you are." This is good advice for those faced with a sudden drop in funding. Necessity, though normally just famous as the mother of invention, may masquerade as your muse inspiring newfound

RESOURCES

■ PICAXE chip and protoboard from SparkFun: **www.sparkfun.com/ commerce/product_info.php? products_id=8321**

■ Joe Grand and Bre Pettis weekend project video on GPS: **http://blog. makezine.com/archive/2007/07/inte grate_lcd_and_gps_mod_1.html**

■ Low cost robotics kits: **www.chaneyelectronics.com/ products/robots www.parallax.com/scribbler www.goldmine-elec.com www.pololu.com**

■ The show "Prototype This!" featuring Joe Grand of Grand Design Studios: **www.discovery. com/prototypethis**

■ The RFID reader from Joe Grand's website: **www.grandideastudio. com/portfolio/rfid-reader/#more-65**

■ The "Virtual Robotics" column from March 2008: **http://nutsvolts.text erity.com/nutsvolts/200803**

■ "The PONGINATOR" column from December 2007: **http://nutsvolts. texterity.com/nutsvolts/200712**

■ Planning and inspiration links: **http://letsmakerobots.com http://hackaday.com http://forums.parallax.com/forums/ default.aspx?f=21**

■ The *Nuts & Volts* Online Forum: **http://forum.servomagazine.com**

■ The Robot Group, in Austin, TX: **www.TheRobotGroup.org**

creativity! Remember, you're not alone. There are thousands of hobbyists out there that share your interest, your hardships, and your triumphs. Why not take a moment to come by the *Nuts & Volts* online forum and meet some of them? In the meantime, feel free to let me know what you're thinking. You can always reach me by email at vern@txis.com. **NV**
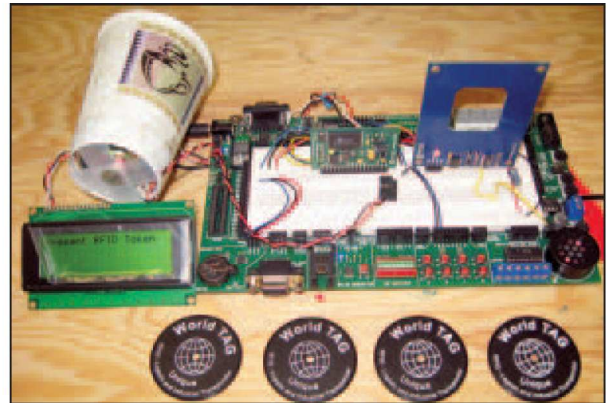
■ FIGURE 15. The Talking RFID Access Control demonstration system I built for "Show and Tell" at The Robot Group meeting in Austin, TX.