PERSONAL ROBOTICS

UNDERSTANDING, DESIGNING & CONSTRUCTING ROBOTS & ROBOTIC SYSTEMS

■ BY VERN GRANER

A PREVIEW OF THE NEW DIGIENCABULATOR

MANY OF US HAVE READ ABOUT (and drooled over!) some of the amazing gadgets the major names in robotics development have displayed over the last couple of decades. Just watching the DARPA Grand Challenge has shown us high-end "LADAR" laser range finders, massive multi-processor computers, and custom-written fuzzy logic based AI computer vision systems.

Schools like CMU and MIT have seven-digit budgets, gobs of space, and tons of components, not to mention the throngs of helpful energy-drink fueled students to assist on such projects. Whereas if you're like me, you're limited to devices you can afford after paying all the household bills and eating mac and cheese for lunch every week. But, every once in a while, folks like us can catch a break and get access to some amazing technology that manages to filter down from the "big shots." I discovered such a device recently while investigating a new product from Parallax.

It seems that the Product Development Team at Parallax has been quietly resurrecting the Digiencabulator. Originally created by General Electric in 1962 as the Turboencabulator (Figure 1), a form of the device is known to have been adopted for use by NASA as far back as the Gemini missions. New and improved versions (such as the Retroincabulator) are rumored to have played pivotal roles in the Mars Rover project, as well as the Hubble telescope. But unlike their expensive counterparts, the Parallax Digiencabulator has been specifically adapted for hobby robotics use. For example, the original models used a difficult to implement version of the TCP/IP-OCP (RFC-1149) protocol (see the sidebar on A Short History Of TCP/IP-OCP) and were encumbered by old-fashioned current-loop I/O. The new Digiencabulator sidesteps this by incorporating a plethora of protocols and industry standard interfaces. The unit has 1-Wire, I^2C, Bluetooth, and serial TTL I/O capabilities, as well as support for the less well known HTCPCP/1.0 (RFC-2324) protocol. They've even included an updated TCP/IP-OCP w/QOS (RFC-2549) to insure backwards compatibility. This makes communication incredibly flexible and compatible with just about every microcontroller and/or computer system on the market.

WHAT A DIFFERENCE A DAY AT MAKE MAKES!

A device like this doesn't just pop up on the market every day, so I'd like to provide a bit of background before we get into my hands-on review of Digiencabulator. At Maker Faire last year, I ran into Chris Savage, a product and support

■ FIGURE 1. Original reproduction of GE product catalog from December 31, 1962.

representative for Parallax. He was excitedly telling me about Parallax's efforts to create the Digiencabulator. Though I was skeptical, I told him that if they could build it, I would be glad to test it. Frankly, I felt they might be over-reaching as creating such a device would obviously be a monumental task. However, true to his word, Chris sent me an almost completely functional pre-release version of the device in March. I've been testing it in conjunction with the Boogiebot robot chassis (Figure 2) I detailed in the October '07 issue of *Nuts & Volts*. I decided to use this large bot as a test platform for a number of reasons, first of which was the power requirements.

Though it was pretty clear that the spec sheet was designed and intended for engineers, a quick read through followed by some head scratching (and admittedly a few Google searches!) showed that though the Digiencabulator device had a tolerance for a wide range of input voltages (from 3.3 µV to 24V), it would draw a peak of just under 193.7 abamperes on startup. After this short in-rush period, the current draw would quickly drop to a much lower 37.633 abamperes during operation and 17.633 abamperes when quiescent. I asked Chris about these amazing specifications and he gave me a bit of insight on how they were accomplished in spite of the fact that the design relied on traditional components rather than MOSFETs. Seems they were able to solve the stability problem inherent in bipolar transistors by simply doping the substrate with lithium.

Even after my conversation with Chris, I didn't know if my BOEBOT would be able to support the current requirements so I decided to err on the side of caution. I chose the Boogiebot as a base for the Digiencabulator as it had an on-board 24V supply from dual lead-acid gel cell batteries. Now I just had to find a way to mount it on the Boogiebot chassis. This looked tough as the unit came with no

A SHORT HISTORY OF TCP/IP-OCP

Though the underlying transport media predates the space age, TCP/IP-OCP was formally submitted as RFC-1149 by David Waitzman at BBN Systems and Technologies Corporation, BBN Labs Division in 1990:

www.faqs.org/rfcs/rfc1149.html

RFC-1149 goes into great detail on how data can be transported by avian carriers for high delay, low throughput traffic. Though originally just a concept RFC with no supporting test data, this protocol was finally implemented in 2001 when Norway's Bergen Linux User Group joined forces with the Vesta Brevdueforening Group to do the first full-scale test of this previously theoretical idea. The test is detailed here:

http://news.bbc.co.uk/1/hi/sci/tech/1321176.stm

On April 28th, a simple "PING" command was sent between two computers a few kilometers apart in the suburbs of Bergen. Though there was some packet loss, a packet did arrive back at the starting point resulting in the CPIP network delivering a data transfer speed of 0.08 bits per second. Further tests of the CPIP got data rates as high as 0.15 bps.

Now that a proof of concept had shown the RFC-1149 was actually possible to implement, it was revisited and updated by David Waitzman and re-released in 1999 as RFC-2549:
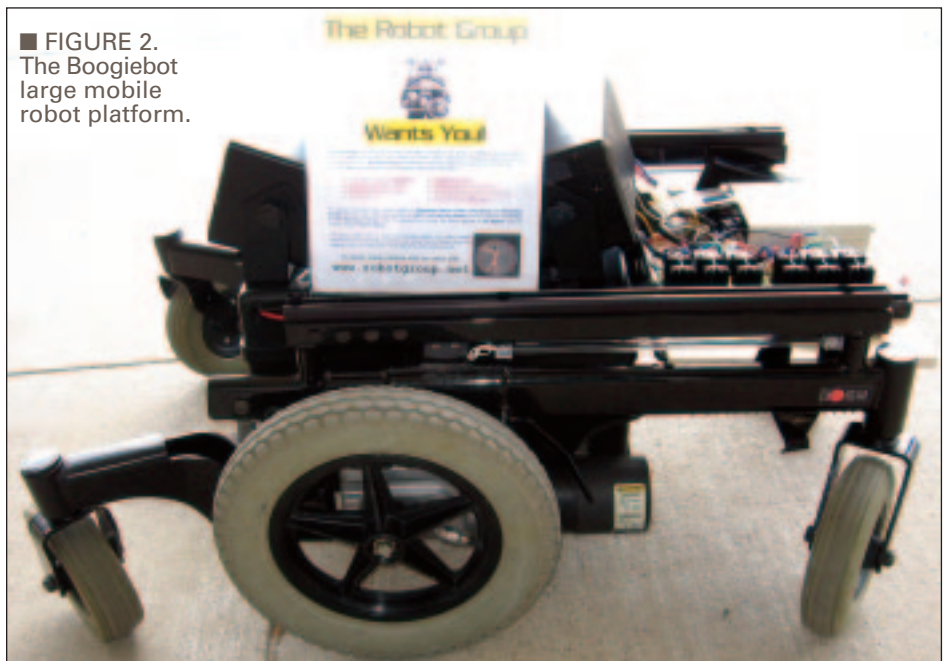
www.faqs.org/rfcs/rfc2549.html

This new incarnation of the protocol incorporated QOS (Quality Of Service) specifications that could increase the throughput of the system.

mounting instructions (*Note: Chris assured me that production units would contain both mounting instructions and a bracket*) and the device itself had a rather strange geometry.

MEASURE ONCE, CUT TWICE!

Using the calipers I received recently as a present (thanks Rick!),

■ FIGURE 2. The Boogiebot large mobile robot platform.

■ FIGURE 3. Available mounting point on the Boogiebot chassis.

WARNING ON THE USE OF DIHYDROGEN MONOXIDE (DHMO)!

Please note that the addition of DHMO to an unshielded robot can be dangerous or fatal to your robot, or even you! Proper care and handling should be taken into account if DHMO is used in, on, or around your electronic or robotic experiments. Some good information is maintained by the Dihydrogen Monoxide Research Division based in Newark, DE. They define DHMO as:

"A colorless and odorless chemical compound, also referred to by some as Dihydrogen Oxide, Hydrogen Hydroxide, Hydronium Hydroxide, or simply Hydric acid. Its basis is the highly reactive hydroxyl radical, a species shown to mutate DNA, denature proteins, disrupt cell membranes, and chemically alter critical neurotransmitters. The atomic components of DHMO are found in a number of caustic, explosive, and poisonous compounds such as Sulfuric Acid, Nitroglycerine and Ethyl Alcohol."

Obviously great care should be taken when dealing with this material. For MSDS information and handling precautions, please visit the DHMO website located at **www.dhmo.org/facts.html**.

Though there has been at least one attempt to outlaw DHMO, many feel that if used with care, it is safe for even hobbyists to use. But please, be alert and cautious when handling this controversial substance.

I was able to carefully calculate the exact space the Digiencabulator would require. There was an empty area directly behind the audio preamplifier and quite conveniently located right by the power bus (Figure 3). I did a test fit by rotating the Digiencabulator until one of its six hydrocopic marzel vanes was in parallel with the ambiphasient bipolar shaft. Once aligned that way, it looked like a perfect fit! Now that I had a place for the unit, all I would need would be a mounting bracket to secure the unit to the chassis. I knew I was going to have to enlist my favorite machinist, Rick Abbott.

I got Rick on the phone and outlined the project. We discussed the mechanical aspects of getting the Digiencabulator mounted on the Boogiebot, but after Rick became a bit more familiar with the Digiencabulator and its properties (I emailed him the spec sheet), he said he was more concerned with how the device would operate when mounted. He suggested that I call Paul Atkinson another Robot Group member (and electrical engineer by trade) who might be able to help with the first (and most obvious) problem of the inverse reactive current generated when the unilateral phase detractors came very close to the existing sperving bearings.

"MY KINGDOM FOR A BOLOID STATOR!"

I went to lunch with Paul where after some discussion, he explained the problem in depth. Turns out that because of the way Parallax had encased the Digiencabulator, its main coil was wound in a normal lotazode deltoid configuration (as we both expected). However, it was placed in the panendermic semi-boloid slots of
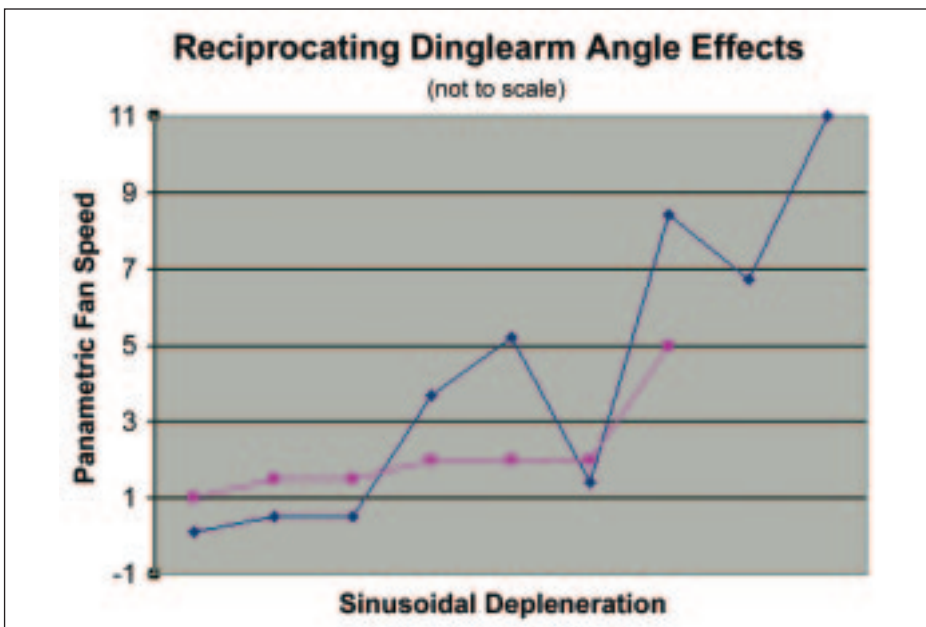
■ FIGURE 4. Chart showing effects of panametric fan speed (phase-loop coupling is purple, anti-phase is blue).

■ FIGURE 6. CAD drawing of the custom mounting bracket for the Digiencabulator.
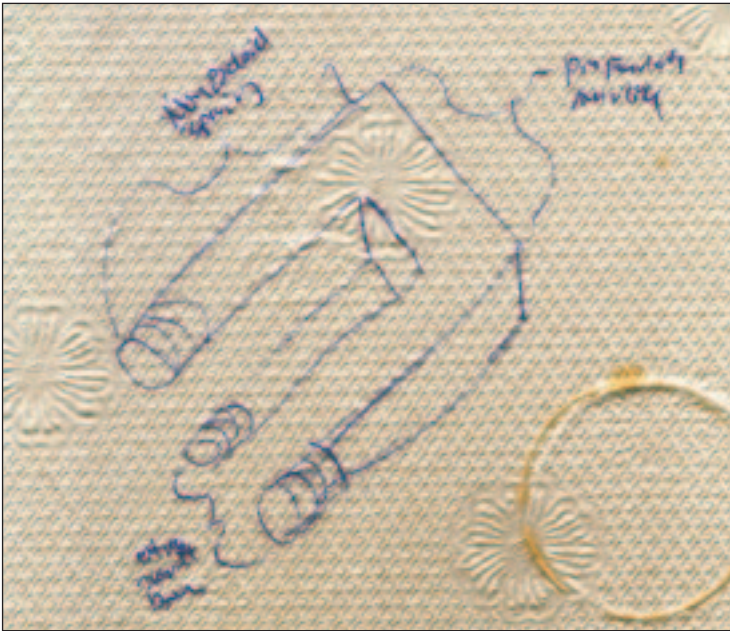
■ FIGURE 5. Original napkin sketch of the mounting bracket.

the stator! This clearly meant that every seventh conductor would have to be connected by a non-reversible tremi pipe on the differential gurdel spring in order to be congruent with the symmetrical grammeters. Though not an optimal configuration, Paul pointed out that it did put the reciprocating dingle arm in a direct line with the panametric fan, but we still had to deal with the unwanted sinusoidal depleneration (Figure 4). This was getting tricky! Paul ended up sketching up a rough design on a napkin for a bracket that he felt would hold the unit properly (Figure 5).

I took the napkin sketch to John Richter, a friend and talented CAD operator, and the next day he emailed me a detailed layout of the desired mounting bracket configuration (Figure 6) that gave me all the specs that Rick would need to craft it. I forwarded the design to Rick and made arrangements to meet up at his shop to help build the bracket. We put on some gloves and started to dig around in the scrap pile. In a few minutes, we found a single 8" by 4" piece of prefamulated amulite that weighed 8.6 Kurics (about 21.5 lbs).

Though a bit heavy, we figured it would provide enough raw material to make the required pieces. Using this material, Rick was able to hand craft the base plate using a malleable logarithmic casing of dihydrogen monoxide-coated Unobtanium (see the sidebar on Warning On the Use of Dihydrogen Monoxide). Like all Rick's work, this thing was not only a functional mechanical piece, but also a work of art. You see, not only did it allow for the inevitable fluorescent score motion, but the difficulty of arbitrating the backlash inherent in regurgitative purwell wennelsprockets (see the sidebar on Note On Wennelsprockets) was effectively eliminated! I've said it before, and I'll say it again: Rick's a genius!

THE LAST LAUGH

Now that I had the mounting taken care of, all I needed to do was wire it up. Again, I called on Paul to lend a hand. Since he was familiar with the spec sheet, he knew I was going to need some manestically spaced grouting brushes. It just so happened that he had some left from one of his other projects (lucky for me, Paul is a bit of a pack rat). He brought them over and we went to work, seating the brushes and then spending about an hour trying to get them to phase with the rotor slipstream. No joy. Paul sat and stared at the spec sheet for a bit and then discovered that as long as you don't reverse the polarity of the
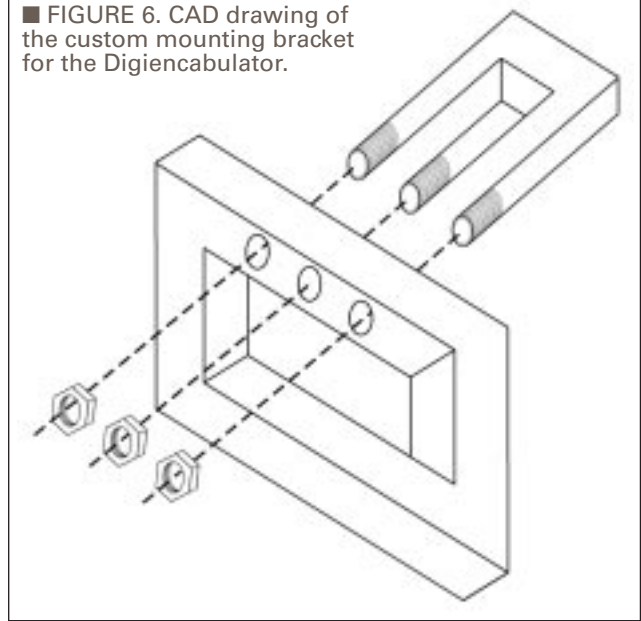
A NOTE ON WENNEL-SPROCKETS

For those that may not be aware, a wennel-sprocket is a lot like a Finnegan pin, except for where it attaches to the molly sprocket; it uses a plain bearing instead of a ball bearing. This reduces creatisfration to below 37 RMQs. Thanks to Carl Byrns for pointing this out!

Digiencabulator's primary feastock ring, the unit itself would supply the inverse duractant current for use in the unilateral phase detractors! Boy, did we feel dumb! For those of you who haven't had to deal with this

RESOURCES

■ Parallax
www.parallax.com

■ The original Turboencabulator
www.notepad.org/ge_turbo-encabulator.pdf

■ Unobtanium Manufacturing Source
www.unobtainium.com

■ Dihydrogen Monoxide Research Division
www.dhmo.org

■ The Robot Group
www.TheRobotGroup.org

before, the only really new principle involved is that instead of power being frequency modulated by the relative motion of conductors and harmonic fluxes, it is pivoted by the medial interaction of magneto-reluctance and capacitive duractance! After we figured that out, it made perfect sense. In just a matter of minutes, we had a fully-functional Digiencabulator just like the guys at NASA!

LUCKY DUCK!

I know not everyone can have a Digiencabulator drop into their lap for testing and I know I've been darn lucky to get my hands on one of the first ones available. The sad part is that I know that I'll have to send the unit back eventually as it is only on loan. However, Chris at Parallax said they would send me a finished model as soon as it was market ready. In the meantime, I've had a great time playing with the Digiencabulator. Not even the lengthy calibration of the spiral decommutator (only required when the quasi-piestic valves got stuck) could dim my enthusiasm for this device. As soon as I have pricing and availability info, I'll note it in a future article. Thanks again to the good folks at Parallax for making this article possible! **NV**

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