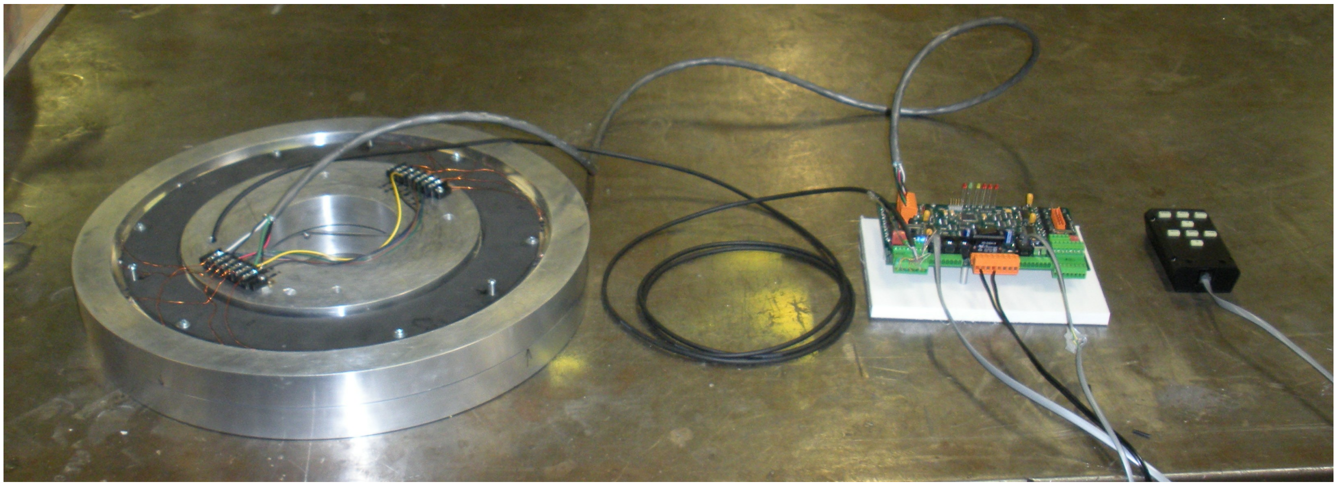
Direct Drive Motors for the Amateur Budget (a work in progress)

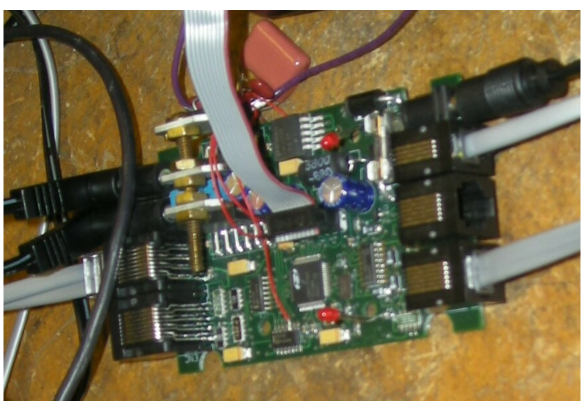
05/18/2008 By Dan Gray, Sidereal Technology

After connecting with Dave Rowe and Russ Genet in mid 2007, we all became involved in a project to make the "perfect" telescope. Russ had seen the direct drive motors from the Magdalena Ridge Observatory last August, and was convinced it was the way to go, but wasn't sure how to implement it. When he mentioned it to Dave, it became obvious that Dave already had been thinking about this, and had actually worked out most of the details for a radial flux motor. I was skeptical at first, but Dave and Russ convinced me that it was worth trying out.



Here's the Direct Drive Motor and Azimuth Bearing Assembly, with the dual Direct Drive Controller

So, Dave designed and made the first direct drive motor, and shipped it to me. I modified one of my dual brush type servo controllers to control one direct drive motor. Then I modified the firmware in the controller for operating the direct drive motor. After some testing, it was found that not only is this doable, but it's fantastic!

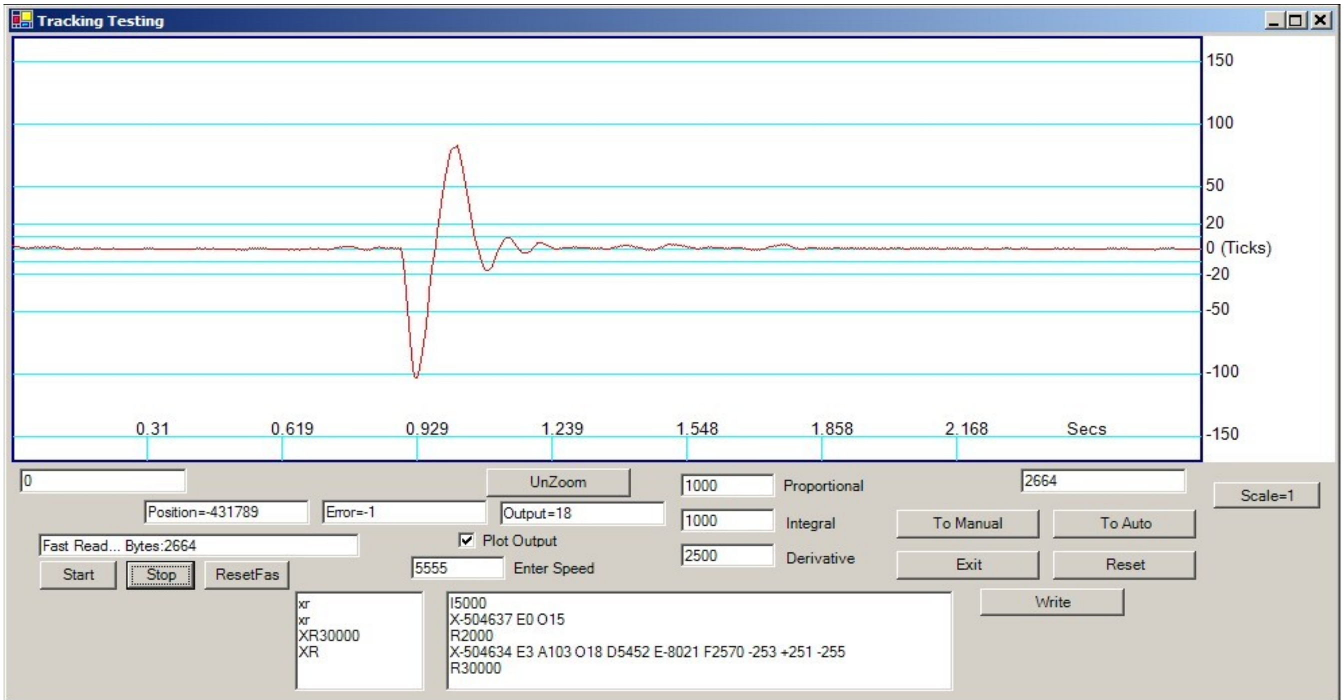


A photo of the modified SiTech Controller use for initial testing

The first prototype motor used for initial testing

Why would you want a direct drive motor for your telescope?

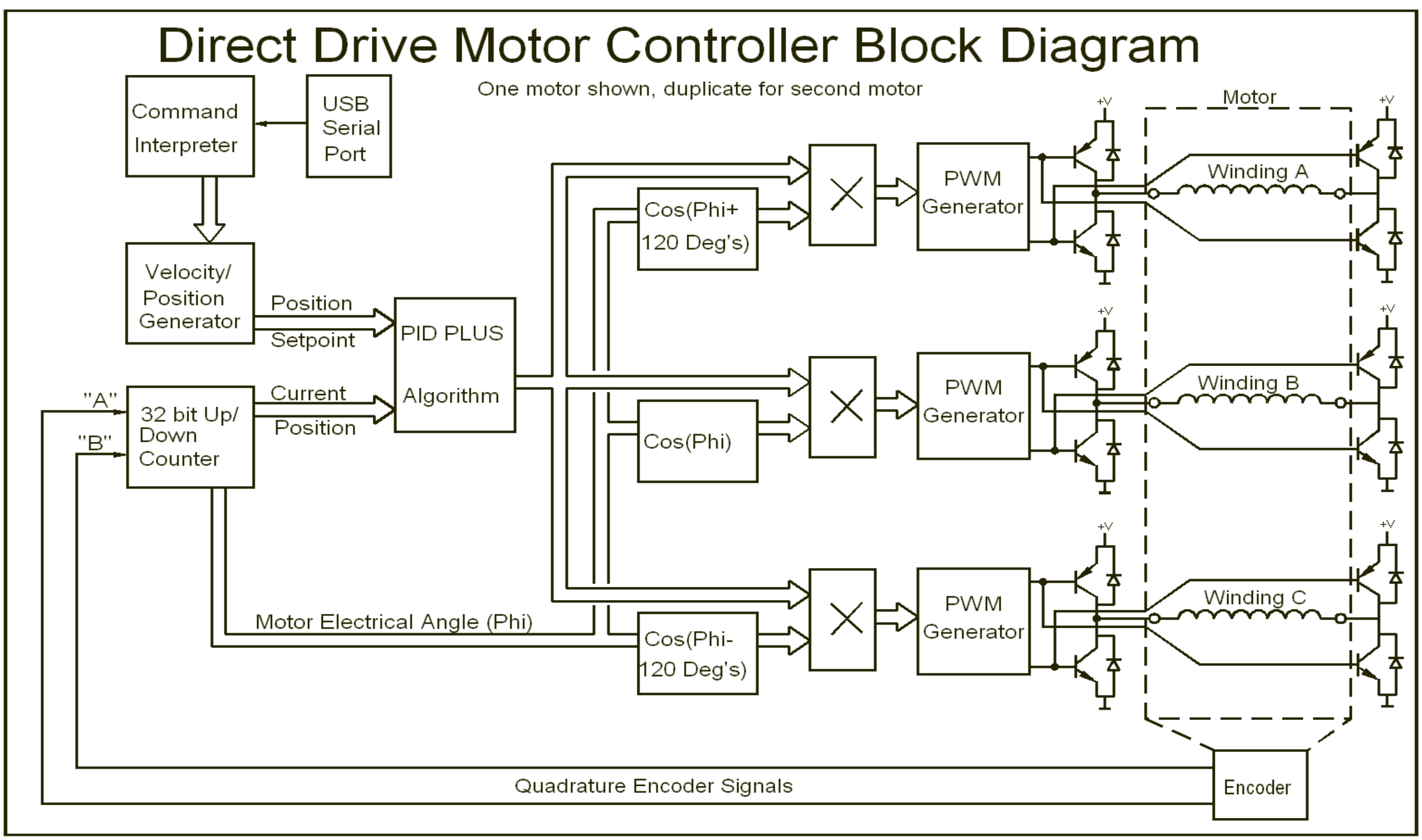
1. Completely eliminate all backlash
2. Completely eliminate all periodic error
3. Completely eliminate all non-periodic error
4. It makes a fast, responsive system, able to counteract small wind gusts
5. Fast, smooth slew speeds, up to 45 deg's per second



One of the many graphs Dave and I made while testing the prototype motor out. You can see the initial disturbance, and the response of the PID to correct it. The scale is in encoder ticks, there are about 10 encoder ticks for each arc second.

Next step, Dave got busy and designed and built an azimuth bearing assembly, with built-in Direct Drive Motor. I got busy and designed a prototype dual direct drive servo motor controller.

As of this writing, I have the new controller controlling the azimuth assembly, yeah!!! This is a lot of work, but it's fun work, and the results are awesome! I made a large push in the last two weeks to have the initial firmware and hardware ready to go for SAS and RTMC.

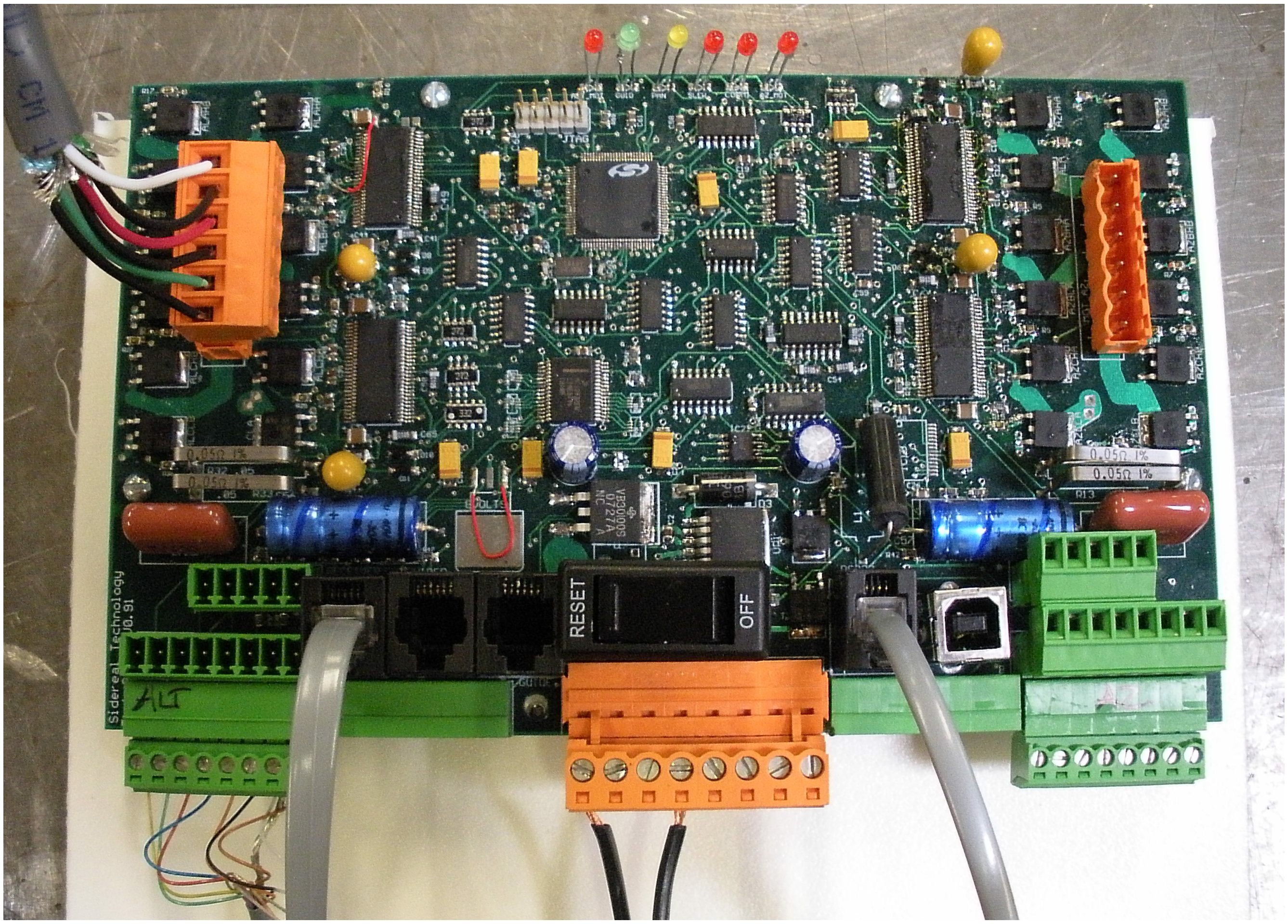


This is the stator and top half of the azimuth bearing assembly that Dave Rowe designed and fabricated.

So, 3 things have made this project possible:

1. The meeting of the minds. Dave Rowe, Russ Genet, and myself.
2. Dave Rowe is probably the main key, as he saw that a radial flux motor would simplify the design, and worked out the engineering. A radial flux motor is not as efficient as an axial flux motor, but much simpler to fabricate. Also, Dave worked out a way to incorporate the motor with the azimuth bearing assembly.
3. We realized most of the firmware was already in place, we just needed a faster microprocessor (same instruction set), and a way to read the encoders faster, plus a little more I/O.

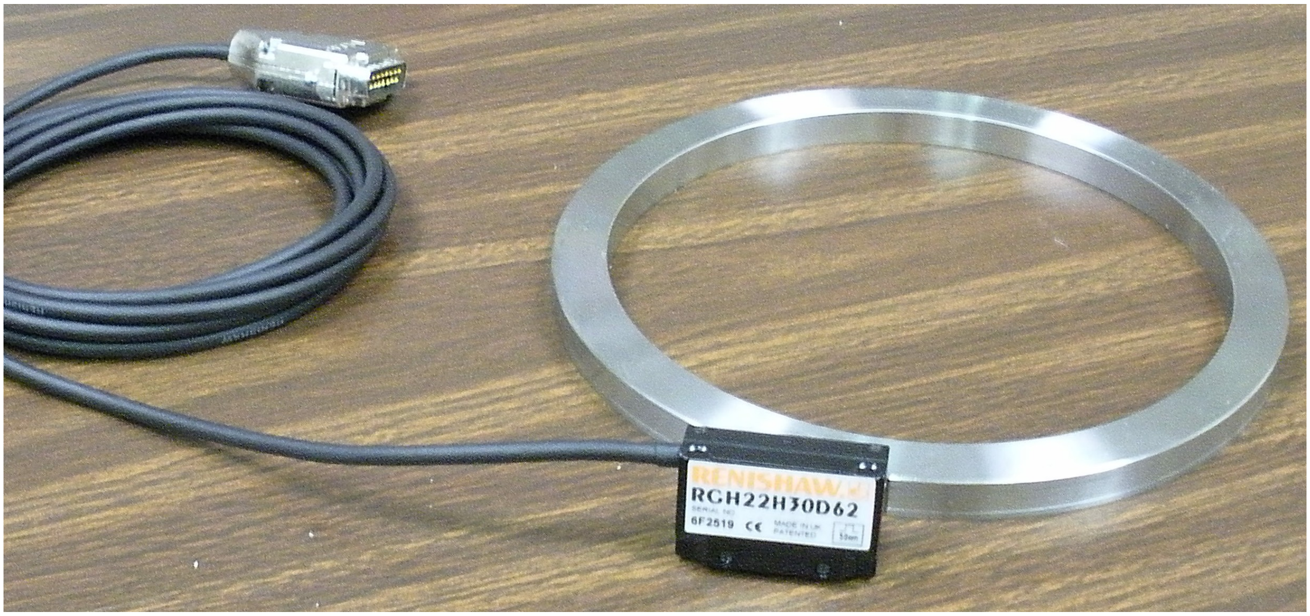
This is the rotor, which is stationary for the azimuth assembly. Notice the precision glass balls for the ball bearings. They need to be non-magnetic or they just hop over to the powerful, rare earth magnets.



Here's a shot of the prototype electronics. You can see the processor near the top middle. It's a Silicone Laboratories C8051F120, which runs at 96 MHz. The four large chips (two on each end) are the H-Bridge Mosfet Pre-Drivers. These are a brand new chip by Freescale Electronics (MCZ33927), which are very versatile.

This controller is capable of operating FOUR brush type D.C. Servo Motors, two brushless D.C. Servo motors, or two Direct Drive Motors. It can connect up to four TTL or RS422 incremental encoders. The encoders can pulse up to 6 MHz. The board is a 6 layer board, and is 4.5" by 7.5"

Recently, Dave and I spent an evening with his 20 inch CDK telescope in the Mohave desert, and we were both reminded of why we are doing this project. The first problem was while we were making the PointXP model, the declination backlash had quite an impact. Next, while in the guiding stage, it was obvious how the periodic error was effecting the guiding. Then sometimes the non-periodic error made us loose the guide star entirely! Ok, we've really got to get busy on this direct drive thing!



Here is the precision Renishaw encoder, and the stainless steel ring, ready to accept the encoder tape. We have a resolution of about 10 encoder ticks for every arc second using this setup.

How much will the direct drive motors cost? We'll, we're not sure just yet. There are a lot of unknowns. But, if you want to save a lot of money, you can simply make your own, with Dave's design. Cost of the parts can be about $300 (less encoder).

Sidereal Technology is planning to have a few motors made, and we would like to keep the cost of the motor assembly (along with the encoder) to be comparable to a precision worm gear, along with a conventional servo motor.

We're hoping that this new technology will benefit many folks in the amateur astronomy world, whether folks are doing "pretty pictures" or science.

Dan, debugging the prototype board, with help from "Little Man" (left) and Sheba (right).

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