PARTS IS PARTS:

Fine-Tuning a Brushless Electronic Speed Controller

● by Pete Smith

My 12 lb Hobbyweight bar spinner Surgical Strike had a problem at the last couple of events. If I tried to spin up quickly, the blade would seem to "stall" at about half speed and stay there unless I backed the throttle off and then backed up again to full speed. It would then run up to its full speed.

In most fights, this wasn't really a problem since there was time to get it spun back up between hits. However, if the opponent was a good driver they could be attacking when the blade was stalled and perhaps even stop the blade completely, getting me jammed against the arena bumpers. Surgical Strike's only defense is its spinning blade and if an opponent could get — and keep — it stopped, they would usually win.

I had noticed this problem first at Franklin in 2010 and then again this year at Motorama. I was competing with several other bots, so never got around to working out what the problems were at the events. I decided to track it down over the summer and if possible, get it fixed before this year's event at the Franklin Institute.

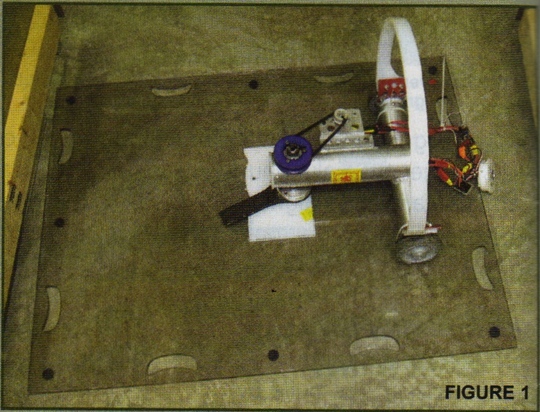

FIGURE 1

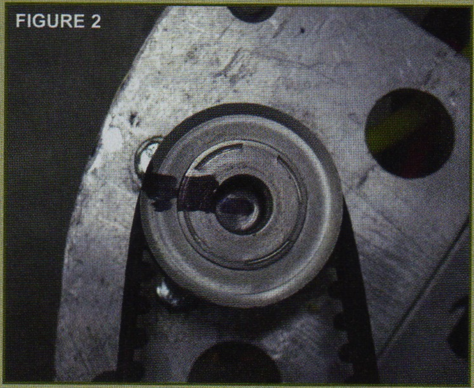

FIGURE 2

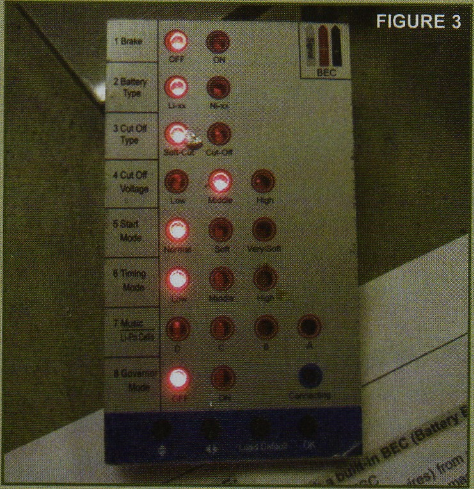

FIGURE 3

I had three main suspects. The first and second were purely mechanical. First, a loose pulley on the motor or the drive shaft could be slipping under the heavy load at start-up but then stop slipping as the blade got up to speed and the load decreased. The second possibility was the motor's bell housing slipping on the motor's shaft. This is a known problem and can usually be fixed by tightening and using Loctite on the screw that secures the bellhousing to the shaft.

The third possibility was that the settings of the Electronic Speed Controller (ESC) were incorrect. I had used a variety of controllers over the last few years but had mostly used the Turnigy Plush 80A. It had worked with few issues. The speed controllers are programmed using a simple programming card, and you can adjust a variety of settings. I suspected that perhaps I was not using the right settings and it was this that was causing the stalling problem.

The ESCs we use are designed for use in model aircraft or cars, so there are no recommended settings from the manufacturer for quickly and smoothly spinning up heavy metal blades. I decided to methodically try all the options and see which worked best. First, I needed a safe setup so that I could spin the blade up without risking an accident if a tooth or even the whole blade came loose.

I used three sections of my Antweight arena with its 3/8" Polycarbonate (PC) walls as an enclosure, and used another old section of PC and some zip ties to secure the bot in a stationary position (**Figure 1**). I screwed a square of thin UHMW under the weapon's axle to reduce friction and to stop the axle from wearing a hole in the PC sheet.

To allow me to check for mechanical slippage, I used a black sharpie to draw lines (**Figure 2**) across the joints of the various

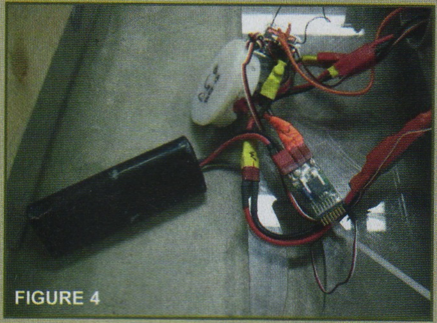

FIGURE 4

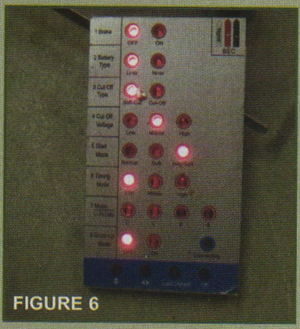

FIGURE 6

FIGURE 5

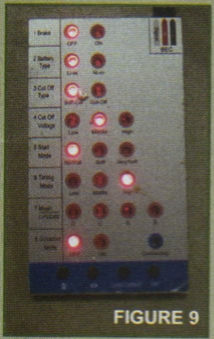

FIGURE 9

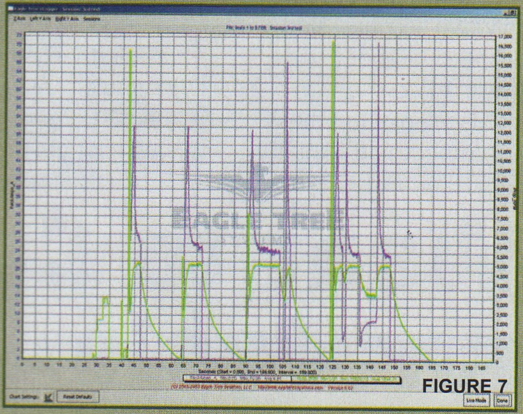

FIGURE 7

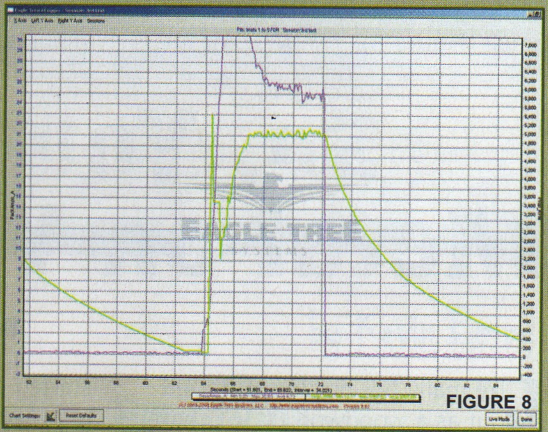

FIGURE 8

FIGURE 10

FIGURE 11

components. If the parts moved relative to each other, the lines would be broken and the problem area revealed. A couple of test runs displayed the same problem powering up, but when all the lines were checked there was no slippage to be found.

Now that I had established there was no mechanical problem, I looked at the settings in the ESC. I plugged in the optional programming card (I consider these a "must have" as they make life so much easier) following the supplied instructions and took a picture (**Figure 3**) so that I had a record of those settings.

I removed the programming card and then attached my E-Logger (**Figure 4**) so that I could record the RPM of the motor and the amperage used. (I described the use of the E-Logger in the June '10 issue of *SERVO*.)

I then did a test run, moving the throttle quickly to maximum and letting it run for a few seconds to get up to full speed, then letting it stop and then repeating the process two or three more times. As expected, the blade stalled at half speed during the initial power-up and had to be throttled back down and back up again to get it to reach full speed.

I then shut the bot down completely and reprogrammed the ESC, changing just one thing at a time for first the "Start Mode" and then the "Timing Mode." I repeated the test until I had run through all nine possible combinations. Each time I took a picture and each time the E-Logger would record the run.

Some combinations would not work at all, others would stall like in the original settings, and some would power-up smoothly taking varying amounts of time.

I downloaded the E-Logger data using the supplied software and cable, and then had a look at the graphs of the various runs. Three were of particular interest. The first run graph (**Figure 5**) shows that the periods of "stalling" at half speed were, in fact, drawing over 50A and with peaks well over 80A. However, once the blade had settled down, it cruised at about 25A and at about 5,000 RPM.

The third run with the Start Mode set at "very soft" (**Figure 6**) and Timing Mode at "low" gave a smooth and uneventful run up to full speed (**Figure 7**) with peak current of about 70A, and again cruising at about 25A and 5,000 RPM. By taking a closer look at the graph (**Figure 8**), it shows that the blade was taking about four seconds to reach full RPM.

The final run of interest was number five. Start Mode was set at "normal" and Timing Mode at "high" (**Figure 9**). This gave a rapid and smooth run up to full speed, peaks of over 115A, and again cruising at 25A and 5,000 RPM (**Figure 10**). A closer look revealed that the blade was reaching full speed in only two seconds, and 90% of full speed in about one second (**Figure 11**).

A quick blade spin-up time is important in combat and I will try out using the same set-up as in run five for the next competition. The high peak amps may be an issue, as might Newton's Third Law of Motion where a rapid spin-up might make the bot spin in the opposite direction for a short time, which may make it hard to drive during spin-up.

The test process has convinced me that it's worth the time to go through all the likely ESC options to find out which is best for any particular bot, and not just settle for the first one that seems to work well enough. SV

So, You Want to Cut Metal on Your Table Saw?

● by Kevin M. Berry

Like many bot builders, I started out as a woodworker. So, I have a shop full of woodworking tools and, now, a serious bot building jones. Some of my woodworking tools work great on metal, like a hand drill, drill press, vice, and screwdrivers. Of course, I had to buy a drill index with metal bits, since brad points don't do so well on steel. I learned a lot about how much sharper metal is than wood when a bit binds up in a hole, and the workpiece does that spinny plate of death number. So, clamping isn't just for glue-ups anymore.

My real learning came when faced with sheets of metal to cut, and no easy access to a shear, arc jet cutter, waterjet, etc. Having a table saw, I thought "Why not?" Thus begins the journey to this short article.

Safety note: I'm a fanatic about doing things right. Face shield, all guards intact, fences, miter gauges, you name it. You should be also!

First, I tried aluminum which is every new bot builder's friend. I started off cutting 1/8" sheet using my plywood thin-kerf blade. I figured tiny teeth, looks like a hack saw, right? Well, it actually cut pretty good, using a slow feed. Pretty soon, however, the teeth sure clogged up.

I also learned something about the heat transfer properties of aluminum. I've never been one to use gloves while cutting on a table saw. I soon learned, though, that the metal sheet got P.D. hot, P.D. quickly. I also (see "spinny plate of death" reference above) paid a lot of attention to what might happen if the cut got bound up. My saw has anti-kickback grippers, but I really don't trust them for wood — much less for slippery metal.

I used a couple mitigations for this: added fences and standing to the side. I clamped a 2 x 4 to the table on the opposite side of the fence, hoping if the plate "kicked," the two fences — plus the anti-kickback pawls — would guide it safely out the door of the shop. (Since my shop is in a cheapo sheet metal shed, I wanted to have a clear line of sight to potential victims before starting the cut.) As far as standing to the side, I've always had a name for anyone who stands in line with material being cut on a table saw: thrill seeker.

I soon graduated to a carbide tipped blade. While there are specialty blades for cutting non-ferrous metals, I've used a regular, high quality, crosscut carbide tipped blade with great success. The little tips scare me, even though I'm pretty sure I've never heard of one flying off when used properly. Still, I took all precautions. (See guards, face shields, standing to the side comments above). Slow feed, steady pressure, push sticks, and clamped guides have combined for many successful cuts — up to 1/2" thick on 6061. The edges are a little rough, but, hey, aluminum cleans up beautifully.

So, next I went for Big Game. Titanium. I bought a bunch, wore out a package of hacksaw blades, and decided to go for it. I wasn't about to pit a steel blade against titanium, especially since anti-