Team Toad Validates the Lifting-Wedge at STEM Tech Olympiad 2014

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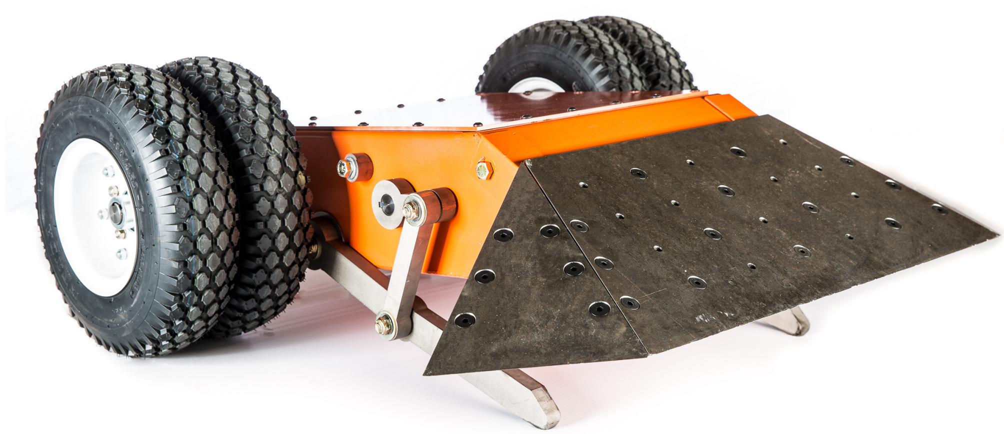
Ever since Peter Abrahamson described the sport of robot combat as *Rochambeau* (spinner, flipper, wedge), the challenge has been to build a robot that could do two things well.

The assumption hidden in Abrahamson's description is that spinners beat lifters, because it's challenging to build a lifting device that can withstand the onslaught of a powerful spinner. In Season 5 of BattleBots, the horizontal spinner *Mechavore* succeeded in completely removing the Champion *Biohazard's* lifting arm, to give just one example.

In January, 2014 we had the sudden inspiration that if the arms pushed down, the nose of the robot would go up. That means you can solidly mount a big piece of armor to the front of your robot and use relatively lightweight arms as lifters.



We decided to build *Polar Vortex*, so-named because, (1) all Team Toad robots are named after cold weather phenomena, and (2) it was topical this year; the Polar Vortex was the scariest thing we could think to take to Miami, Florida.

Biohazard used a four-bar linkage to power an arm that moved up and away from the robot. We wanted a mechanism to push the arms down enough to lift the front of the robot about 60 degrees and still be able to fit the whole linkage within the 6 inch body height so that the robot could drive upside-down, if necessary.

Another important constraint in a lifter is that your robot must win the see-saw battle. The fulcrum point of your lifting must have sufficient weight behind it to lift the opponent and not your own robot's rear end. This was the design flaw in our previous lifter *Avalanche*; when we tried to pick up *Sewer Snake*, our robot pitched forward instead. So for *Polar Vortex* the rocker arms were extended almost one foot so they were just behind the wedge. The drive and weapon motors were mounted low and as far to the rear as possible [See Figure 1].

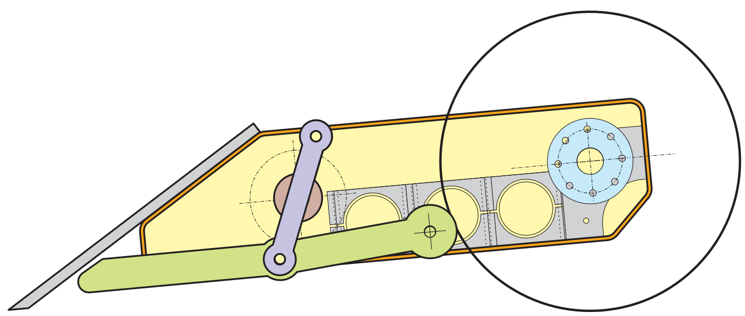


Figure 1: Four-bar link lifting arms retracted

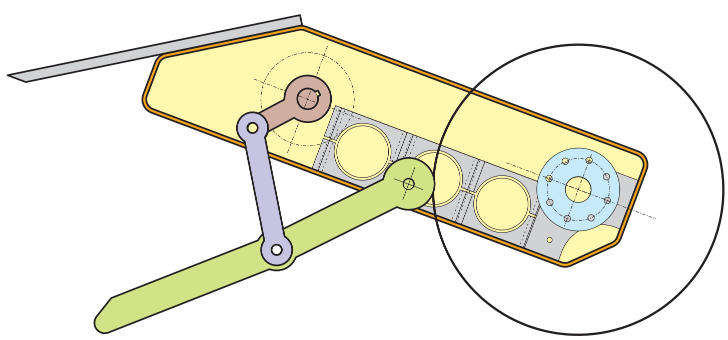


Figure 2: Four-bar link lifting arms partially extended

Figure 2 shows the four-bar linkage partially extended. There are actually two lifting arms, one on each side of the robot. The **crank arm** is shown in red, and is connected by an ANSI standard key and keyway to a one-inch titanium shaft that goes completely through the robot to the other lifting assembly. The **coupler arm** is shown in blue, and is connected by two half-inch bolts to the end of the crank arm and the middle of the rocker arm.

The **rocker arm** is shown in green, and it connects to the **frame** (considered the fourth bar in a four-bar linkage) by another half-inch bolt that acts as a hinge. The rocker arm extends 9-1/2 inches forward of the middle hinge point.

The crank arm is turned by an *AmpFlow* motor with both planetary gear and roller chain reduction, but the specific arrangement of *Polar Vortex's* four-bar linkage provides additional variable leverage. Figure 1 shows the retracted arms with the crank arm at a theoretical "zero" angle. Figures 3 and 4 shows that as the crank arm starts moving at a constant rate, the rocker arm moves very slowly at first, but with great leverage. That means that the robot can lift a lot of weight a short distance, and the rated weight about 60 degrees.

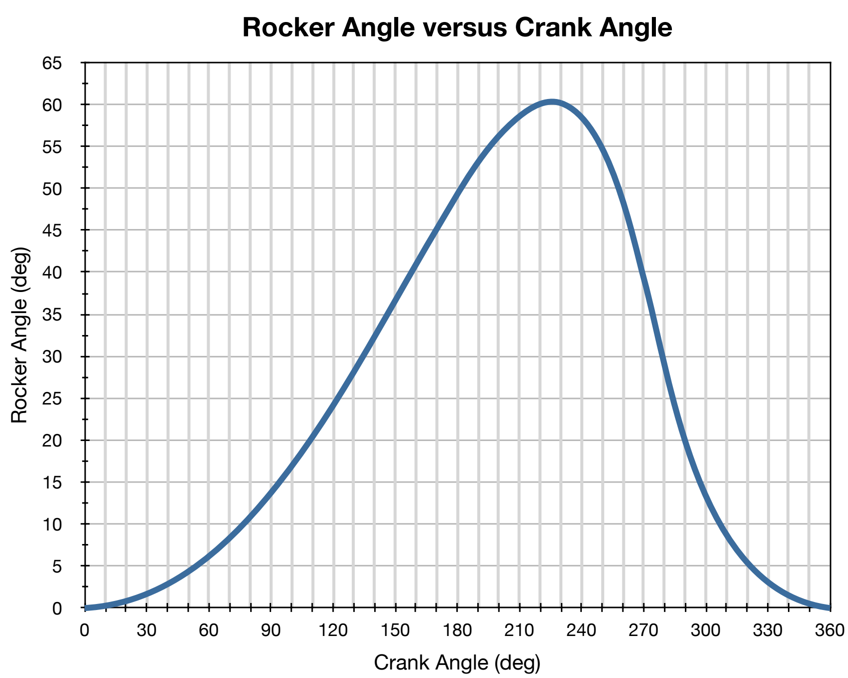


Figure 3: Rocker Angle vs Crank Angle

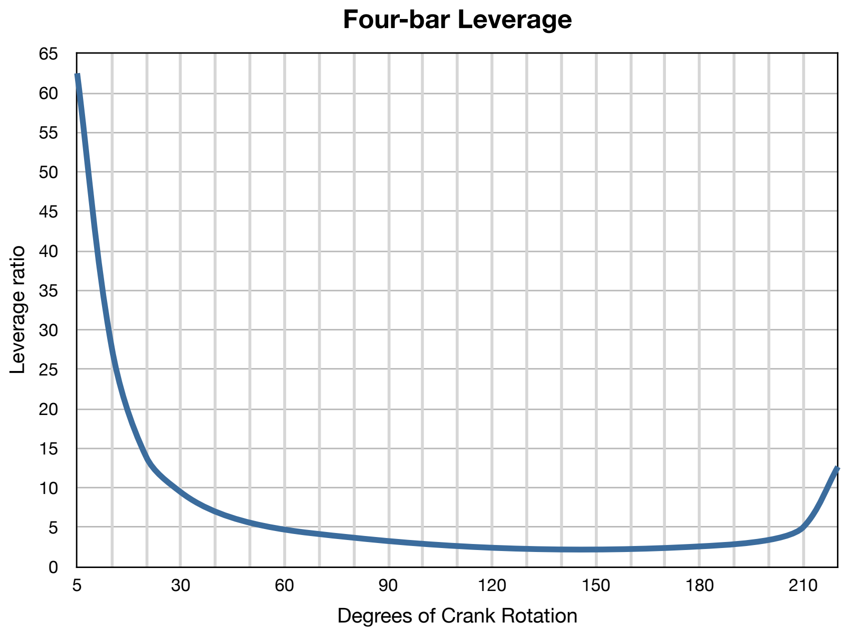
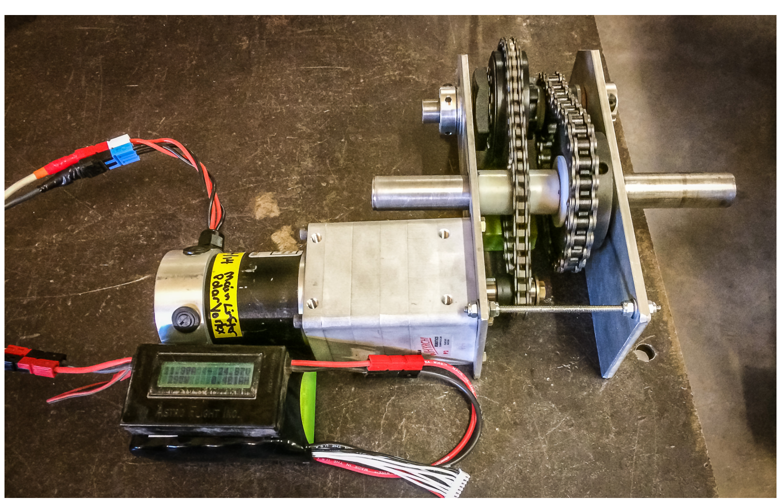
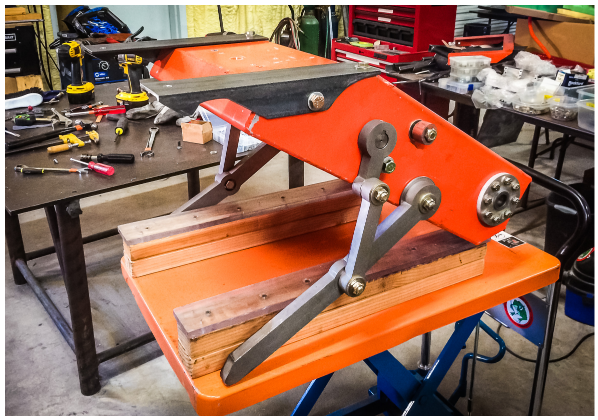


Figure 4: Four-bar leverage

A torque limiter in the roller chain reduction stage limits the current draw to about 60 amps, well within the limits of our Vantec RSFR-48e speed controller. The clutch slips if the arms encounter an immovable object. That happened in one fight in Miami Beach: *Polar Vortex* had *Shrederator* stopped and against the bumpers in a corner, and was under him lifting. *Shrederator's* shell was wedged into the bumpers so that we were trying to lift the entire BattleBox. Without the clutch, we could have easily stalled the motor and burned out a speed controller. Figure 5 shows a photo of the lifter motor, planetary gearbox and roller chain reduction assembly. The unloaded current draw is about 12 Amps at 24 Volts.



The design also makes it easy to install mechanical stops instead of using limit switches. Figure 6 shows the side of the robot with the lifter arms extended. The rubber-covered bolt up behind the crank arm is the retract stop and the stack of washers to the bottom is the extend stop. When the crank arm hits the stop, the clutch just slips. Notice that the wedge mounts had to have cutouts to allow the rocker arm to fully retract.



We entered Polar Vortex in the heavyweight (220 pound) division of USATL's STEM Tech Olympiad 2014, organized by Nola Garcia. Although the heavyweight division had only five robots, the opponents included wedges, a fierce horizontal spinner, and a fierce vertical spinner. We knocked out all four of our opponents once (in our fight against *Shrederator* we flipped him at the buzzer, so the fight is officially recorded as a judges' decision). We lost the second final match in a judges' decision, and took second place for the tournament with a record of 4 wins (including 3 knockouts) and 2 losses by judges decision.

We consider this a very successful first event for Polar Vortex, and as the photo in Figure 7 shows (photo credit to Henry Aird), we used the lifting wedge to immobilize the eventual tournament winner in the first final round of this double elimination tournament. We also flipped him onto the wall in the second final near the Pulverizers, but his team used the hammers to knock him back onto his wheels.