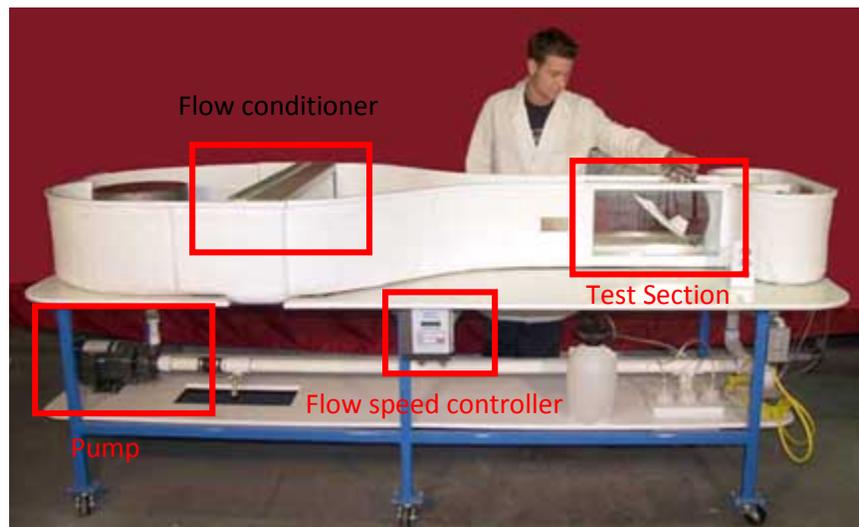


# Operator's Manual: Seal Team 16 Flipper Rig

## 1. Introduction/Safety

We hope you have get meaningful results using the Seal Team 16 Flipper Rig. This rig was designed and build by Cal Poly Mechanical Engineering students for their senior project in 2016. This is meant to be a brief introduction to the use and maintenance of the device. For a full part description and design specifications, please refer to the report in Cal Poly's digital commons available through lib.calpoly.edu and searching for "Biomimetic Seal Flipper Rig"

**Disclaimer: the model you are about to use is a prototype and may not be perfect! Additionally you will be dealing with electricity and water! Please exercise caution when using or modifying the rig.**



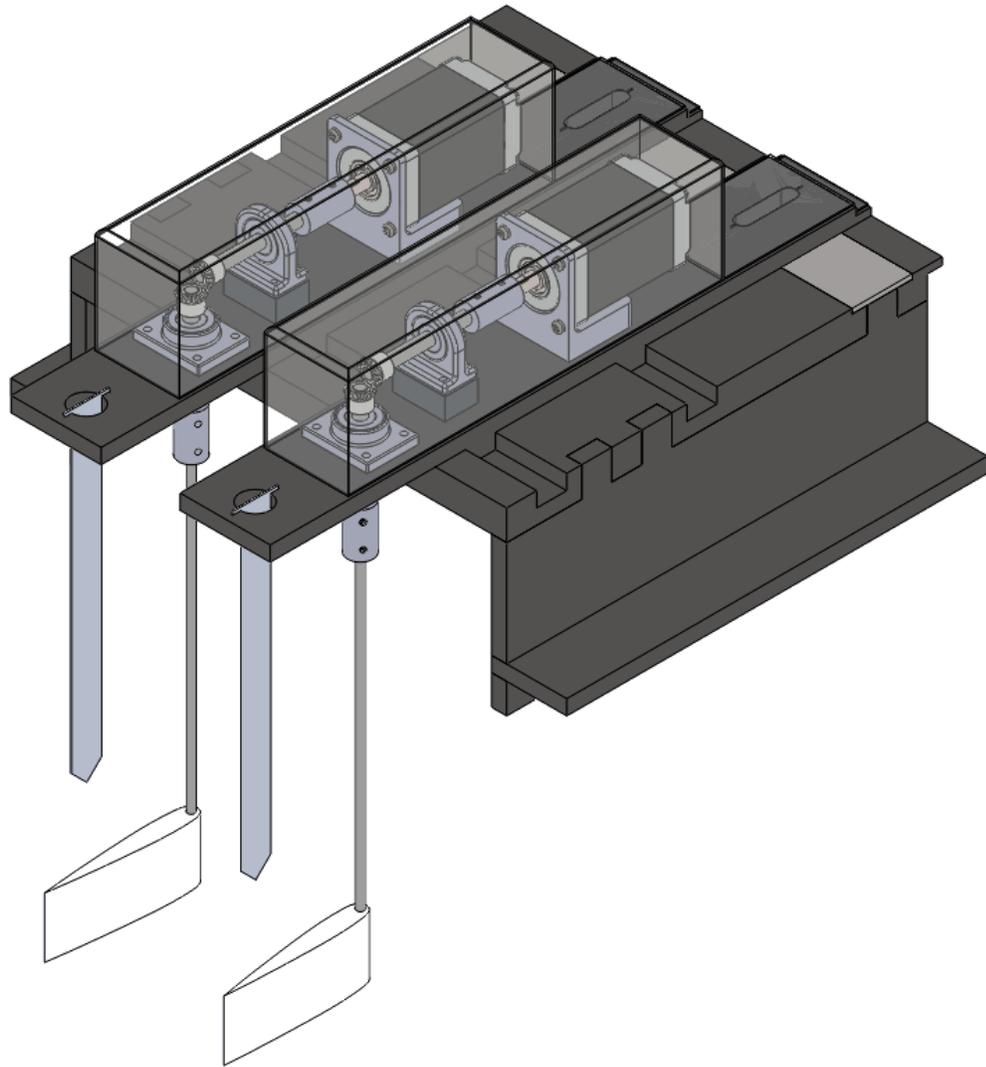
**Figure 1.** Rolling Hills Research Corporation Model 0710 University Desktop Water Channel.

For water channel operation refer to the user guide online:

"University Desktop Water Tunnel Model 0710." *Rolling Hills Research Corporation*. N.p., n.d. Web. 4 Nov. 2015.

[http://www.rollinghillsresearch.com/Water\\_Tunnels/Brochures/Model\\_0710\\_&\\_Experiment\\_Overview.pdf](http://www.rollinghillsresearch.com/Water_Tunnels/Brochures/Model_0710_&_Experiment_Overview.pdf)

## 1. Description of Parts



**Figure 2.** Final design model

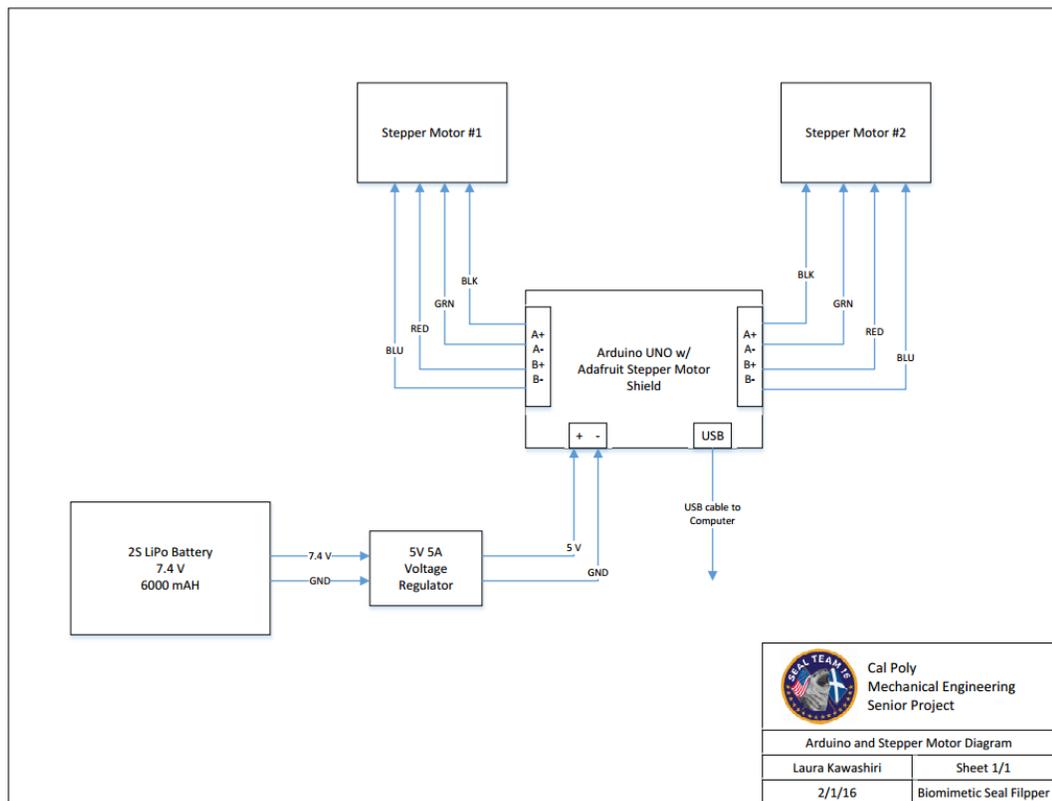
The rig is composed of four main subsystems:

1. Drivetrain
2. Baseplate and Motor Planks
3. Locating Tool
4. Flipper Mounts

The drivetrain consists of bevel gears driven by NEMA 11 stepper motors, supported by bearings in their respective housings. The drivetrain sits on two “motor planks” which slide across the baseplate in machined slots, helping laterally position the flippers. The locating tool is a removable device used to initially position the flipper in the 0° position before testing. The flippers are epoxied to shafts and attached to a coupler above the surface of the water



**Figure 3.** Electronics in the project box



**Figure 4.** Wiring Diagram

## 2. Installing a 'flipper'

Take one 1/8" brass shaft piece and glue it to your flipper using waterproof epoxy (recommended: xxx). Refer to epoxy manual for specific directions.

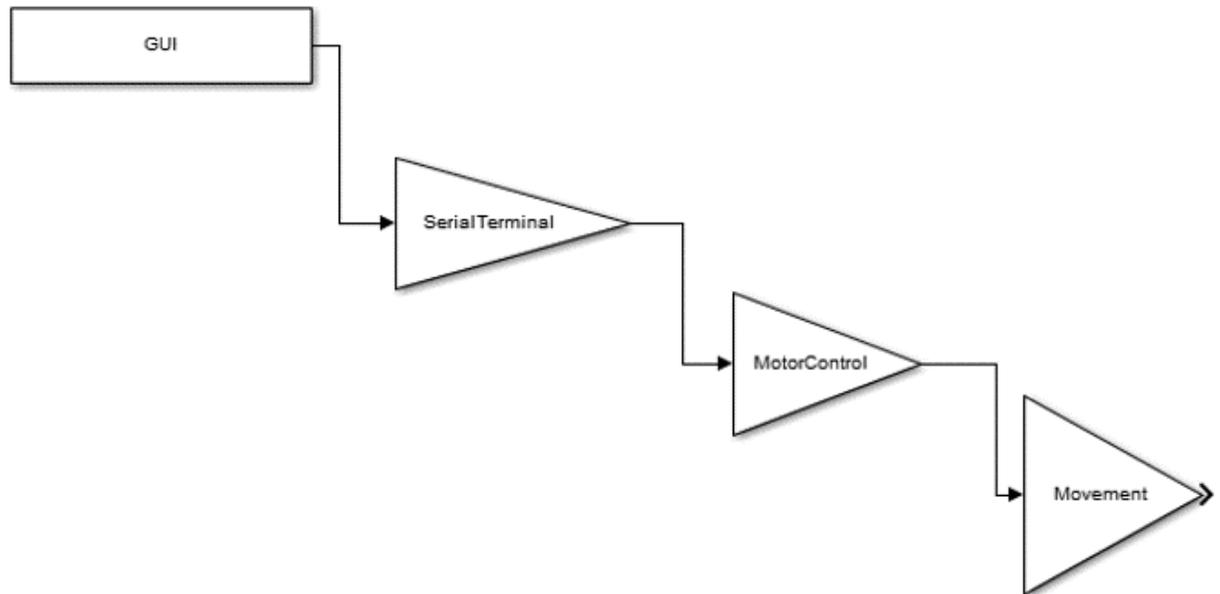
Check for cylindricity between the shaft and the flipper hole

Allow 24hr to set and cure

After cure process, install onto 1/8" to 5mm shaft coupler using 3/32" hex key.

## 3. Code basics

The motors are controlled with an Arduino and an Adafruit stepper motor shield. User inputs can change the frequency, stepping style, and sweeping distance of each flipper



**Figure 5.** Basic coding flowchart from GUI inputs to movement

## 4. Running code

a. To send serial commands to the device, the user must type a command string into the serial monitor command box, located at the top of the window left of the "Send" button in the Arduino interface.

b. Before sending commands, be sure that the drop-down menu box second from the bottom right corner of the monitor is set to "Newline".

c. The following example illustrates the command string structure:

1R 60

d. The first character indicates which flipper to command. Type "1" to control the flipper labeled "Flipper 1", "2" for "Flipper 2", or "3" to change the same parameter for both flippers at once.

e. The second character indicates which parameter the user wants to change. Options include "E" to enable a flipper, "R" for range of motion in degrees, "F" for frequency in RPM, and "S" for stepping style.

- f. The following characters define the new value of the parameter to be changed. They are not necessary for enabling, so the enable command ends after typing "E". The other parameters, however, require a new value. **Be sure to have a space between the second character and the new value characters otherwise the command will not be executed.**
- g. For "R", the new value can be any integer between 0 and 100 degrees. Example:  

$$2R\ 25$$
 Translates to "change Flipper 2's range of motion to 25 degrees".
- h. For "F", the new value can be any integer between 0 and 200 RPM. Example:  

$$3F\ 130$$
 Translates to "change both flipper frequencies to 130 RPM".
- i. For "S", there are four stepping style options:
- i. M = MICROSTEP; smoothest and most refined option that allows for steps less than 1. Tradeoff is lower speed and torque.
  - ii. I = INTERLEAVE; alternates between single and double to improve resolution but at half the speed. Still faster than microstep, but more vibrations.
  - iii. S = SINGLE; powers one coil at a time to get step-by-step resolution. Decent speed and torque, but noisy with much vibration.
  - iv. D = DOUBLE; powers both coils at once to get maximum torque and speed, but with poor resolution and the greatest vibration and noise.
- Example:  

$$1S\ M$$
 Translates to "change Flipper 1's stepping style to microstep".

## 5. Experimental procedure

- a. Ensure battery is fully charged using a LiPo approved charger.
  - i. **Never charge above 1 C (5000mAh = 5 amps max charge!)**
  - ii. **Charge in provided fire-safe bag**
- b. Check all hardware for proper torque.
- c. Ensure shafts spin freely and that they are not bent
- d. Replace any defective components (see report for BOM).
- e. Install a slipper/shaft assembly on to each motor. Install only one flipper/shaft assembly if only one is required for the test.
- f. Position the flipper and locate using the locating tool.
- g. Power switch off
- h. Plug in battery
- i. Power switch on
- j. Attach USB to computer and start \*serial command\*
- k. Serial command stuff
- l. Etc....
- m. Unplug battery and low voltage alarm after use. DO NOT let LiPo battery drop below 3.0 volts per cell. Use a low voltage alarm/auto

6. Maintenance and Repair

- a. Keep shafts well-oiled to resist corrosion.
- b. Clean the rig periodically to ensure dyes and chemicals do not corrode the rig.
- c. Make sure the battery is charged and does not ever drop below 3.0 V per cell.
- d. All tools needed to remove and replace parts on the rig are supplied with the tool kit.
- e. Spare parts such as bearings, gears, stepper motor, and bolts/nuts are also supplied.
  - i. Additional parts may be ordered off the BOM available in the final report.
  - ii. available in the final report.