

## NUWAVE NON-ROV DEVICE - FLOAT: RICHARD

### The Onboard Power System:

The onboard power system is one of the primary areas of design in NUWaves's buoyancy engine. NUWave designed custom printed circuit boards to create an onboard power system that both optimized electrical power and capacity while minimizing footprint and points of failure. The initial on-board power system was designed to use the maximum allotted 9.6 Volts by connecting eight AA 1.2 Volt Nickel Metal Hydride (NiMH) batteries in series. Those batteries in series offered an expected capacity of 2,500 mAh, more than enough to supply the proposed design. A secondary and nearly identical 9.6 Volt battery pack was added to the system in parallel, doubling battery life and maximum current supply capacity and allowing the device to accommodate a stepper motor with greater torque.



Figure 1: Battery Packs

Selecting an appropriate fuse began with determining the full load amperage (FLA) in water. The reported FLA is 2.12 amps in active motion mode and 0.50 amps in buoyancy holding mode. Based on this, a Littelfuse ATO blade fuse rated for 3 Amps was selected. Our PCBs were designed with the fuses placed within 5 centimeters of the positive and negative terminals of the primary battery pack. The secondary battery pack has an independent fuse placed within 5 centimeters of its positive terminal, and the negative terminal was connected to the fuse of the negative terminal primary battery board, creating a shared fuse connection. These precautions ensure that all electronics remain protected from overcurrent throughout the buoyancy engine.

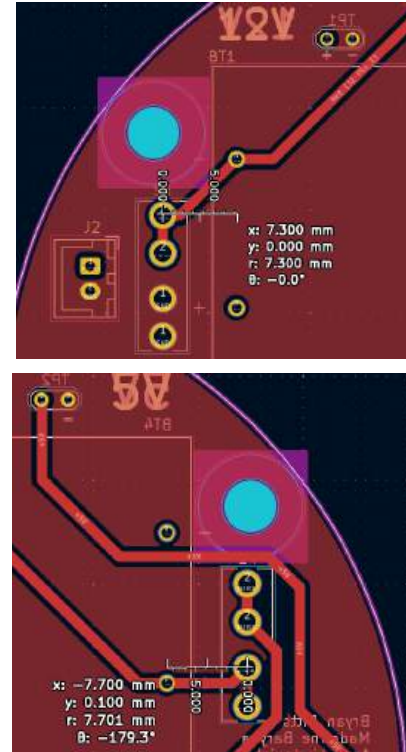


Figure 2: Distance of ATO Mini Blade Fuse(s) from the Terminal(s)

All components were properly spec'd for their application and implementation within this design. One-way diodes were added on the main PCB board for both 5 and 9.6 V power to prevent current from flowing in the backwards direction. As an additional precaution, heat sinks were added to components that were expected to dissipate the most heat, such as the Linear Dropout Regulator (LDO).

The major area of redesign this year targeted improved controls by incorporating an intermediary Arduino Nano between the Raspberry Pi Zero and stepper driver. Last competition season, the float experienced issues related to stepper motor control and reliability. Because the Pi is not a microcontroller, the PWM signals are not as reliable compared to a microcontroller such as the Arduino Nano. Using a microcontroller to send PWM timing signals to the stepper driver allows for more reliable control of the stepper motor. The Pi is connected to the Arduino via serial communication (USB), which the Arduino converts to PWM to communicate with the stepper driver.

**Software System:**

Our system uses a Raspberry Pi Zero onboard the float that automatically connects to the Wi-fi network generated by the router in our topside box. On the operator laptop, we initiate a secure shell (ssh) session over the Local Area Network (LAN) with the command: `ssh pi@192.168.0.111` into the Pi's command line. Once the ssh connection is established, the operator runs the start-up shell script by entering `/run.sh` which prints the team number and current time and initiates the control loop that executes the vertical profiles. The depth and pressure are continuously recorded once every second as the float descends and ascends, and the measurements are continuously written to a .csv file. Once it resurfaces, the device is retrieved, and a secure shell session is initiated over the LAN to retrieve the collected time and depth data.

**Mechanical System:**

The profiling float utilizes a BlueRobotics 4" ID series watertight enclosure for ROV/AUV application. The enclosure features interchangeable aluminum end caps with double O-ring sealed flanges on either end of a 300mm long and 112mm outer diameter cast acrylic tube, tested to a depth of 65 meters. One end cap utilizes a custom SLA-printed triple o-ring housing to properly seal around the volume-actuation system extending beyond the acrylic tube of the device. A BlueRobotics depth sensor, capable of measuring up to 2 bar absolute pressure, is set into this housing to collect the necessary depth data. A pressure relief plug, 2.5 centimeters in diameter, and radio antenna is set into the other end cap. To equalize pressure, the end caps of the acrylic enclosure sit within the tube such that should the pressure in the tube housing be greater than the outside pressure, the end caps will separate from the housing to release the internal pressure.

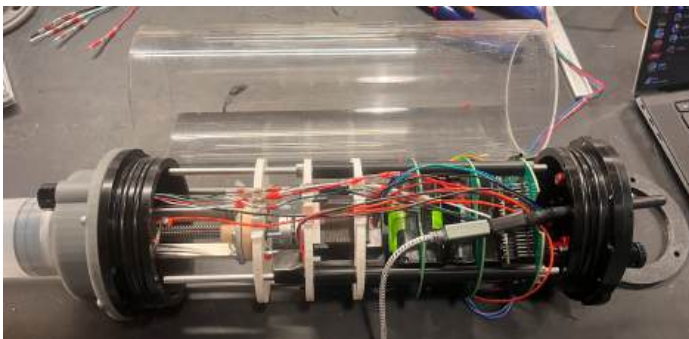


*Figure 3: Float Internal Components*



*Figure 4: Float, Fully Assembled*

Within the acrylic enclosure, a lead-screw system, consisting of a trapezoidal 10 mm diameter lead screw with a 2mm lead and an igus JFRM lead screw nut, is coupled to a NEMA 17 stepper motor with a Misumi shaft coupler to actuate the plunger of a modified 350 mL syringe, changing the volume of the float and the volume of water displaced. The lead screw is fixed axially, translating the rotational motion of the stepper motor into linear motion of the lead screw nut, which is connected to the plunger within the syringe with a custom aluminum waterjet and welded feature. The lead screw begins in a fully extended position,

with the device slightly positively buoyant. The stepper motor then drives the lead screw system such that the volume decreases, reducing the buoyant force and causing the device to sink. When the device volume increases, the buoyant force also increases and the device rises to the surface. Limit switches at either end of travel, in addition to the 'steps' of the stepper motor, are used to monitor the position of the nut on the screw (and thus the change in volume) along the path of movement.

An external ballast containment system was added to the device to allow for poolside buoyancy adjustment without opening the enclosure and exposing the electronics.

Non-ROV  
Device SID

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