# **Hackley Aquatic Engineers** - Non-ROV Device: The Float

Our custom-designed float complements the ROV perfectly by adding additional functionality whilst maintaining the main goals we had in mind for our robot. The float is fully 3D printed (with the exception of metallic weights and electronics), is able to autonomously sink to the bottom of a body of water and back to the surface, and finally can transmit information to the main ROV, and thus to the engineers at the surface. This is very practically useful as it allows one to take various kinds of readings and measurements at, for instance, the sea floor in a particular location, such as temperature and pH level, and even take a sample of water up to the surface. Since our float functions as a *buoyancy engine* rather than any motors, very little power is used, and the entire apparatus can be powered by a single 9V battery. Finally, the float communicates wirelessly with the main robot and the base station when above the water level; because of this, the float may be used relatively far from the robot and collect data from much deeper than a tether would allow.

Our float uses syringes in the float to expel/pull in water, effectively decreasing or increasing the density of the device. We have manufactured it to be almost completely neutrally buoyant, so that this change in density is enough to induce floating or sinking, respectively. A stepper motor is utilized to actuate water-tight plungers which either draws water into or pushes water out of the three syringes in the float (see Fig. 1).

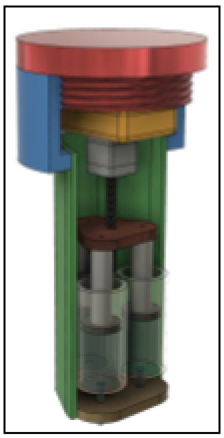

**Fig. 1** A rendering of the float cut out so the internal components are visible. The threading on the float cap ensures that any parts of the float outside of the syringe bodies are completely water tight. A rubber gasket (not pictured) is also used to maintain water-tightness. A Raspberry Pi microcontroller (pictured in yellow) is used to actuate the stepper motor and communicate with the base station when above water. The motor rotates the threaded bolt, which translates the syringe plungers, either drawing water in or out.

The float also wirelessly communicates with the base station. We decided to limit all communication to the period when the float is above the water, and run motion cycles on a timer. We used a Raspberry Pi with a wireless extension module to allow for data transfer back and forth between the base. So, for example, if a temperature reading was needed from the bottom of a water body, the technician at the base station would initiate a float sequence to descend to the sea/ocean floor, wait for a fixed time during which a few temperature samples would be recorded, and then ascend. Once the float rises to the surface, the data collected would be transferred back to the base. This entire procedure needs only a 9V battery to run, which lasts for at least 20 cycles.

Our main constraints when choosing the electronic components for the float were that 1) it had to be powered independently of the robot, but with a small enough battery that fits in the housing, 2) it had to be able to send *and* receive data wirelessly to and from the base station, 3) the electronics were small enough to fit in the limited space in their closed container, and 4) the motor was powerful enough to allow the robot to descend into higher pressure regions and to do so quickly given the strict time limitation of the competition. Firstly, to achieve this last goal we chose a NEMA 17 two-phase stepper (see Fig. X), which is a fast, high-torque motor which can run on a 9V power supply and draws about 1.9 A of current while actuating. To support this motor, we decided to use a Duracell 9V alkaline battery; in addition, the motor's relatively large size limited the size of the electronic housing (see Fig. 2, in yellow) to only 80mm x 57mm. Therefore, we decided that a normally-sized microcontroller would not fit, and instead opted for the Arduino Micro, which has dimensions 48mm x 18mm, leaving space for the other necessary components. Next, as we needed two-way communication between the Arduino and the base station, we chose a 2.4 GHz dual-direction transceiver; this firstly allows the float to receive and interpret the signal to initiate the control sequence, and also lets it send data to the main base station such as sensor or timer readings.

Another big consideration for the Float electronics was power consumption. Firstly, the powerful Nema 17 uses almost 2A while in operation, which is very high when compared to the normal specifications of the Duracell 9V. Thus, we wanted to minimize the amount of power used by the rest of the control system such as the Arduino, transceiver, and stepper driver. But based on the necessity for water tightness, we did not want to have to open and close the Float frequently to replace the battery. Therefore, we created a unique power circuit using a MOSFET transistor and a second RF receiver module which we could use to turn our system on and off; this secondary circuit only uses about 0.5 mA, and thus can run almost indefinitely.

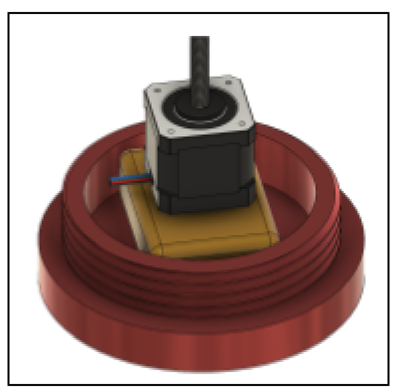

**Fig. 2** A rendering of the Nema 17 45 Ncm Stepper mounting just below the electronics housing within the Float cap.

All safety requirements of ELEC-NRD-004 have been met as well. In our float, we used one 9V alkaline primary battery. The battery is mounted in a specialized electronics housing within the container, and a 5A fuse is connected directly to the battery. In addition, we have employed a 4 cm relief plug in our float so that pressure will be released if much is built up in the container.