

Non-ROV Device

1 OVERVIEW

Our float system is designed for the autonomous profiling and depth-hold tasks required in the competition. According to the task requirements, the float must first dive to 2.5 m and hover for 40 s, then rise to 40 cm below the water surface and hover for another 40 s. After surfacing, it transmits the recorded depth data via WiFi. To achieve these goals, the system is designed around four objectives:

- stable and controllable buoyancy regulation;
- real-time depth sensing, onboard data logging, and post-surfacing data transmission;
- reliable mechanical structure, ease of maintenance, and electrical safety within a compact volume;
- improved response speed and stability during depth holding through an appropriate control strategy.

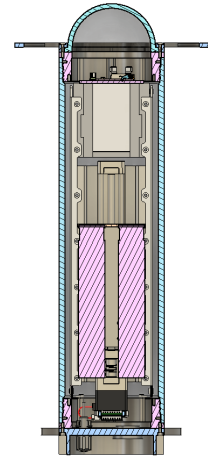


Figure 1: Section view of the float internal structure

2 MECHANICAL

2.1 BUOYANCY ENGINE

The float utilizes a buoyancy engine, with two syringes each with a volume of 150 ml installed inside the compartment. A lead screw controls the intake or discharge of water to regulate buoyancy. The lead screw is driven by a 35 step stepper motor with closed loop control via a driver board.

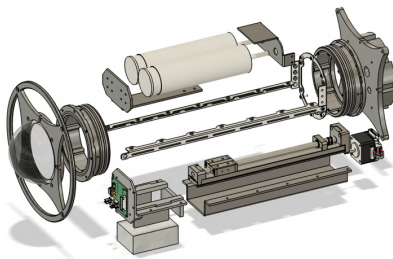


Figure 2: Exploded view of the float

2.2 Float Body

The float body consists of an acrylic tube with a diameter of 115 mm and a length of 400 mm, sealed with aluminum alloy flanges and end caps. Rubber sealing rings are placed between the flange and the acrylic tube, as well as between the flange and the end cap, to ensure water resistance. The bottom end cap is equipped with a 25 mm diameter rubber plug and a water pressure gauge. Meanwhile, the bottom end cap features two cable glands through which silicone tubes pass for water suction and drainage by the syringes. Inside the compartment, two aluminum alloy frames are arranged to secure components.

3 ELECTRICAL SYSTEM & SID

The electrical system consists of the power supply module, ESP32 main controller, stepper motor driver interface circuit, and protection circuitry. It provides stable power delivery, signal processing, and actuation for the float. The overall design emphasizes simplicity, reliability, and safety.

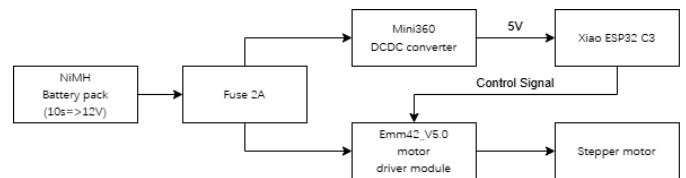


Figure 3: Functional block diagram of the float electrical system

3.1 Power Supply

The system is powered by a **10S NiMH 12 V battery pack**, which supplies energy to the stepper motor, controller, and related modules.



Figure 4: NiMH Battery Pack

The main power line is stepped down to provide a regulated low-voltage supply for the control electronics. This architecture is simple, self-contained, and suitable for deployment and maintenance in competition.

3.2 PCB

The float's control and drive functions are integrated on a custom PCB. The PCB processes control signals, communicates with the external actuator driver, and interfaces with the power supply, communication modules, and peripheral devices.



Figure 5: Custom control and drive PCB with XT30 power connectors

XT30 connectors are used for the power input. An 8-pin XH2.54 connector is integrated on the PCB for interconnection with the off-the-shelf stepper motor driver module. This connector supplies 12V power to the driver and establishes UART serial communication between the ESP32 and the stepper driver.

3.3 Stepper Driver Module

A commercial closed-loop stepper driver module is used to actuate the lead screw mechanism for buoyancy regulation, powered by 12V directly from the main power supply. Motor output and motion control are implemented entirely on the dedicated driver module, which receives position and speed commands from the ESP32 through the serial interface.



Figure 6: Stepper Driver Module

3.4 Fuse Protection/FLA

To prevent overcurrent caused by motor stall, short circuits, or wiring faults, a 2 A fuse is installed at the main

power input. The fuse is placed between the battery and downstream loads so that the circuit can be disconnected promptly under abnormal conditions, protecting the battery, wires, and driver module.



Figure 7: 2A FUSE

For an independently powered float, front-end overcurrent protection is essential. The 2 A fuse satisfies normal operating requirements while providing basic protection against abnormal current conditions. Based on the measured component currents, the total full-load current is 1060 mA, which remains well below the fuse rating.

Component	Max Current (mA)
Stepper Driver Module	950
ESP32 Controller	100
Pressure Sensor	10
FULL LOAD AMPS	1060

4 SOFTWARE

The software system is responsible for task-state switching, depth-hold control, and data logging/transmission. With the ESP32 as the core controller, the system performs depth acquisition, control output generation, and task-flow management.

4.1 Control System/Depth Holding Method

The ESP32 serves as the main controller and implements a PID control algorithm to maintain target depth. Based on the error between measured depth and desired depth, the ESP32 sends position and adjustment commands to the stepper driver via UART serial communication. The stepper motor and lead screw mechanism then regulate displacement to adjust net buoyancy, achieving stable diving, surfacing, and precise depth holding. This standard PID approach ensures fast response, minimal overshoot, and good hovering stability under competition conditions.

4.2 Communication

Because wireless communication is limited underwater, the system records depth data locally during the underwater phase. After the float surfaces, the ESP32 transmits the recorded data to the topside computer or shore-side device via WiFi. This approach satisfies the competition requirement for post-mission data transmission while improving data reliability during underwater operation.

5 FLOAT SID (SYSTEM INTEGRATION DIAGRAMS)

System Integration Diagrams (SIDs) of Float



Electrical SID

