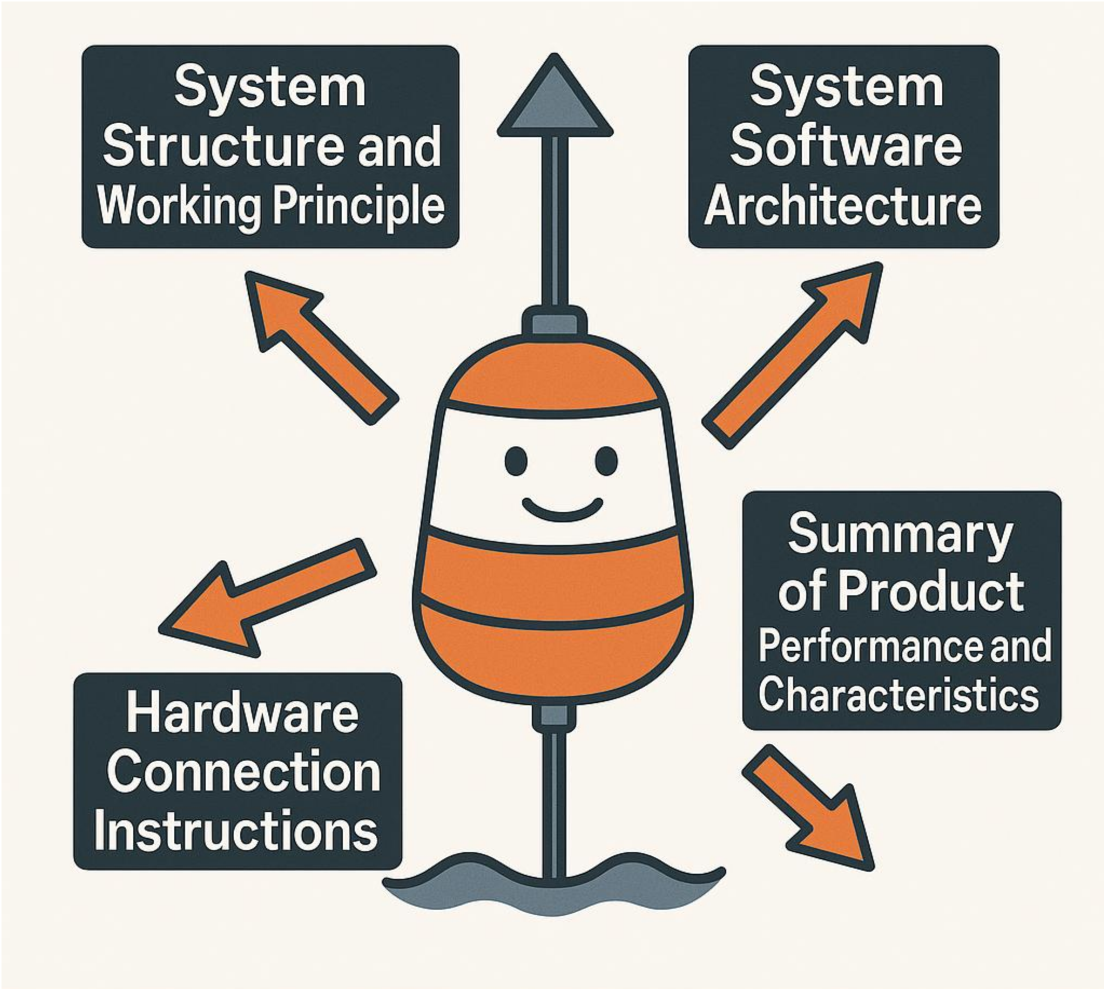

BUOY Design

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MATE ROV Challenge

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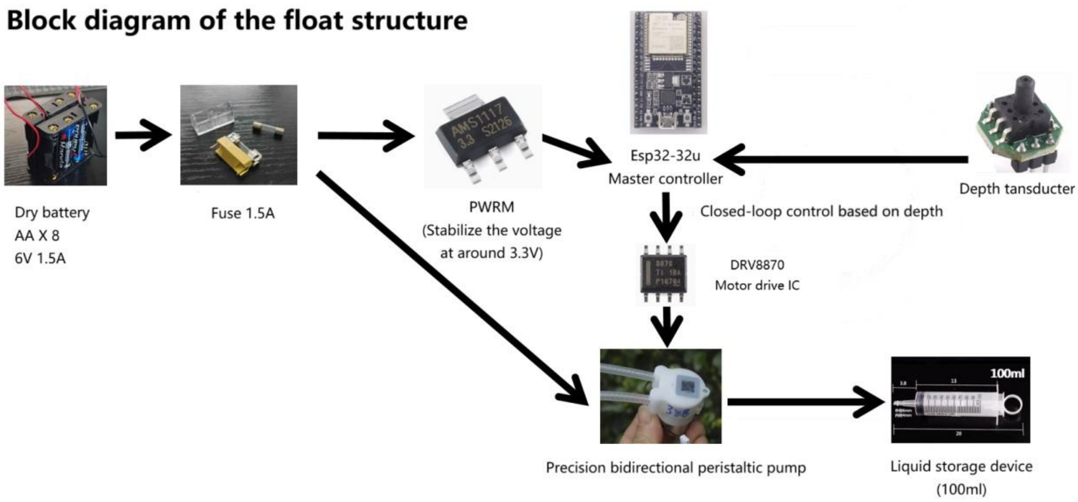
1. Project Overview

This project aims to develop an underwater floating system based on the principle of electronic buoyancy adjustment. The floater adopts a syringe - type liquid tank adjustment structure and combines with a peristaltic pump to achieve high - precision control of liquid increase and decrease. In this way, it can make the floating body rise and sink in water.

The system is composed of core components such as an ESP32 - 32U main control module, a DRV8870 motor driver, and an MS5837 depth sensor. It is powered by a battery and uses the ESP - NOW wireless communication protocol to upload data and realize remote control.

This system has the characteristics of low power consumption, high integration, and a compact structure. It is suitable for application scenarios such as underwater monitoring, teaching demonstrations, and scientific research detection.

2. System Structure and Working Principle



The basic structure of the underwater float system is divided into the following modules:

2.1 Power Supply Module

Battery Pack

The system utilizes eight AA batteries arranged in two parallel banks of four series-connected batteries each, providing a stable output voltage of 6V. This power configuration offers good compatibility and portability, making it suitable for short-term experimental tasks or field deployments.

Fuse Protection

A 1.5A fuse is connected in series at the battery pack output to provide overcurrent protection, ensuring safe circuit operation and preventing sudden current surges from damaging the motor or main control board.

2.2 Control Module

Main Control Chip ESP32-32U

The ESP32-32U is a high-performance wireless MCU based on the Xtensa dual-core 32-bit LX6 microprocessor. It operates at a processing frequency of 240MHz and integrates Wi-Fi and Bluetooth LE communication capabilities.

In this project, the ESP32-32U manages the state machine workflow, handles sensor data acquisition, motor drive control, and wireless communication tasks.

The module supports deep sleep and low-power operation modes, facilitating energy-efficient management.

2.3 Actuator

Liquid Regulation Mechanism

The system employs a syringe and peristaltic pump mechanism to adjust the volume of liquid inside the float.

By rotating the peristaltic pump forward/reverse, the syringe draws in or expels water, altering the float's overall density to achieve ascent or descent.

This design eliminates the need for solenoid valves and external liquid storage tanks, resulting in a simpler structure with better sealing performance.

Driver IC DRV8870

The DRV8870, introduced by Texas Instruments (TI), is a high-current, single-channel DC motor driver supporting a maximum continuous current of 3.6A

(peak 5A). It features integrated protection mechanisms (overcurrent, overtemperature, undervoltage, etc.).
Speed regulation is achieved via PWM control pins, enabling soft starts and linear flow rate adjustment.
The DRV8870 supports both low-side and high-side drive configurations, making it suitable for controlling 6V-powered motors.

2.4 Sensor Module

MS5837-30BA Pressure Sensor

Supplied by BlueRobotics, this sensor has a measurement range of 0–30 bar (equivalent to approximately 0–300m water depth) and a resolution of up to 0.2 mbar.

It features integrated temperature compensation and supports I2C interface communication.

In the system, it is used to collect real-time water depth data, determine changes in the floating body's state, and trigger corresponding state machine reactions.

2.5 Communication Module

ESP-NOW Protocol

A low-power, short-range communication protocol developed by Espressif. Built on the IEEE 802.11 MAC layer, it enables peer-to-peer or broadcast communication between devices without the need for a Wi-Fi router.

Used in this project for communicating depth data and status between the main control device and the host computer, supporting an ACK response mechanism.

3. System Software Architecture

3.1 State Machine Logic

The core operational logic of the system is based on a finite state machine design, primarily consisting of the following states:

Idle State: The system awaits a start signal.
Observation State: Continuously monitors depth changes to detect any natural drift or environmental variations.
Recording State: Initiates data collection and buffering tasks.
Driving State: Controls motor operation to achieve ascent or descent.
Transmission State: Sends data packets to the host computer in batches via ESP-NOW.
Confirmation State: Receives ACK feedback to verify complete data transmission.

State transitions occur through specific trigger conditions, ensuring timely system responses and stable operation.

3.2 Motor Control Algorithm

The speed of the peristaltic pump is regulated by using PWM (Pulse - Width Modulation) technology, and the speed adjustment is achieved by changing the pulse width of the electrical signal.

A linear gradient speed - regulation strategy (soft - start) is adopted to avoid the transient impact of large currents and ensure the stable start - up of the system.

The control period and duty cycle are adjustable, enabling precise control of different flow rates and liquid injection volumes.

3.3 Software I2C Support (Optional)

Considering that motor interference may cause instability in the I2C bus, the system provides an alternative implementation of SoftwareWire software I2C to enhance anti-interference capabilities.

4. Hardware Connection Instructions

Name	Pin - Connection Instructions
MS5837	SDA -> GPIO21, SCL -> GPIO22
DRV8870	IN1/IN2 -> GPIO16/17, EN -> PWM control
Peristaltic Pump	Powered by a 6V power supply and connected to the output terminal of DRV8870

Fuse	Connected in series between the positive - pole of the battery pack and the main power input
ESP32 - 32U	3.3V logic level, and the power supply is obtained through LDO voltage regulation

5.Summary of Product Performance and Characteristics

High Integration

The system integrates control, power supply, sensing, and communication functions into a single-board design, significantly reducing equipment volume, optimizing space utilization, and achieving compact integration of functions.

High Reliability

Equipped with fuse protection devices and over-current motor drivers, it can effectively handle abnormal current conditions. Additionally, it has excellent anti-interference performance, ensuring stable operation in complex electromagnetic environments.

Easy Maintenance

With standardized interface and structural design, component replacement is straightforward in case of faults. It also facilitates the expansion of new functional modules to meet diverse usage requirements.

Open Source and Scalable

Developed based on PlatformIO, the code features a clear structure and strong readability, offering good portability. This enables developers to easily carry out secondary development and functional optimization.