Project Title: IoT Aquarium Automation System Using ESP32

Submitted To: Dr. Nasir Mahmood

Due Date: 04-01-2026

Section: BSCS-5B

Group Members Details

Student Name	Registration Number	Role in Project
Muhammad Umar	23-NTU-CS-1078	Software Development and Coding
Muhammad Hassan Baig	23-NTU-CS-1070	Hardware Wiring and Circuit Implementation
Muhmmad Naveed	22-NTU-CS-1205	Documentation and Project Reporting

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Table of Contents

1. Project Overview

The IoT Aquarium Automation System Using ESP32 is an embedded IoT-based project designed to automate and monitor essential aquarium operations in order to maintain a healthy environment for fish growth. The system focuses on controlling key parameters such as water temperature, lighting, water circulation, and fish feeding, which are critical for the well-being and growth of aquatic life.

The ESP32 microcontroller acts as the core processing unit, coordinating sensor inputs, actuator control, and wireless communication. An RTC (DS1302) module is used to maintain accurate timekeeping, enabling reliable time-based automation even when internet connectivity is unavailable. Based on predefined schedules, the system automatically controls an aquarium heater via a relay to regulate water temperature, manages LED lighting to simulate day–night cycles, operates a DC water pump for water circulation, and activates a servo motor-based feeding mechanism to dispense food at fixed intervals.

To enhance usability and flexibility, the system integrates with an IoT platform such as Blynk or Node-RED, allowing users to monitor system status and manually control devices remotely through a mobile or web interface. This IoT capability ensures real-time interaction, manual overrides, and improved system supervision.

Overall, the project demonstrates the practical application of embedded systems, IoT technology, and automation in aquaculture. It reduces manual effort, minimizes human error, and provides a scalable solution for smart aquarium management, making it suitable for educational, domestic, and small-scale aquaculture applications.

2. Team Participation

The successful completion of the **IoT Aquarium Automation System Using ESP32** was made possible through effective collaboration and clear division of responsibilities among the group members. Each member contributed according to their technical strengths to ensure smooth project development and implementation.

2.1 Muhammad Umar

2.1.1 Role: Software Development and Coding

Muhammad Umar was responsible for the complete software development of the project. His tasks included programming the ESP32 microcontroller, implementing control logic for the aquarium heater, lighting system, water pump, and servo-based feeding mechanism. He also handled the integration of the RTC module for time-based automation and configured IoT communication using Blynk or Node-RED to enable remote monitoring and manual control. Additionally, he tested and debugged the code to ensure system reliability and proper synchronization between hardware and software components.

2.2 Muhammad Hassan Baig

2.2.1 Role: Hardware Wiring and Circuit Implementation

Muhammad Hassan Baig managed all hardware-related tasks for the project. His responsibilities included designing and implementing wiring connections between the ESP32, relay module, servo motor, RTC module, LEDs, aquarium heater, and DC water pump. He ensured correct pin mapping, stable power distribution, proper grounding, and safe relay connections. He also focused on hardware testing to verify correct operation of each component and ensured electrical safety throughout the system.

2.3 Muhammad Naveed

2.3.1 Role: Documentation and Project Reporting

Muhammad Naveed was responsible for preparing the complete project documentation. His work included writing the project overview, defining objectives, describing system architecture, listing components, and documenting hardware and software operation. He also manage proper wiring

descriptions, as well as compiling testing results and conclusions. His documentation ensured that the project was clearly presented, well-structured, and aligned with academic requirements.

3. Instruments Used in the Project

The **IoT Aquarium Automation System Using ESP32** utilizes several hardware components to automate aquarium operations such as temperature control, lighting, water circulation, and fish feeding. Each instrument plays a specific role in ensuring efficient system functionality and reliable automation. The details of the instruments used in this project are discussed below.

3.1 Aquarium Heater

The aquarium heater is used to maintain an appropriate water temperature required for healthy fish growth. Stable temperature conditions are essential to prevent stress and disease in aquatic life. In this project, the heater is controlled automatically using a relay module, allowing the ESP32 to switch the heater ON or OFF based on predefined conditions or schedules.

Connection Details:

- Controlled via **Relay Channel 1**
- Relay control pin connected to **ESP32 GPIO 18**
- Heater operates on external power and is electrically isolated using the relay for safety

Purpose:

- To regulate water temperature
- To provide automated temperature management
- To reduce manual intervention

3.2 5V DC Water Pump

The 5V DC water pump is used to support water circulation within the aquarium. Proper circulation helps maintain oxygen levels, evenly distribute heat, and improve overall water quality. The pump operation is controlled through a relay, enabling scheduled or manual activation.

Connection Details:

- Controlled via **Relay Channel 4**
- Relay input connected to **ESP32 GPIO 16**
- Pump powered using **5V from an external adapter**

Ground connected to **ESP32 GND**

Purpose:

- To circulate water inside the aquarium
- To support filtration and oxygenation

To enable automated water movement

3.3 RTC Module (DS1302)

The Real-Time Clock (RTC) module is used to keep accurate time for scheduling aquarium operations. It allows the system to perform time-based automation such as feeding, lighting, and pump control, even when internet connectivity is unavailable.

Connection Details:

- CLK connected to **ESP32 GPIO 25**

Purpose:

- DAT connected to **ESP32 GPIO 26**
- RST connected to **ESP32 GPIO 27**
- Powered using **3.3V from ESP32**
- Ground connected to **ESP32 GND**

- To maintain real-time clock functionality
- To enable scheduled automation
- To ensure system reliability during power or network interruptions

3.4 Servo Motor

The servo motor is used to automate the fish feeding mechanism. It rotates to dispense a controlled amount of food at scheduled intervals, ensuring consistent feeding and preventing overfeeding.

Connection Details:

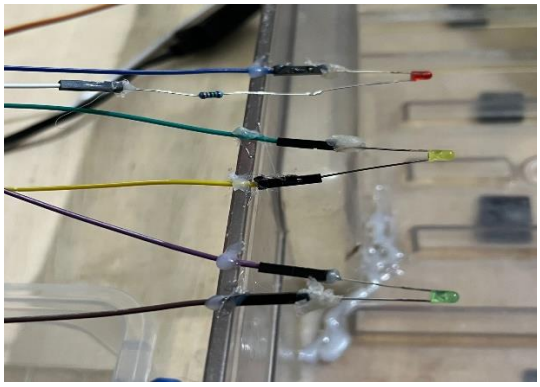
- Signal pin connected to **ESP32 GPIO 4**
- Powered using **5V from an external adapter**
- Ground connected to **ESP32 GND**

Purpose:

- To automate fish feeding
- To control food portion size
- To allow scheduled and manual feeding operations

3.5 LEDs with 220Ω Resistors

LEDs are used to provide artificial lighting in the aquarium, simulating day and night cycles. Proper lighting helps regulate fish activity and supports overall aquarium health. Each LED is connected with a 220-ohm resistor to limit current and protect the ESP32.



Connection Details:

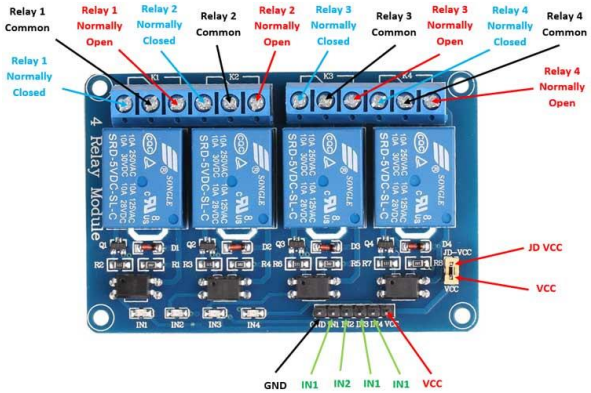
- LED anodes connected to **ESP32 GPIO 23**
- Each LED uses a **220Ω current-limiting resistor**
- Cathodes connected to **ESP32 GND**

Purpose:

- To control aquarium lighting
- To simulate natural light cycles
- To support fish activity and growth

3.6 4-Channel Relay Module

The 4-channel relay module acts as an interface between the low-voltage ESP32 and high-power devices such as the aquarium heater and water pump. It allows the ESP32 to safely control external electrical loads.



Connection Details:

- Relay input pins connected to ESP32 GPIO 16 and GPIO 18
- Relay VCC powered using 5V supply
- Ground connected to ESP32 GND

Purpose:

- To safely control high-power devices
- To provide electrical isolation
- To enable automated switching of aquarium equipment

- Individual relay channels used to switch different devices

3.7 IoT Platform (Blynk or Node-RED)

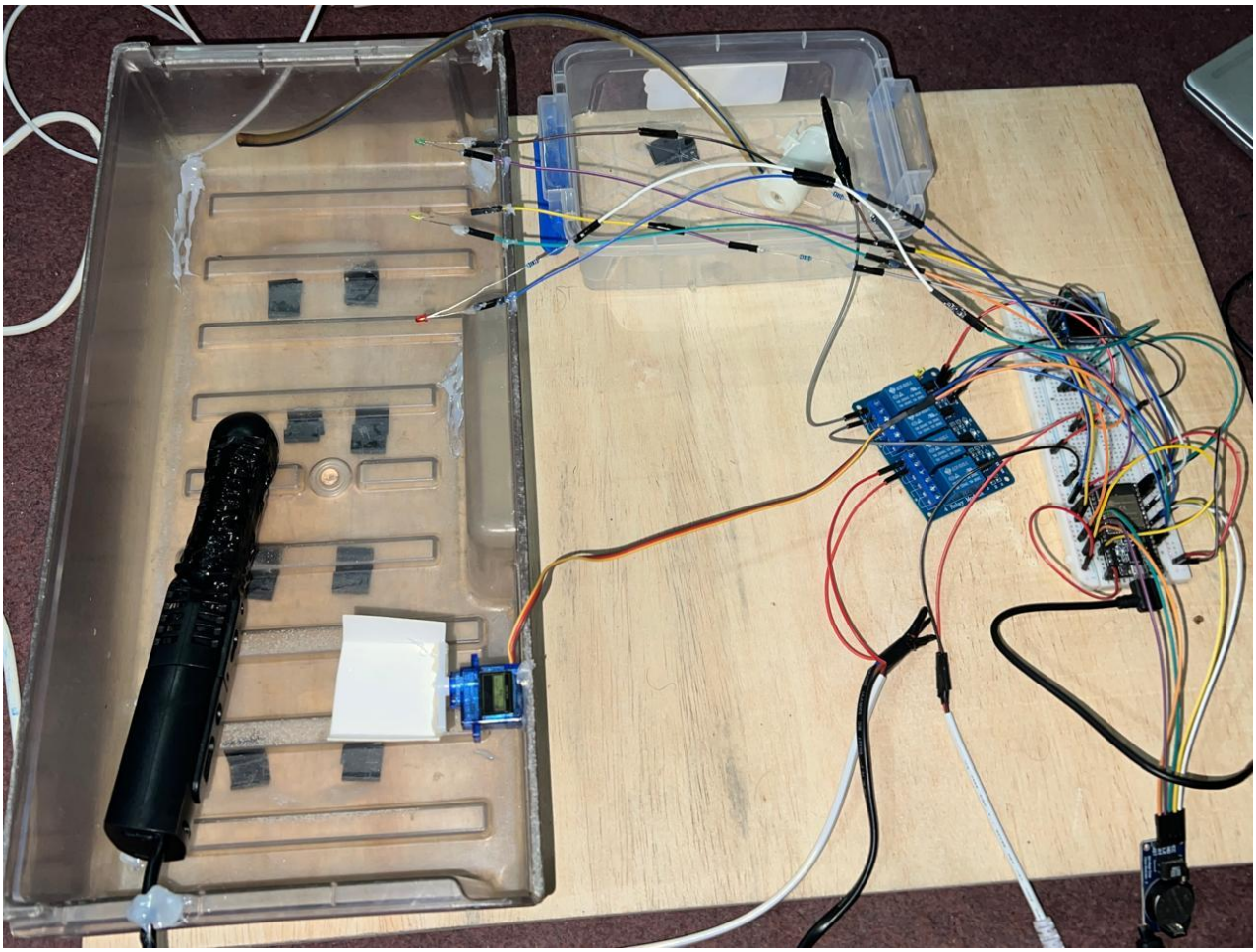
In this project, **either Blynk or Node-RED** will be used as the IoT platform for **online monitoring and remote control** of the aquarium system. One of these platforms is selected based on project requirements and availability to provide a user-friendly interface for controlling aquarium operations remotely.

The selected IoT platform enables users to monitor system status and manually control devices such as the aquarium heater, water pump, lighting system, and feeding mechanism through a mobile application or web-based dashboard. Communication between the ESP32 and the IoT platform is established via **Wi-Fi**, allowing real-time data exchange and remote access.

Purpose:

- To enable remote control of aquarium devices
- To provide online monitoring of system operations
- To allow manual override of automated functions
- To enhance system accessibility and user convenience

4. Overall Project Prototype



5. Working of the IoT Aquarium Automation System

The working of the IoT Aquarium Automation System Using ESP32 will be based on the integration of hardware components with an online IoT platform. In this project, either Blynk or Node-RED will be selected as the IoT platform to create a control interface for remote monitoring and control.

Initially, all hardware components such as the aquarium heater, water pump, servo motor, LEDs, relay module, and RTC will be connected to the ESP32 according to the specified pin configuration. After completing the wiring and powering the system, the ESP32 will connect to a Wi-Fi network and establish communication with the selected IoT platform.

A user interface (dashboard) will then be created on the chosen IoT platform. This dashboard will include different control buttons for each device. Using these buttons, the user will be able to control the aquarium equipment remotely.

When the heater control button on the dashboard is turned ON, a command will be sent to the ESP32, which will activate the corresponding relay channel and turn the aquarium heater ON. Similarly, when the button is turned OFF, the heater will be switched OFF. The same working principle will be applied to the water pump, allowing it to be turned ON or OFF through the dashboard.

For fish feeding, a dedicated servo motor control button will be provided on the interface. When this button is pressed, the ESP32 will rotate the servo motor to dispense food into the aquarium and then return it to its initial position.

The LED lighting system will also be controlled through an ON/OFF button on the dashboard, allowing the user to manage aquarium lighting remotely. Additionally, the RTC module will maintain accurate time, enabling time-based operations and ensuring reliable system behavior even if internet connectivity is temporarily unavailable.

Overall, the system will provide remote and centralized control of aquarium operations through a single online interface. This approach will reduce manual effort, improve efficiency, and ensure better management of aquarium conditions.

6. Conclusion and Future Work

6.1 Conclusion

The IoT Aquarium Automation System Using ESP32 is designed to provide an efficient and smart solution for managing essential aquarium operations through automation and IoT technology. The system integrates various hardware components such as an aquarium heater, water pump, servo motor for feeding, LED lighting, relay module, and RTC with the ESP32 microcontroller to enable centralized control of the aquarium environment.

By using an online IoT platform such as either Blynk or Node-RED, the project allows remote monitoring and control of aquarium devices through a user-friendly interface. Manual control

through dashboard buttons simplifies operations such as turning the heater, pump, lighting, and feeding mechanism ON or OFF. The inclusion of an RTC module ensures reliable time-based operation and supports automation even in the absence of internet connectivity.

Overall, this project demonstrates the practical application of embedded systems and IoT concepts in aquaculture automation. It reduces manual effort, improves efficiency, and enhances control over aquarium conditions, making it suitable for educational and small-scale aquarium management applications.

6.2 Future Work

Although the proposed system provides basic automation and remote control, several enhancements can be implemented in the future to further improve its functionality and intelligence. Additional sensors such as a water temperature sensor, pH sensor, turbidity sensor, or water level sensor can be integrated to enable real-time monitoring and fully automatic decision-making.

In future versions, advanced features such as automatic temperature regulation, intelligent feeding based on fish growth stages, and data logging with graphical analysis can be added. Integration of cloud storage and notification systems can provide alerts in case of abnormal conditions. Moreover, the system can be extended to support mobile notifications, voice control, and AI-based decision support, making it more robust and suitable for commercial aquaculture applications.