# HARDWARE DESIGN-

# WATER QUALITY MONITORING

**GROUP 3**

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# CONTENT

# 1. Introduction

The aim of the CO326 project is to develop an IoT module with sensors and actuators.

The data read or collected from the hardware nodes will be set to a central MQTT broker. The computer that is connected to the broker will then display the data collected and do necessary analysis on a SCADA and will also store the data in a database.

## 1.1 Problem

Water quality has an impact on both human health and the ecosystem. Contaminants in water, such as chemicals, germs, and viruses, can have a harmful effect on the environment and public health. Therefore, it is essential to monitor water quality to ensure the safety of water sources for human consumption, recreational activities, and the health of the ecosystem.

Traditional methods of water quality monitoring are often expensive, time-consuming, and require trained personnel. In addition, they may not provide real-time data, making it difficult to respond quickly to any changes in water quality.

The need thus arises for a low-cost, practical, and continuous water quality monitoring system that can provide real-time data accurately.

## 1.2 Solution

Our solution to the issues mentioned above is to develop a water quality monitoring system using an ESP32 microcontroller, which will continuously monitor the temperature and TDS level of the water. The system will then process this data and compare it with predetermined acceptable limits. After comparing the values, our system will indicate whether the quality of water is good or bad using LEDs.

The collected data from the sensors will be transmitted to a Mosquitto MQTT broker using the MQTT protocol, and then stored in a MySQL database. A Node-RED dashboard will be used as a SCADA system to display the water quality data in real-time. This will allow continuous monitoring and timely detection of any changes in water quality.

Our solution will lead to a cost-effective and efficient way of monitoring water quality continuously, enabling the detection of any changes in water quality in real-time. This allows us to take necessary actions in order to prevent potential health and environmental problems.

The below diagram shows a brief overview of our solution.

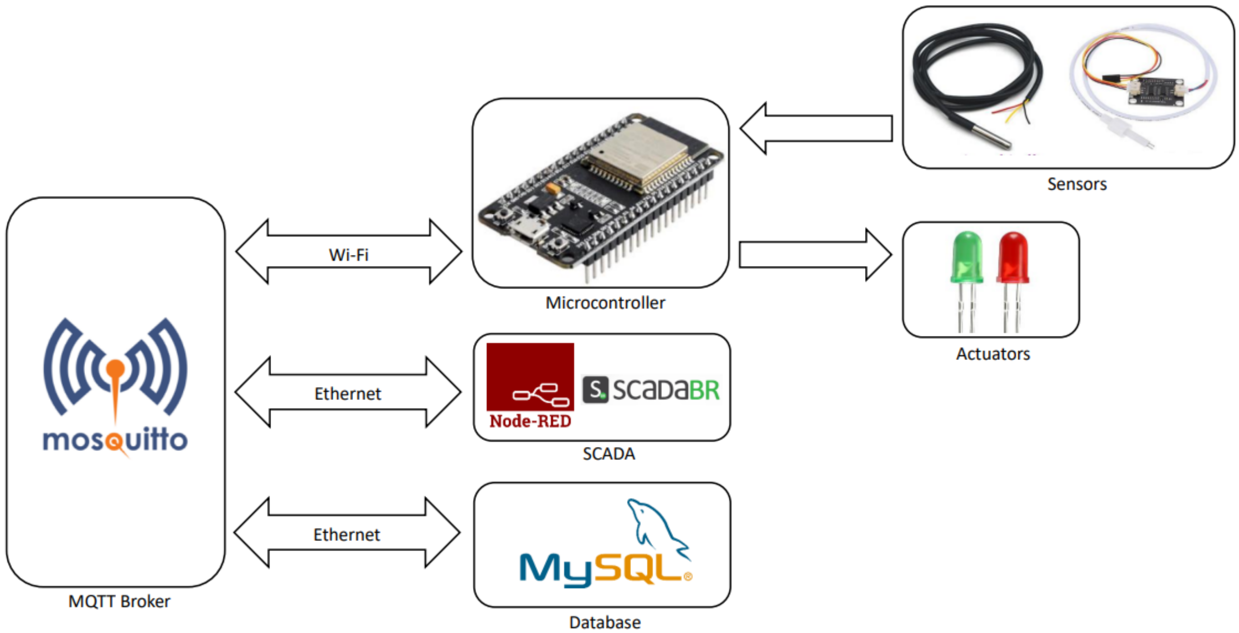


Figure 1- Solution overview

## 2. Hardware

To achieve the necessary requirements, sensors and actuators are connected directly to an ESP32 microcontroller.

Details of the sensors and actuators to be used can be found in the subsequent sections.

### 2.1 Sensors

**DS18B20 Waterproof temperature sensor**

Figure 2- Temperature sensor

The DS18B20 is a digital temperature sensor that can be used to measure temperature of water with a high degree of accuracy. It is waterproof, making it well suitable for use in environments where moisture or water may be present. In our project, this sensor sends temperature readings of water to the microcontroller.

Specifications:

- Input voltage: 3.0V to 5.5V
- Operating temperature range: -55°C to +125°C (-67°F to +257°F)
- Storage temperature range: -55°C to +125°C (-67°F to +257°F)
- Accuracy over the range of -10°C to +85°C: ±0.5°C.
- Output lead: red (VCC), yellow(DATA) , black(GND)
- Cable length: 100 cm
- High quality stainless steel tube encapsulation (waterproof, moisture proof, prevent rust)

**Analog TDS water conductivity sensor**

This is used to measure the total dissolved solids of water. The sensor measures the electrical conductivity of water, which is proportional to the concentration of dissolved salts and minerals in the water. These readings are sent to the microcontroller for further analysis.

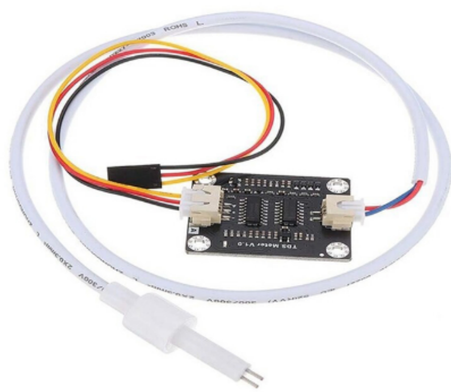

Figure 3- TDS sensor

Specifications:

- Input voltage: 3.3~5.5V
- Working Current: 3 ~ 6mA
- TDS measurement range: 0~1000 ppm
- TDS measurement accuracy: ±10% F.S. (25°C)
- Overall length: 83cm
- Waterproof probe for long-term immersion in water

## 2.2 Actuators

**LED**

Used to indicate whether the quality of water is good or bad. Green LED indicates good water quality while red LED indicates poor water quality. These LEDs can be easily controlled using digital output pins of ESP32.

Figure 4- LEDs

Specifications:

- Forward operating voltage approximately: 1.2~3.6V
- Current rating: 12~20mA most common range

## 2.3 Other components

**ESP32 board**

This is a low cost, low power and high performance microcontroller which can handle multiple sensors and actuators. The ESP32 board is widely used in IoT applications such as environmental monitoring, home automation and industrial control.

This is used to set the parameters such as acceptable range of temperature, TDS levels and control the LEDs based on the readings received from the sensors.

Figure 5- ESP32

Specifications:

- Built-in Wi-Fi & Bluetooth module
- USB micro connector
- Support for Arduino IDE and other popular development environments.

**3.7V Li-ion 18650 battery**

Used to power the water quality monitoring system. This battery provides a high capacity and can be easily recharged.


Figure 6- Battery

Specifications:

- Battery Type: 18650 Rechargeable Li-ion Battery soldered pin
- Output voltage: 3.7V
- Capacity: 2200 mAh
- Rechargeable times: Up to 1800 times

## 3. Data flow

Using the sensors connected to the ESP32 controller the temperature and electrical conductivity of water will be measured.

The measured data will be sent at predetermined intervals to the central MQTT broker and will be stored in the database. Additionally, the data sent will be analyzed to determine the quality of water. This analysis will be done on a SCADA as process control functions.

The analysis will then be published on the MQTT broker which will be used by its subscribers to control the actuators. In our case, the lighting up of LEDs will be controlled via this process.

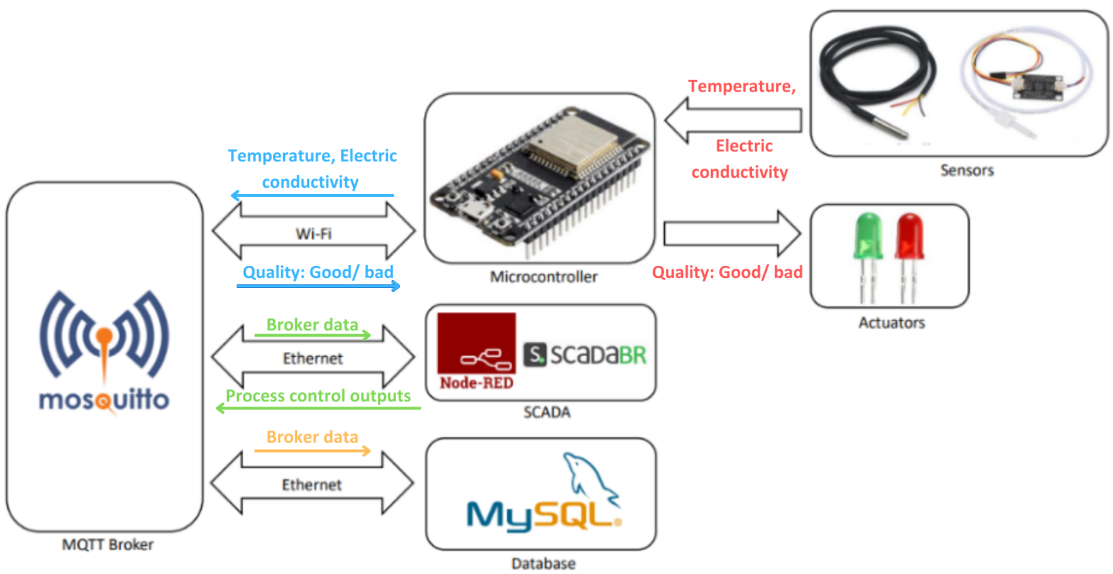


Figure 7- Data flow diagram

# 4. Preliminary design

Under this section we will be looking at the design concepts and project requirements.

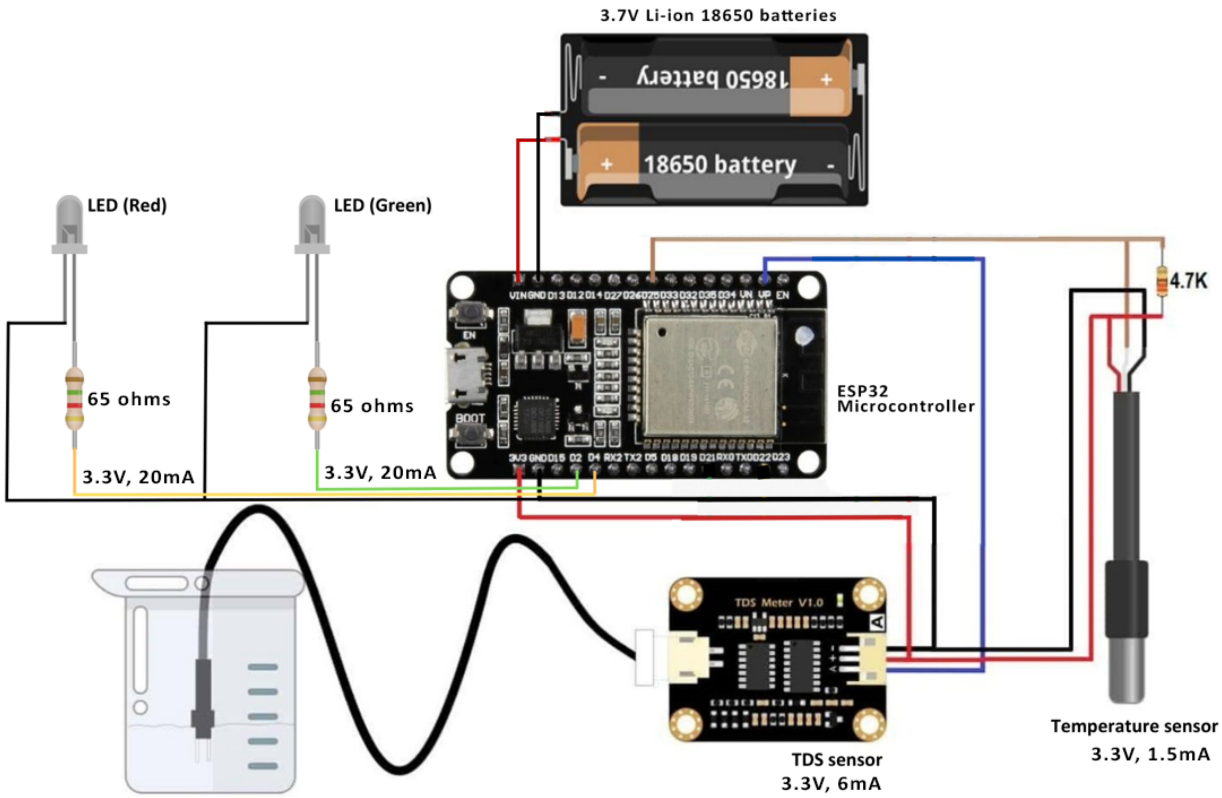


Figure 8- Wiring diagram

The reason for using a temperature sensor is that the temperature parameter is required during Electrical Conductivity EC Value compensation. The EC values change a lot with rising and falling temperatures.

Here we have powered our microcontroller by using two 3.7V Li-ion 18650 batteries through the Vin pin. A voltage between 5V to 12V should be connected to the ESP32 Vin pin for its operation.

Our supply voltage, Vin = 3.7x2 = 7.4V
As 5V < Vin < 12V our supply voltage is in a safe region.

Operating voltage of the sensors,

1. DS18B20 Waterproof temperature sensor: 3.0V to 5.5V
2. Analog TDS water conductivity sensor: 3.3V to 5.5V

As we have used the 3.3V pin of the microcontroller as the input voltage for sensors, the voltage requirement is satisfied.

Let's consider a LED,

Forward voltage drop (Vf) = 2V

Forward current (If) = 20mA

Supply voltage by GPIO pin (Vcc) = 3.3V

As the supply voltage is high a resistor should be connected serially. Resistance of this resistor can be calculated as,

R = (Vcc-Vf)/If = (3.3V-2V)/0.02A = 65 ohms

Let's consider the current ratings of the microcontroller, sensors and actuators.

Maximum current rating of ESP32 = 500mA

Current draw of DS18B20 sensor = 1.5mA

Current draw of analog TDS sensor = 6mA

Current draw of 2 LEDs = 40mA

Total current draw of the system = 1.5 + 6 + 40 = 47.5mA

As the total current draw of the system is less than the maximum current rating of the ESP32 microcontroller, the design is safe in terms of current rating.

# 5. Component list

## 5.1 Bill of materials

| Component name | Quantity | Unit price (Rs.) | Cost (Rs.) |
|---|---|---|---|
| ESP32 board | 1 | 2090.00 | 2090.00 |
| DS18B20 waterproof temperature sensor | 1 | 525.00 | 525.00 |
| Analog TDS Water Conductivity Sensor | 1 | 4390.00 | 4390.00 |
| 4.7k resistor | 1 | 5.00 | 5.00 |
| Jumper wires | 10 | 8.00 | 80.00 |
| Breadboard | 1 | 285.00 | 285.00 |
| LEDs | 2 | 5.00 | 10.00 |
| 3.7V Li-ion 18650 battery | 1 | 455.00 | 455.00 |
| Battery holder | 1 | 85.00 | 85.00 |
| Total | | | 7925.00 |

## 6. Other microcontrollers

An ESP-01S microcontroller costs around $5, while an ESP32 microcontroller costs roughly $27. An ESP12F microcontroller would be $5.

All three microcontrollers have a built-in wifi module. Our application needs at least four GPIO pins as shown in figure 8. Two for inputs and two for outputs. The ESP-01S microcontroller has only 2 GPIO pins making it not appropriate for our application.

On the other hand, the ESP12F microcontroller has enough GPIO pins to satisfy our hardware design specifications. Therefore, there is in fact a possibility of using the ESP12F microcontroller for our project.

## 7. References

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