IOT Based Automated Water Level Monitoring and Controlling System

A Mini-Project Report submitted in partial fulfillment of the requirements for the award of the degree of.

BACHELOR OF
TECHNOLOGY IN
COMPUTER SCIENCE AND ENGINEERING (IOT)

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CERTIFICATE

This is to certify that the project report entitled **"**IOT Based Automated Water Level Monitoring and Controlling System**"** is a bonafide record of work carried out by **B. SAI SWAROOP (600184), MYTHRI. J (600192), RAGAVI. M (600196)** submitted in partial fulfillment of requirement for the award of degree of **Bachelors of Technology in Computer Science and Engineering**.

SIGNATURE OF THE INCHARGE

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CHAPTER 1: INTRODUCTION

In modern households, efficient water management is crucial for maintaining a steady and uninterrupted supply of water while minimizing wastage. One of the most effective ways to automate water usage is by employing an intelligent water level monitoring system integrated with sensors and an automated motor control mechanism. This system ensures that the water tank is always maintained at an optimal level without manual intervention. It operates using ultrasonic sensors, which are installed in both the overhead water tank and the underground sump. When the water level in the overhead tank falls below a predefined threshold, the sensor detects the low level and sends a signal to the sump's sensor. The sump sensor then assesses the available water level, and if there is sufficient water, it triggers the motor to pump water from the sump to the overhead tank automatically. This approach not only eliminates the need for human supervision but also optimizes water usage by ensuring that the motor operates only when necessary.

Furthermore, the system incorporates additional intelligence to prevent overflows and dry running of the motor, ensuring efficiency and longevity of the equipment. Once the water level in the overhead tank reaches the predefined high level, the ultrasonic sensor detects it and signals the system to turn off the motor, thereby preventing wastage due to overflow. Similarly, if the sump's water level drops too low while the motor is running, the system immediately shuts off the motor to prevent it from running dry, which could cause damage. This automated solution is particularly beneficial in areas where water supply is irregular, as it ensures that available water resources are utilized optimally while also reducing energy consumption. By implementing this system, households can significantly improve their water management, reduce manual effort, and enhance the durability of their water pumping infrastructure.

1.1 OBJECTIVE:

To develop an IoT-enabled system that monitors and controls water levels in tanks automatically, preventing overflow and dry running of pumps.

1.2 PROBLEM STATEMENT:

Water wastage due to manual control of water pumps and inefficient monitoring leads to resource depletion and high electricity consumption. An automated system is needed to efficiently manage water levels, reduce human intervention, and optimize water usage.
Manual water level checks are often unreliable and lead to water wastage through overflows or pump damage from dry running. The absence of automated control results in inconsistent water levels and unnecessary consumption, demanding frequent human intervention. Existing systems struggle to maintain optimal levels, leading to inefficiencies and potential damage. Furthermore, variations in water demand and supply are difficult to manage without automated adjustments, causing either shortages or excessive pressure on the system. The lack of precise, automated regulation creates a need for a reliable system that can proactively respond to changing water levels and maintain a consistent supply.

1.3 ANALYSIS:

The proposed automated water level monitoring and control system is designed to efficiently regulate water usage in households while minimizing human intervention. The system primarily relies on ultrasonic sensors installed in both the overhead water tank and the underground sump to detect water levels in real time. When the tank reaches a low water level, the sensor communicates with the sump sensor to determine if there is enough water available. If the sump has sufficient water, the system automatically turns on the motor to pump water into the overhead tank. This ensures a continuous supply of water while preventing manual errors, such as forgetting to turn the motor on or off. Additionally, the automation enhances convenience and eliminates the need for frequent supervision, making it an efficient solution for modern households.

A key strength of the system is its ability to prevent water wastage and motor damage through intelligent control mechanisms. By turning the motor off when the water reaches the high level in the tank, the system prevents overflow, thus saving water. Furthermore, the sump’s sensor plays a crucial role in ensuring that the motor does not operate under dry conditions, which could lead to motor burnout and increased maintenance costs. The integration of these automated checks enhances system reliability and ensures energy efficiency by preventing unnecessary motor operation. However, potential challenges include sensor accuracy, system calibration, and maintenance requirements to ensure long-term efficiency. Despite these challenges, the system offers a robust and effective solution for water conservation and efficient household water management.

CHAPTER 2: DESIGN

The automated water level monitoring system consists of key components that work together to efficiently regulate water levels in a household water tank and sump. The primary components include the tank sensor, sump sensor, microcontroller (Arduino Uno R3), and relay module, all of which function in coordination to automate the motor operation. The system ensures that water is pumped only when necessary, thereby preventing wastage and protecting the motor from dry running or overload conditions.

1. Tank Sensor (Ultrasonic Sensor in the Overhead Tank)

The tank sensor is responsible for continuously monitoring the water level in the overhead storage tank. This ultrasonic sensor measures the water level and determines whether it has reached a low or high threshold based on predefined limits.

When the water level is low: The sensor sends a signal indicating that the water needs to be refilled. This signal is then sent to the sump sensor to check the availability of water in the sump.

When the water level is high: If the water level reaches the predefined high threshold, the sensor sends a signal to stop the motor, preventing overflow and water wastage.

The tank sensor acts as the first trigger in the automation process, ensuring that the tank maintains an adequate water level without requiring manual monitoring.

2. Sump Sensor (Ultrasonic Sensor in the Underground Sump)

The sump sensor is placed in the underground or ground-level sump and is crucial for determining whether enough water is available for pumping. Once the tank sensor detects a low water level and requests water, the sump sensor checks the sump's water level before activating the motor.

If the sump has enough water: The sump sensor sends a signal to the Arduino Uno R3 microcontroller, indicating that the motor can be safely turned on.

If the sump water level is too low: The sump sensor sends a signal to not turn on the motor or to turn it off immediately if it is already running. This prevents the motor from dry running, which can cause damage to the pump.

This sensor ensures that water is only pumped when it is available, reducing strain on the motor and preventing unnecessary power consumption.

3. Microcontroller (Arduino Uno R3)

The Arduino Uno R3 is the central processing unit of the system, responsible for making decisions based on inputs from the tank sensor and sump sensor. It acts as the brain of the system, processing signals and sending commands accordingly.

When the tank sensor detects a low level, the microcontroller waits for confirmation from the sump sensor before activating the motor.

If the sump sensor confirms sufficient water, the Arduino sends a signal to the relay module to turn on the motor.

Once the tank reaches a high level, the microcontroller instructs the relay module to turn off the motor.

If the sump level gets too low, the microcontroller ensures that the motor is turned off to prevent damage.

The microcontroller processes these conditions in real time, ensuring efficient water management without human intervention.

4. Relay Module (Motor Control)

The relay module acts as an electronic switch that controls the motor based on signals received from the Arduino Uno R3. Since the motor operates on high voltage, the Arduino cannot directly power it. Instead, the relay module acts as an interface between the Arduino and the motor.

When the Arduino signals the relay module to turn ON, the relay activates the motor, allowing it to pump water.

When the Arduino signals the relay module to turn OFF, the relay disconnects the motor, stopping the water flow.

This component ensures that the motor operates only under the correct conditions, preventing unnecessary power usage and reducing maintenance requirements.

2.1 Hardware and Software Requirements

Hardware Requirements

- Ultrasonic Sensors (HC-SR04) – 2 Units (For overhead tank and sump)
- Arduino Uno R3 (Microcontroller to process signals and control the motor)
- Relay Module (5V, Single-Channel) (To switch the motor on/off)
- Water Pump Motor (For pumping water from sump to tank)
- Power Supply (12V Adapter or Battery) (To power the system)
- Jumper Wires & Breadboard (Optional) (For connections and testing)

Software Requirements

- Arduino IDE (For coding and uploading programs)
- Embedded C/C++ (Programming language for logic control)
- Serial Monitor (Arduino IDE) (For debugging sensor readings)
- Libraries (NewPing.h for ultrasonic sensors, if needed)

UML (Unified Modeling Language) Diagrams:

UML diagrams are used to visualize, design, and document software systems. They are divided into Structural Diagrams and Behavioral Diagrams.

1. Structural Diagrams (Depict system structure)

- Class Diagram: Represents classes, attributes, and relationships.
- Component Diagram: Shows software components and dependencies.
- Deployment Diagram: Displays system architecture and hardware.

2. Behavioral Diagrams (Depict system behavior)

- Use Case Diagram: Represents user interactions with the system.
- Sequence Diagram: Shows object interactions in order.
- Activity Diagram: Represents workflows and processes.
- State Diagram: Depicts object states and transitions.

2.2 USECASE DIAGRAM:

The Use Case Diagram provides a visual representation of the interactions between different actors (users, service providers, and admin) and the functionalities offered by water level monitoring system.

NOTATIONS:

- Actor
- Use Case
- Association
- System Boundary
- Include
- Extend

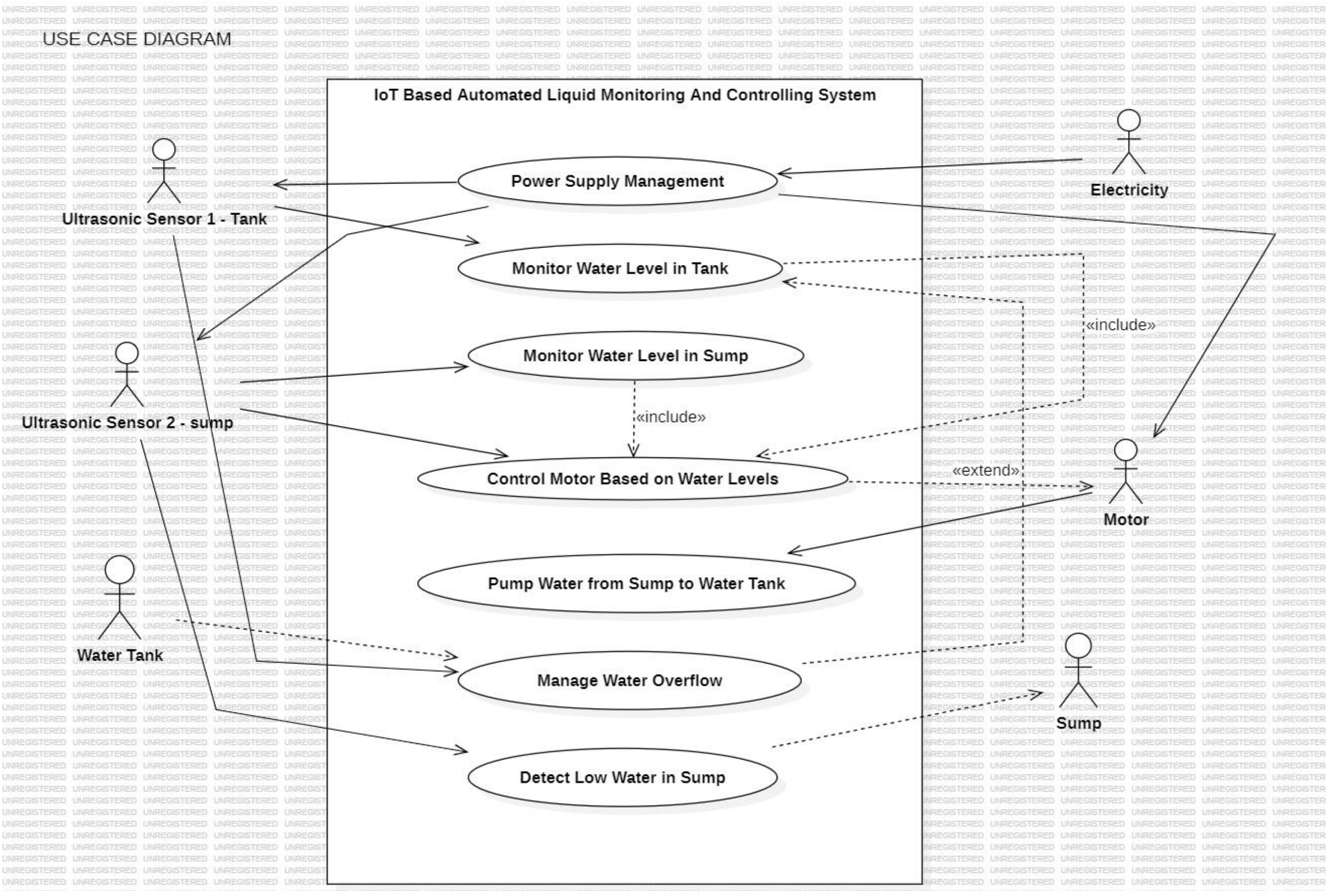

FIG.NO:2.1-Use Case Diagram

2.3 CLASS DIAGRAM:

The Class Diagram represents the structure of automated water level controlling system, detailing its key entities, attributes, and relationships among different components.

NOTATIONS:

- Class
- Attributes
- Methods
- Association
- Multiplicity

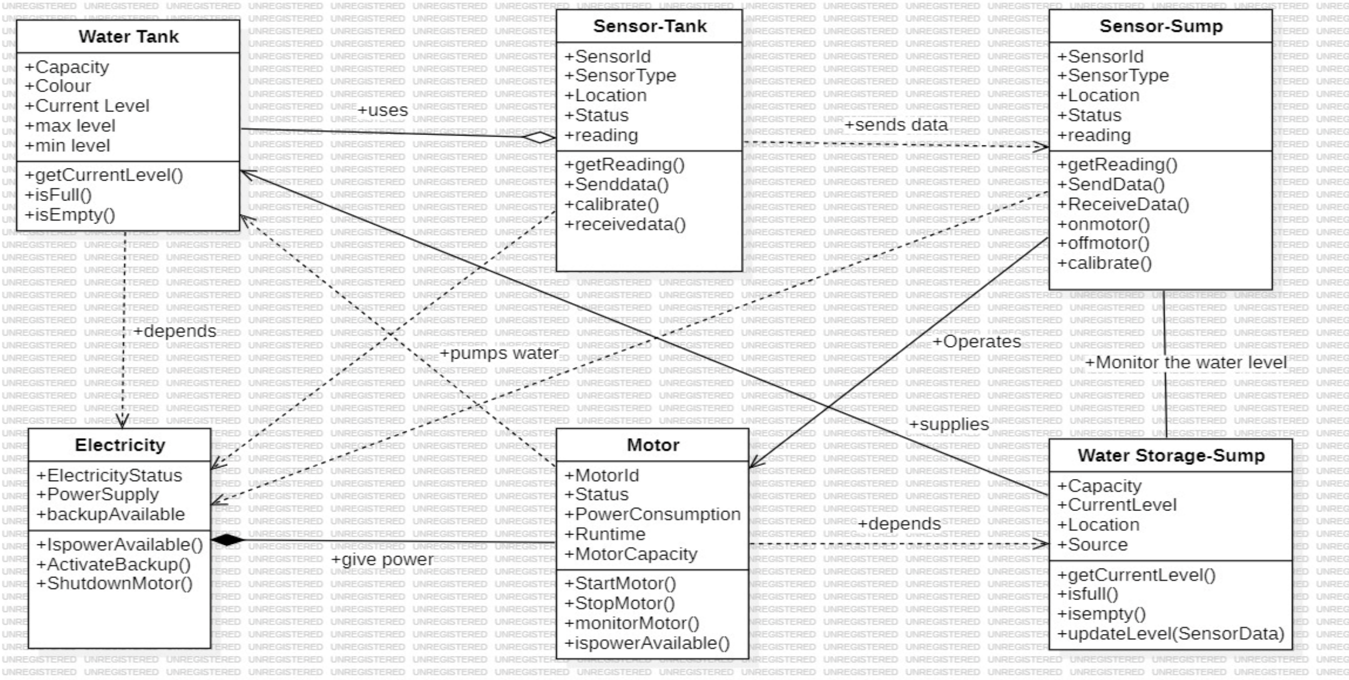

FIG.NO:2.2-CLASS DIAGRAM

2.4 SEQUENCE DIAGRAM:

This is a Sequence Diagram for automated water level controlling system, illustrating the interaction between different components during monitoring and controlling process. It represents the order of messages exchanged between sensors and motor switch.

NOTATIONS:

- Actor
- Object
- Lifeline
- Message
- Asynchronous Message
- Return Message

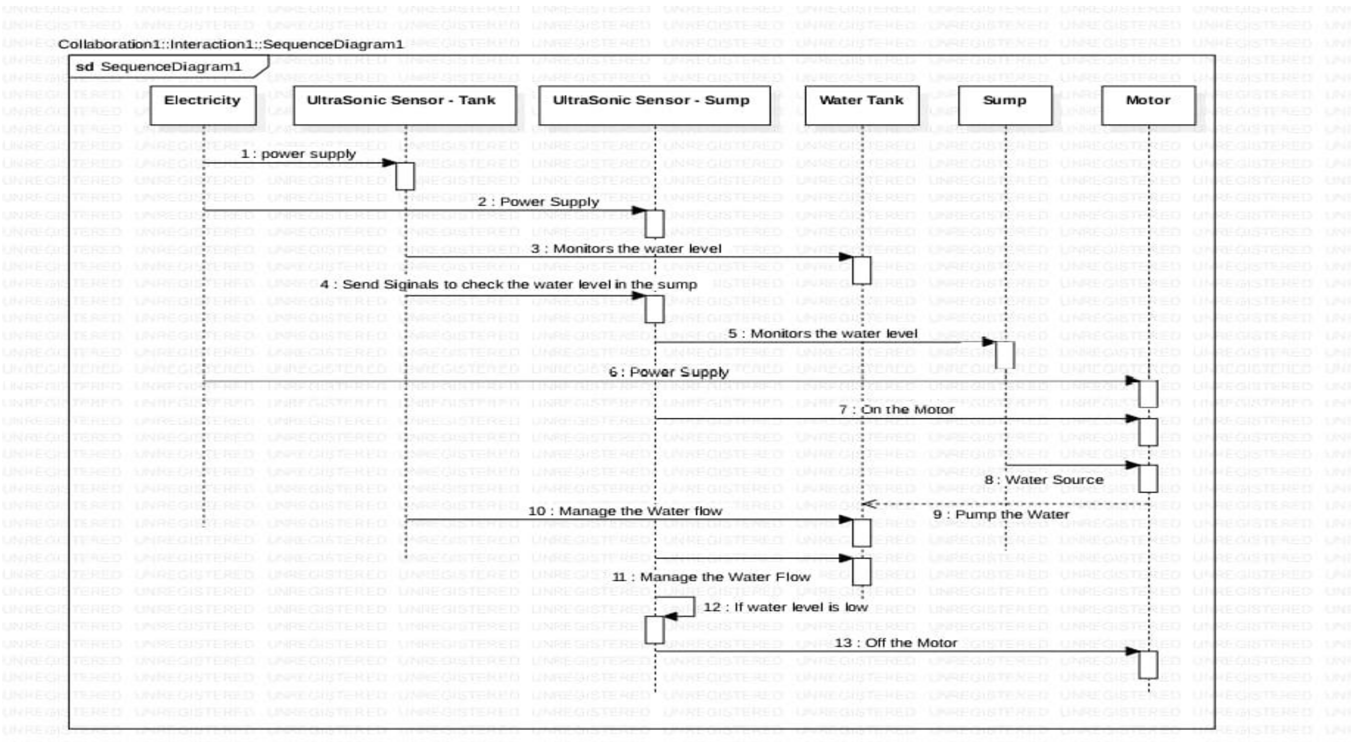

FIG.NO:2.3-SEQUENCE DIAGRAM

2.5 ACTIVITY DIAGRAM:

This is an Activity Diagram for automated water level controlling Process. It visually represents the step-by-step flow of monitoring the water level using sensors and automated turning off and on of the motor with some conditions.

NOTATIONS:

- Start Node
- Activity
- Decision Node
- Merge Node
- Fork Node
- Join Node
- Transition
- End Node

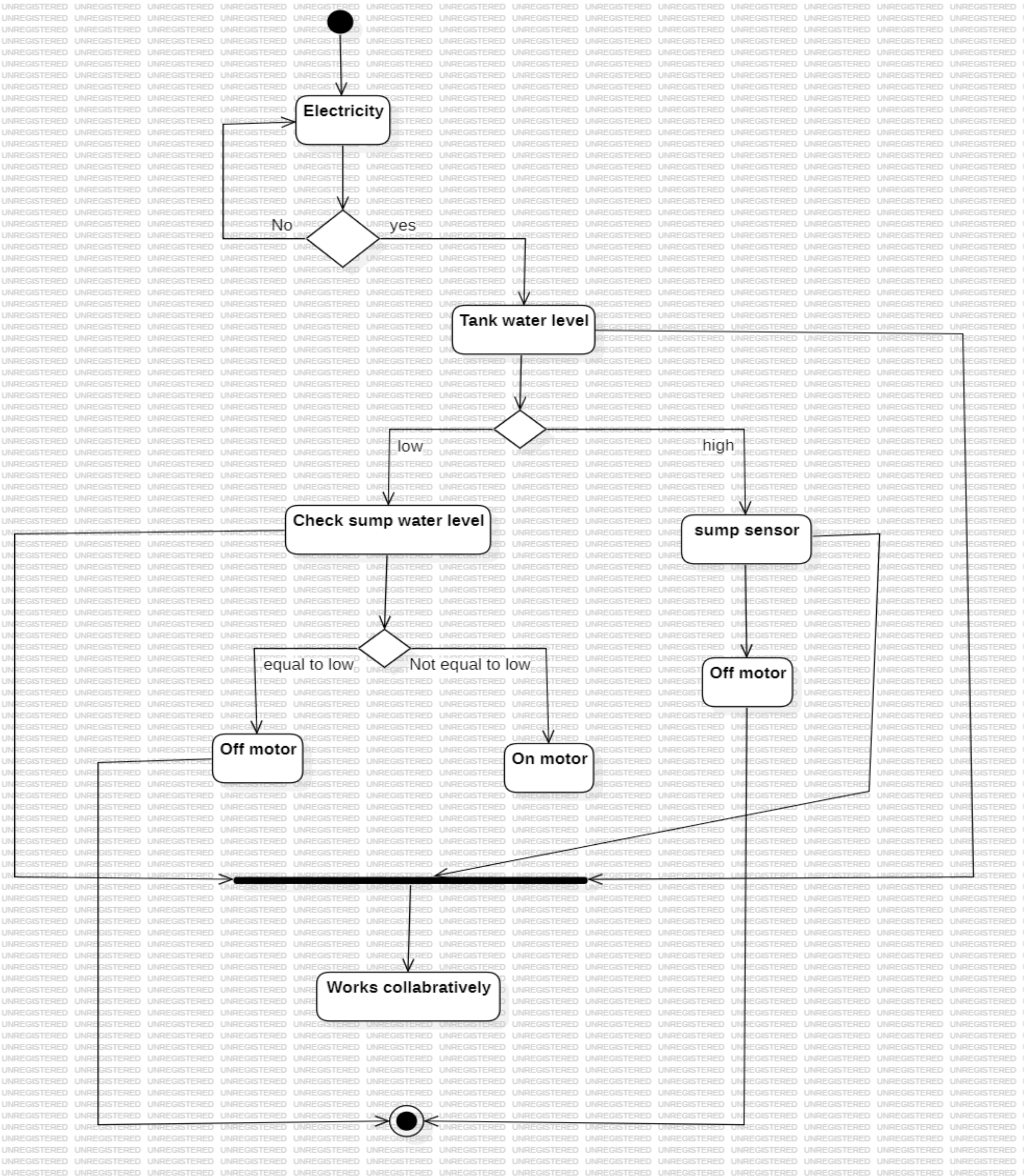

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FIG.NO:2.4-ACTIVITY DIAGRAM

2.6 STATE CHART DIAGRAM:

The State chart Diagram represents different states the system goes through while sensing the water level using sensors. It shows how the system transitions between states based on sensors.

NOTATIONS:

- Initial State
- State
- Transition
- Decision Node
- Final State

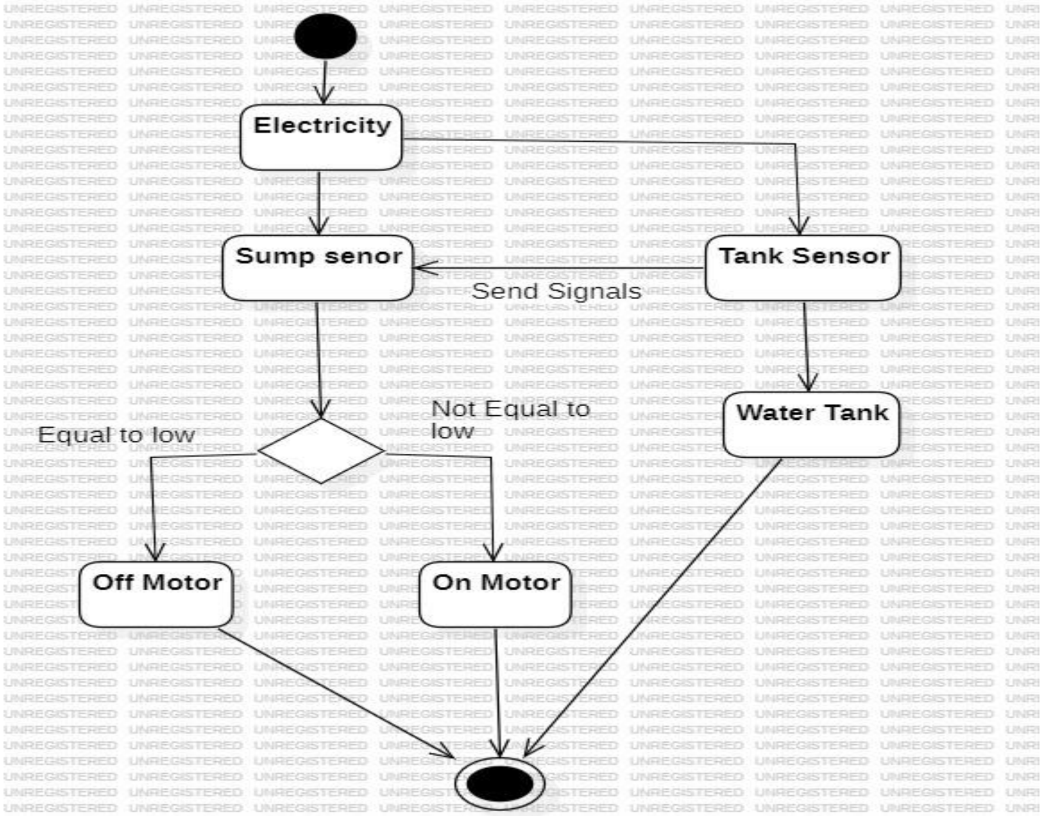


FIG.NO:2.5-STATE CHART DIAGRAM FOR SERVICE BOOKING APP

2.7 PACKAGE DIAGRAM:

This is a Package Diagram representing the structural organization of different components in automated water level monitoring and controlling system.

NOTATIONS:

- Package
- Class Inside Package
- Dependency
- Import
- Access
- Merge
- Interface
- Generalization
- Association
- Realization

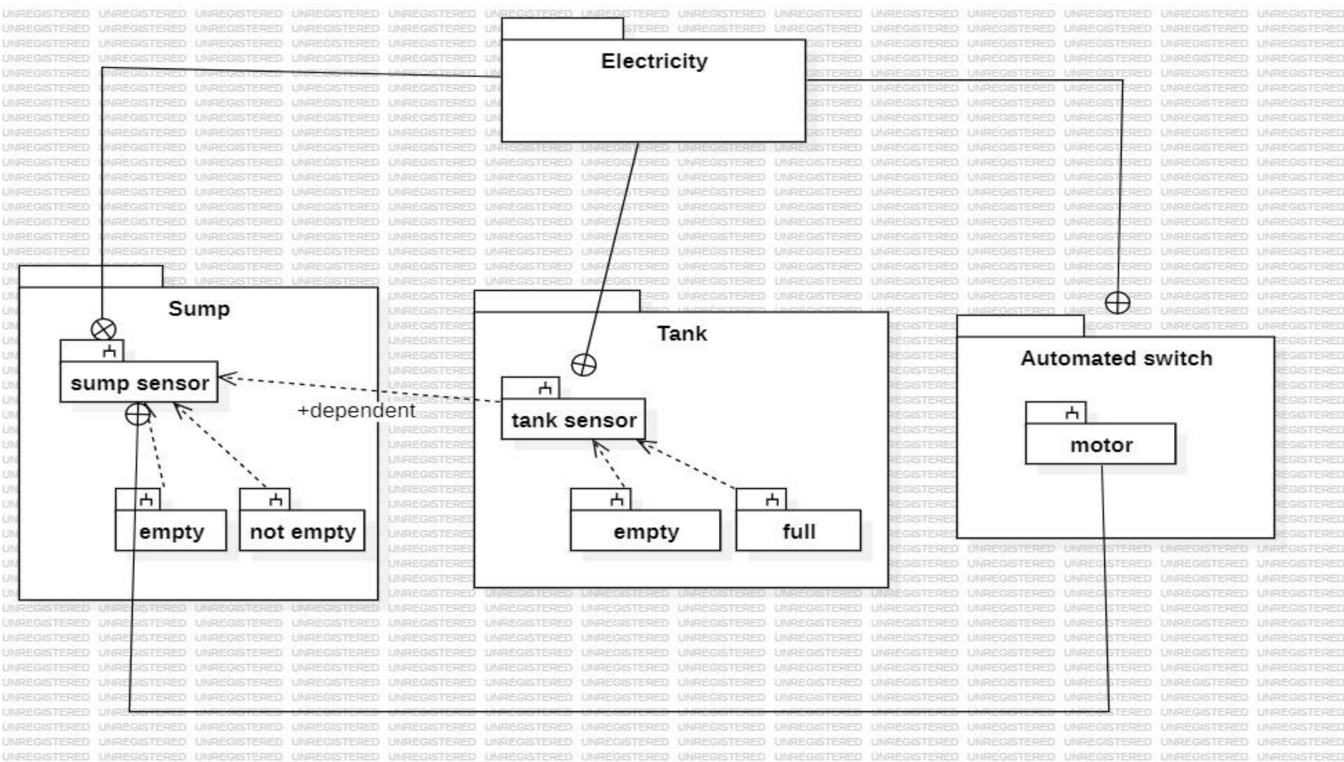


FIG.NO:2.6-PACKAGE DIAGRAM

2.8 OVERALL ARCHITECTURE DIAGRAM:

This Overall Architecture Diagram represents different functional modules of Automated water level monitoring and controlling system and their interactions. Tank sensor will sense the water level either it is low or high and sends that signal to the sump sensor to turn on or off the motor. The sensor in the sump will send signals to Aurdino Uno R3(microcontroller) and then it sends to relay module to turn on or off the motor. The entire system is controlled by the microcontroller according to the provided conditions and acts accordingly.

NOTATIONS:

- Rectangle
- Arrows
- Oval
- Decision box

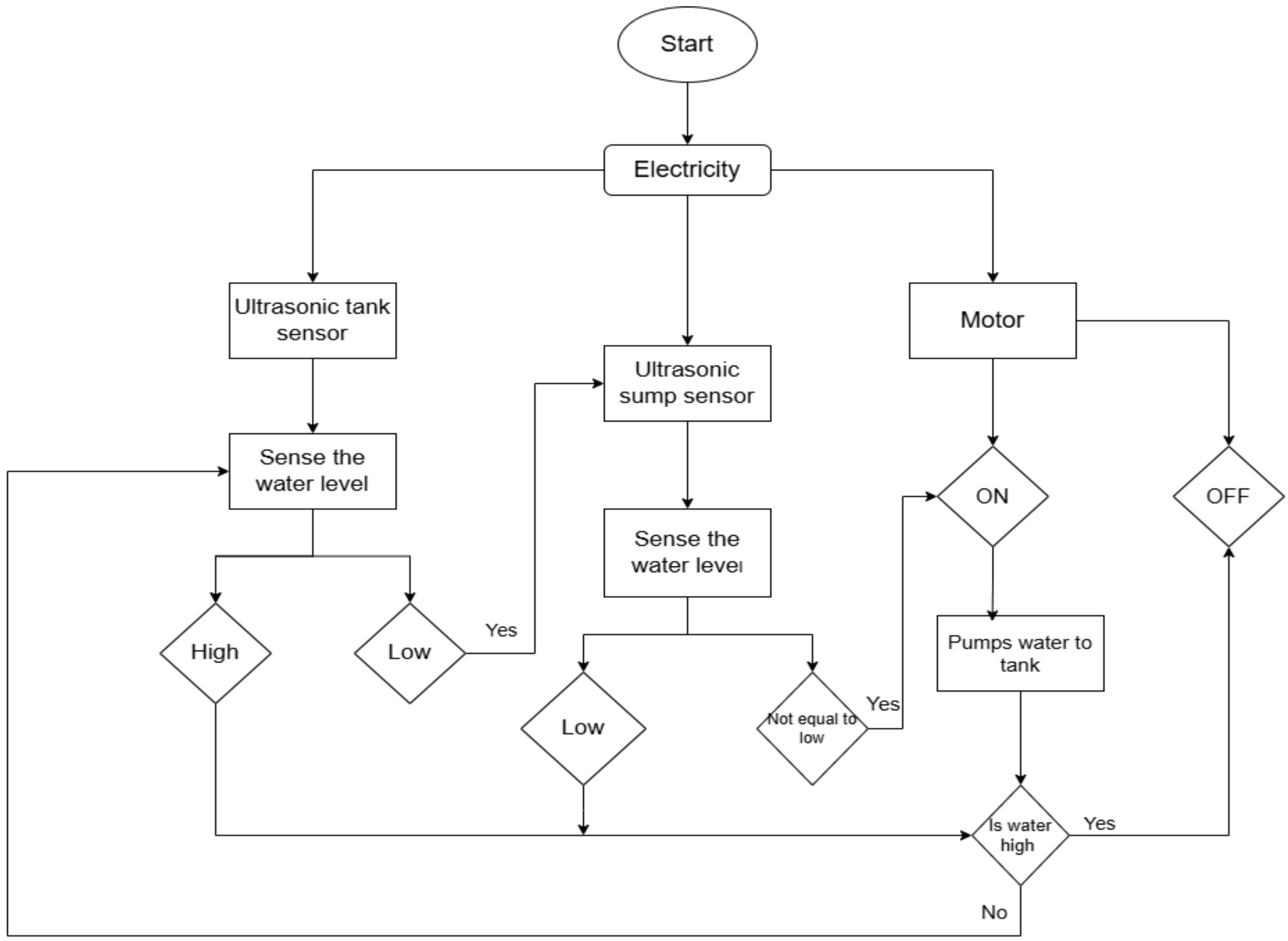


FIG.NO:2.7- OVERALL ARCHITECTURE DIAGRAM

CHAPTER 3: IMPLEMENTATION

Modules and Descriptions for Automated water level monitoring and controlling system:

3.1 List of modules

- Hardware configuration
- External communication
- Sensor automation
- Water flow
- Simulation
- Software/code implementation

Hardware configuration:

- An **IoT-based automated water level management system** efficiently monitors and controls water levels in tanks using sensors and microcontrollers. The system consists of an ESP32 or NodeMCU (ESP8266) microcontroller, an ultrasonic or float sensor for water level detection, a 5V/12V relay module, and a water pump. The water level sensor measures the water level and sends data to the microcontroller, which processes the information and triggers the pump accordingly. When the water level drops below a predefined threshold, the microcontroller activates the pump via the relay module to fill the tank. Once the desired water level is reached, the pump is turned off to prevent overflow.
- The relay module controls the water pump by switching it on or off based on sensor readings, ensuring automated and efficient water management. The entire system is powered using a 5V or 12V power supply, depending on the components used. The schematic diagram of the system includes connections where the water level sensor's trig and echo pins are connected to GPIO pins of the microcontroller, while the relay module's input pin is connected to another GPIO pin to control the pump. If an external Wi-Fi module is used, its TX and RX pins connect to the microcontroller's RX and TX pins, respectively.

External communication:

- Microcontroller/IoT Board: ESP32 or NodeMCU (ESP8266)
- The ESP32 and NodeMCU (ESP8266) are low-power, Wi-Fi-enabled microcontrollers used to process sensor data and communicate with cloud platforms. They control the relay module to switch the pump on or off based on water level readings.
- Water Level Sensors: Ultrasonic Sensor (HC-SR04) or Float Sensor
- The HC-SR04 Ultrasonic Sensor measures water level using sound waves, providing precise distance readings. The Float Sensor detects water level changes mechanically by floating at different levels, triggering an electrical signal when the water reaches a set threshold.
- Pump Relay Module: 5V or 12V Relay Module
- The relay module acts as a switch, controlling the water pump based on commands from the microcontroller. It allows low-power microcontrollers to manage high-power electrical loads safely.
- Water Pump: Submersible or Motor Pump (as required)
- A submersible pump operates underwater, ideal for tanks and reservoirs, while a motor pump is used for higher-capacity pumping, typically placed outside the water source. The pump is activated when the water level is low and stops when the tank is full.
- Power Supply: 5V/12V adapter or battery pack
- The system is powered using a 5V or 12V power adapter or a battery pack, depending on the components used. The microcontroller typically runs on 5V, while pumps may require 12V.

Sensor automation:

1. Real-Time Water Level Monitoring
    - The ultrasonic sensor continuously measures the water level by calculating the distance between the sensor and the water surface.
    - The float sensor acts as a switch, detecting predefined water levels (low, medium, high).
    - The microcontroller (ESP32/ESP8266) processes the sensor data at regular intervals and determines whether the pump needs to be activated or stopped.
2. Automated Pump Control
    - If the water level is low, the microcontroller automatically turns ON the pump via the relay module.

- If the water level reaches the high threshold, the pump automatically turns OFF, preventing overflow.
- The relay module ensures safe switching between the low-power microcontroller and high-power pump.

Water flow:

1. Overflow Detection

- The ultrasonic sensor (HC-SR04) or float sensor measures the water level in real time.
- If the water level exceeds the maximum threshold, the system turns off the pump to prevent overflow.

2. No Water Detection (Dry Run Protection)

- A water flow sensor (YF-S201) or a dry-run sensor can detect if the pump is running but no water is flowing.
- If the flow rate is zero while the pump is on, it indicates that the water source is empty or there is a blockage.
- The system then Automatically shuts off the pump to prevent damage.

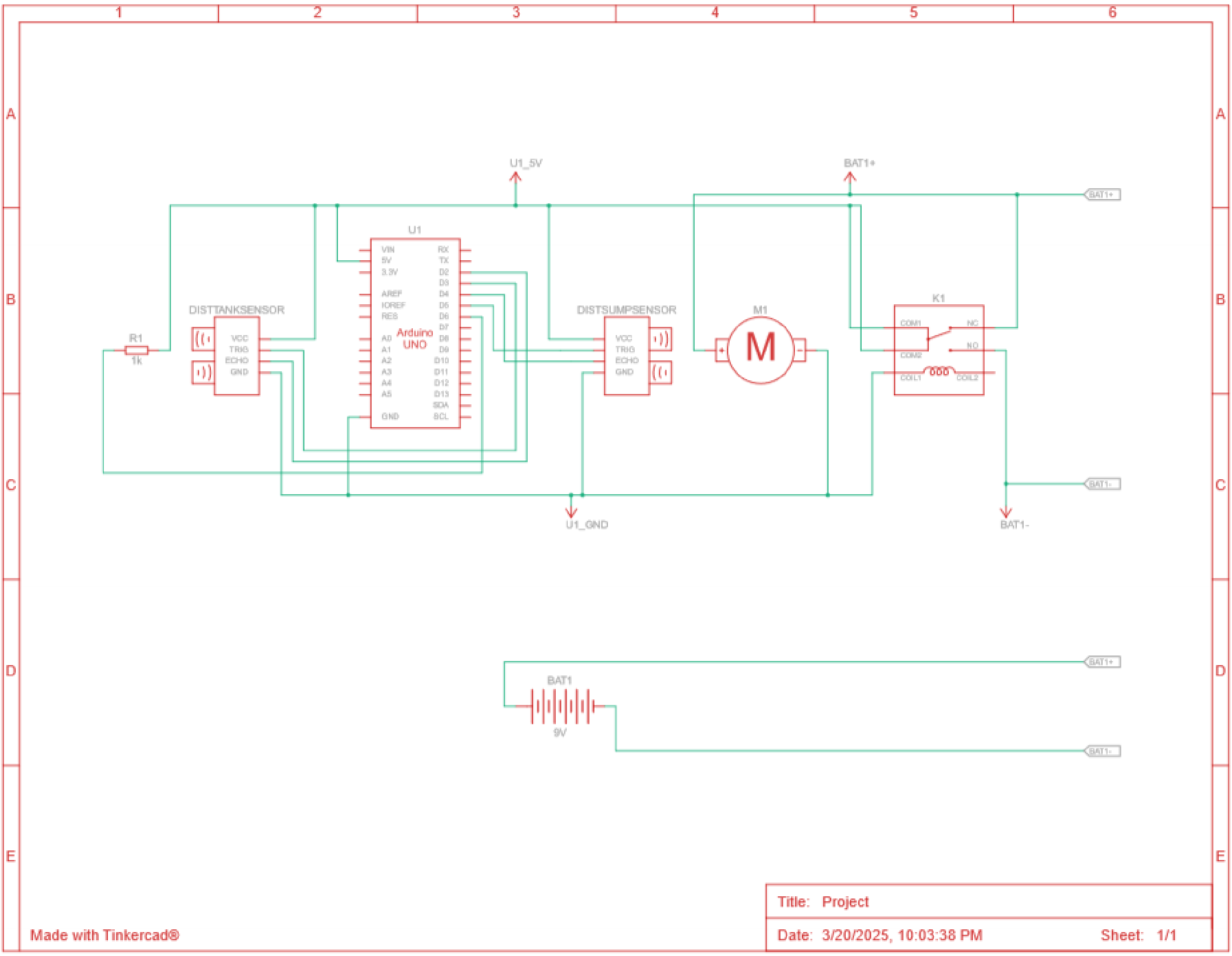
Simulation:

Implemented the model in TINKERCAD, in which simulation has been done with the use of components like Aurdino Uno R3, two ultrasonic distance sensor, DC motor, relay SPDT, battery(9v), resistor(1kΩ).

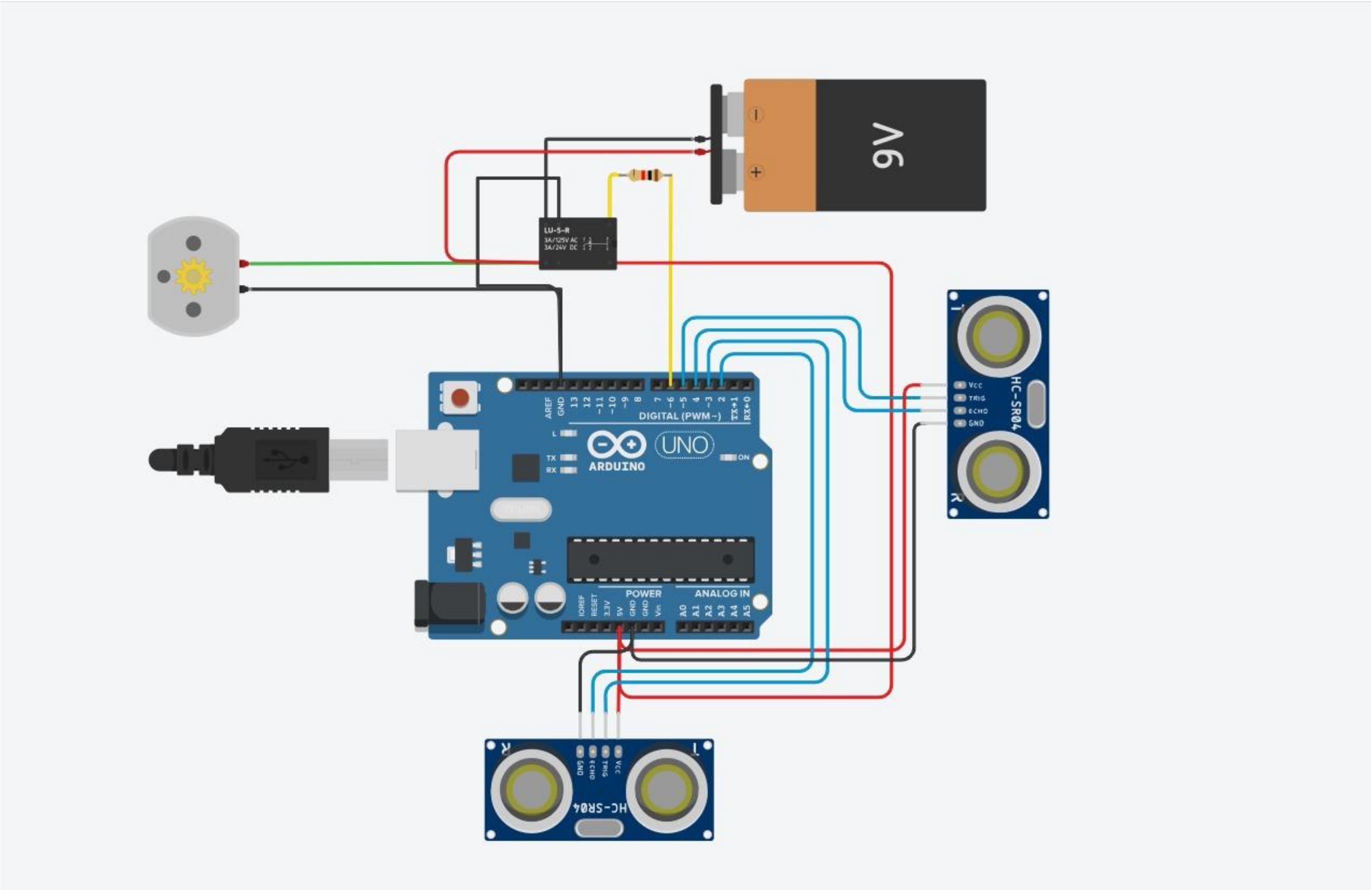
Software/code implementation:

- When implementing the software aspects of an IoT-based water level monitoring and control system, utilizing tools like VS Code and the Java programming language offers a robust and versatile approach. Java's platform independence is particularly valuable in IoT, where diverse hardware and operating systems are common. Within VS Code, developers can establish a structured project, organizing Java classes for different functionalities. This includes modules handling the code connected to the sensors, establishing network communication, processing control logic.

CIRCUIT DIAGRAM:



SIMULATION:



CODE:

```
// Define Ultrasonic Sensor PinsA
#define TRIG_TANK 3
#define ECHO_TANK 2
#define TRIG_SUMP 5
#define ECHO_SUMP 4

// Define Relay for Motor Control
#define MOTOR_RELAY 6

// Define Thresholds (in cm)
const int TANK_LOW = 15;   // Adjust based on tank size
const int TANK_HIGH = 80;  // Adjust based on tank size
const int SUMP_LOW = 10;   // Adjust based on sump capacity

// Function to measure distance using Ultrasonic Sensor
long getDistance(int trigPin, int echoPin) {
   long total = 0;
```

```
  int readings = 5;  // Take 5 samples for better accuracy

  for (int i = 0; i < readings; i++) {
    digitalWrite(trigPin, LOW);
    delayMicroseconds(2);
    digitalWrite(trigPin, HIGH);
    delayMicroseconds(10);
    digitalWrite(trigPin, LOW);
    long duration = pulseIn(echoPin, HIGH);
    total += duration * 0.034 / 2;  // Convert to cm
    delay(10); // Small delay between readings
  }
  return total / readings;  // Return average value
}

void setup() {
  pinMode(TRIG_TANK, OUTPUT);
  pinMode(ECHO_TANK, INPUT);
  pinMode(TRIG_SUMP, OUTPUT);
  pinMode(ECHO_SUMP, INPUT);
  pinMode(MOTOR_RELAY, OUTPUT);
  digitalWrite(MOTOR_RELAY, LOW);  // Ensure motor is OFF at start
  Serial.begin(9600);
}

void loop() {
  long tankLevel = getDistance(TRIG_TANK, ECHO_TANK);
  long sumpLevel = getDistance(TRIG_SUMP, ECHO_SUMP);

  Serial.print("Tank Level: "); Serial.print(tankLevel); Serial.print(" cm, ");
  Serial.print("Sump Level: "); Serial.print(sumpLevel); Serial.println(" cm");

  // Turn ON Motor: If Tank Level is LOW and Sump Level is OK
  if (tankLevel <= TANK_LOW && sumpLevel > SUMP_LOW) {
    digitalWrite(MOTOR_RELAY, HIGH); // Turn ON Motor
    Serial.println("Motor ON");
  }

  // Turn OFF Motor: If Tank is Full OR Sump Level is too Low
  if (tankLevel >= TANK_HIGH || sumpLevel <= SUMP_LOW) {
    digitalWrite(MOTOR_RELAY, LOW); // Turn OFF Motor
    Serial.println("Motor OFF");
  }

  delay(2000); // Wait before next reading
}
```

CHAPTER 4: RESULTS AND DISCUSSION

RESULTS:

Serial Monitor

```
Tank Level: 85 cm, Sump Level: 22 cm
Motor OFF
Tank Level: 47 cm, Sump Level: 22 cm
Tank Level: 12 cm, Sump Level: 22 cm
Motor ON
Tank Level: 15 cm, Sump Level: 22 cm
Motor ON
Tank Level: 15 cm, Sump Level: 22 cm
Motor ON
```

The serial monitor output shows the real-time tank and sump water levels and the corresponding motor status (ON/OFF) based on predefined conditions. The system is successfully detecting changes in the water level and controlling the motor accordingly. When the tank level is high (85 cm), the motor is OFF as the tank does not require water.

- As the tank level decreases (47 cm → 12 cm), the motor is turned ON to pump water from the sump.
- The motor remains ON as the tank level remains low (15 cm), ensuring water is being refilled.
- The sump level is constant at 22 cm, indicating that sufficient water is available for pumping.

DISCUSSION:

System Functionality:

- The system is correctly turning the motor ON when the tank water level is low.
- The motor remains OFF when the tank level is sufficient, preventing unnecessary operation.

Efficiency and Automation:

- The automated process eliminates the need for manual intervention.
- Continuous monitoring ensures the motor only operates when needed, saving energy.

Potential Improvements:

- The tank level changes could be tracked over time to optimize the refill process.
- A delay mechanism could be added to prevent frequent ON/OFF switching if the tank level fluctuates slightly.
- The system could include an alarm or notification feature to alert users when the sump water level gets too low.

CHAPTER 5: CONCLUSION

In essence, an IoT-based automated water level monitoring and controlling system delivers substantial improvements in water management. It provides precise, real-time monitoring and automated control, drastically reducing water waste and energy consumption. The system's data-driven approach facilitates informed decision-making, while its scalability and adaptability make it suitable for diverse applications. Ultimately, this technology fosters a more sustainable and efficient use of precious water resources, addressing critical challenges in water management.

Furthermore, this technology fosters a shift towards sustainable water usage by promoting a culture of conservation. The predictive maintenance capabilities minimize downtime and extend equipment lifespan, while integration with other smart systems creates a more efficient ecosystem. Ultimately, the widespread adoption of IoT-based water level monitoring contributes to more resilient water infrastructure, particularly in regions facing water scarcity, and empowers users with the tools to manage this vital resource responsibly.

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