

Introduction

The **Home Automation System** is designed to automate and simplify the management of key household appliances, such as water pumps, lighting, and ceiling fans, while ensuring safety through real-time monitoring and fault detection. The system provides users with the flexibility to control and monitor their home environment through various interfaces, including a mobile app, IR remote, and manual switches. The mobile control aspect of the system is powered by the **Blynk App**, allowing for convenient remote operation from anywhere.

This system is built around multiple microcontrollers, with the **NodeMCU ESP32** acting as the central controller responsible for coordinating the primary tasks, while **ESP8266** and **Arduino UNO** handle supplementary operations. Each microcontroller plays a critical role in ensuring efficient communication and functionality across different subsystems, such as water pump automation, lighting control, and fan speed adjustment. By automating these everyday tasks, the system helps reduce energy consumption, enhances convenience, and ensures seamless home management.

The **Blynk App** provides a user-friendly interface for remotely controlling and monitoring the system's features. Through the app, users can check real-time statuses of devices, adjust settings, and receive instant notifications about any system faults or safety concerns. This documentation provides a comprehensive overview of the Home Automation System, detailing its features, components, and operational workflow, as well as future enhancements, to serve as a complete guide for both end users and developers.

System Overview

The **Home Automation System** is a multi-functional, microcontroller-based platform that automates essential household tasks and provides the homeowner with remote and local control over critical appliances. It consists of three key subsystems: **Water Pump Control**, **Lighting Control**, and **Ceiling Fan Control**, all designed to work in tandem for a smarter, more efficient home environment.

➤ **Water Pump Control System:**

The water pump subsystem manages the operation of two 220-volt induction water pumps, automating pump activation based on water levels, time schedules, and seasonal adjustments. The system prevents manual intervention by offering automated, remote, and local pump control options. The system not only ensures proper water management but also incorporates safety features like pump shutdown during faults, and power-outage operation through an independent circuit.

➤ **Lighting Control System:**

The lighting control subsystem manages home lighting, providing flexible operation through mobile app control, manual switches, and IR remotes. This enables homeowners to manage their lights remotely, reducing energy consumption and enhancing convenience.

➤ **Ceiling Fan Control System:**

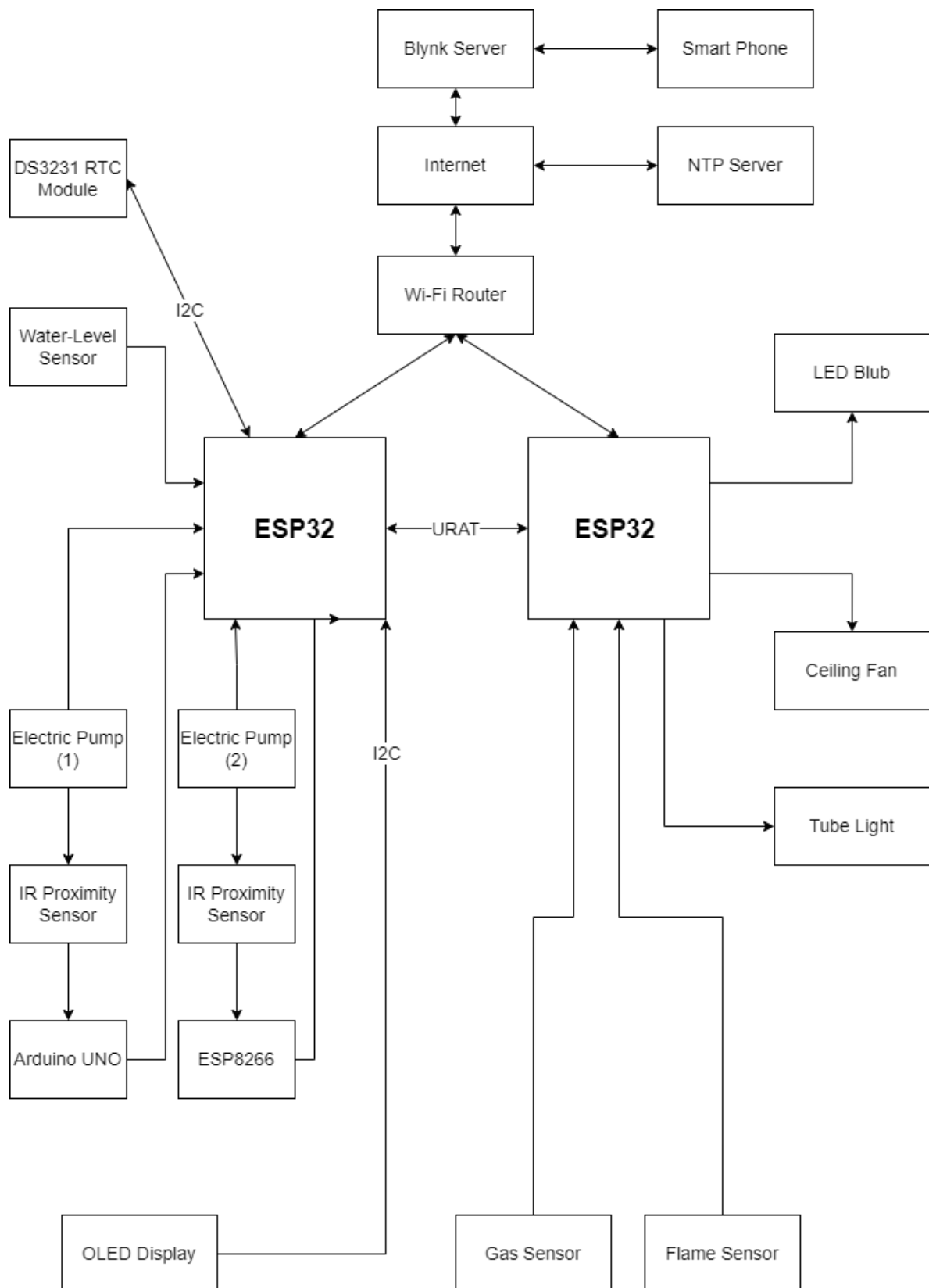
This subsystem provides versatile control over both BLDC and induction ceiling fans, allowing users to adjust fan speed and operation type. Fans can be controlled through manual switches, the mobile app, or an IR remote, offering flexible control options for the user.

➤ **Safety and Fault Detection:**

The system's built-in safety features ensure reliable operation by continuously monitoring the status of the water pumps, lighting, and fans. In case of faults or hazardous conditions, such as a pump failure or fire detection, the system automatically notifies the user via the mobile app and email, and initiates necessary actions, such as shutting down the relevant subsystem.

The **Home Automation System** seamlessly integrates all these subsystems to provide a robust solution for modern home management, ensuring safety, convenience, and energy efficiency.

Block Diagram



System Features

1. Pump Control System Features

The pump control system includes advanced features for managing and monitoring two 220-volt induction water pump motors, each with up to 1.5 horsepower. The system is designed for flexible operation, efficient control, and user convenience.

a) Water-Level-Based Operation:

- **Normal Water-Level Threshold:** Pumps are set to automatically turn on when the water level reaches 23%.

b) Time-Based Operation:

- **Daytime Operation (8:00 AM - 12:59 PM):**
 - The pump will activate if the water level reaches 23%.
- **Afternoon Operation (2:46 PM - 9:29 PM):**
 - The pump will activate if the water level reaches 23%.
- **Early Afternoon Operation (1:00 PM - 2:45 PM):**
 - The pump will activate if the water level reaches 38% (higher than the normal threshold of 23%).
- **Night-time Operation (9:30 PM - 11:30 PM):**
 - The pump will activate if the water level reaches 38% (higher than the normal threshold of 23%).

c) Seasonal Adjustments:

- **Winter Night-time Operation:**
 - To minimize disturbance from pump noise during the night, the system will check if any pumps are running after 11:30 PM.
 - If any pump is detected running after this time, the system will automatically turn off the pumps.

d) Device Specifications:

- **Pump Motors:** The system can control two 220-volt induction water pump motors, each with a maximum power rating of 1.5 horsepower.

e) Control Methods:

- **Mobile App:** Pumps can be operated remotely via a mobile application.
- **Manual Switches:** Pumps can be controlled using manual switches on the main control panel.
- **IR Remote:** Pumps can be operated using a pre-configured IR remote control.

f) Water-Level Display:

The system continuously monitors the water level in the tank at regular intervals of 2 minutes, ensuring accurate and up-to-date information on the water supply. Users can view the current water level through two interfaces:

- **Mobile App:** The water level is displayed in real-time on the mobile application, allowing users to remotely monitor the status of the tank from anywhere.
- **Main Control Panel:** The water level is also shown on an OLED display located on the main control panel, providing immediate visual feedback when operating the system locally.

This dual-display approach ensures that users are always informed of the water levels, whether they are at home or accessing the system remotely.

g) Default and Non-Default Pump Operation:

- **Default Pump:**
 - One pump can be set as the default pump, which will automatically start whenever the water level reaches a pre-defined low level.
- **Non-Default Pump Operation:**
 - To prevent air-lock or loss of priming, the system will activate the non-default pump once every 24 hours.
 - The non-default pump will start when the water level reaches a certain low threshold and will be turned off automatically when the water level rises by one level. Subsequently, the default pump will activate to fill the remaining tank.

h) Pump Disable Feature:

➤ **Manual Disabling:**

- Any of the two pumps can be disabled from the main control panel board if needed.

i) Power Outage Water-Level Check:

➤ **LED Indicator:**

- Users can check the current water level using LEDs on the main control panel by pressing a designated switch.
- This feature operates on a separate 9-volt battery circuit, ensuring functionality even when the main power is out.

j) Night-time Pump Activation Restriction:

➤ **Post-11:30 PM Restriction:**

- To avoid sound disturbance at night, the system will not start any pump after 11:30 PM, even if the water tank is empty.

2. Home Lighting Control Features

The home lighting control system allows for flexible management of lighting within the home, specifically for one tube light and one electric bulb.

Control Methods:

- **Mobile App:** Lights can be operated remotely via a mobile application.
- **Manual Switches:** Lights can be controlled using manual switches located in the home.
- **IR Remote:** Lights can be operated using a pre-configured IR remote control.

3. Ceiling Fan Control Features

The ceiling fan control system provides versatile options for managing both BLDC and induction ceiling fans.

a) Fan Types:

- **BLDC Ceiling Fan:**
 - Operates with a simple on/off control (does not support external regulator).
- **Induction Ceiling Fan:**
 - Controlled using a 6-step regulator to adjust fan speed.

b) Manual Changeover Switch:

- **Fan Type Selection:**
 - A manual changeover switch on the main control panel allows users to select the fan type (BLDC or Induction) and adjust the corresponding control settings.

c) Control Methods:

- **Mobile App:** Fans can be operated remotely via a mobile application.
- **Manual Switches:** Fans can be controlled using manual switches.
- **IR Remote:** Fans can be operated using a pre-configured IR remote control.

Safety Features

The system includes robust safety mechanisms to monitor pumps and sensors, taking immediate action in case of malfunctions or hazards to ensure reliable operation and home protection.

a) **Power Supply and Motor Monitoring:**

- The system continuously monitors the power supply to the electric water pumps and ensures the motors are functioning correctly.

b) **Fail-Safe Pump Shutdown:**

- **Normal Operation:** A switch located in the water tank automatically cuts off power to the pump when the tank is full.
- **Microcontroller Backup:** If the tank switch fails to operate, the microcontroller will cut off the power supply to the pump after a delay. Users will be notified of this issue through the mobile app and via email.

c) **Time Synchronization:**

- To address potential timing shifts caused by environmental factors, the system retrieves and updates time from an NTP server every 24 hours.

d) **Fire and Smoke Detection:**

- **Sensors:** Equipped with flame and smoke sensors (MQ2) to detect fire and smoke.
- **Response:** If fire or smoke is detected:
 - The system will turn off any active pump after a 4-second delay.
 - Pump automation will be disabled, preventing any pump from turning on until the issue is resolved.

e) **Networked Fire and Smoke Detection:**

- **Microcontroller Network:** The system is connected with other microcontrollers spread throughout the house, which are used to detect fire and smoke.
- **Communication Method:** Microcontrollers use the ESP-NOW communication method to relay information.
- **Response:** If any remote microcontroller detects fire or smoke in any room, it communicates this to the main pump microcontroller via ESP-NOW. The main microcontroller will then stop any active pump after a 4-second delay.

f) **Remote Management for Malfunction:**

- **Blynk App Control:** If no one is at home and the device is malfunctioning or needs to be put into deep sleep for an indefinite period, it can be managed using the Blynk app. This allows for forced restart or deep sleep modes to be activated remotely.

Fault Detection & Status Monitoring

The system monitors the status of the pumps, water level, and other features, and autonomously detects faults. Errors or faults are displayed on the OLED display on the Control Panel and the Blynk app, and users are notified via email. Designed for self-diagnosis, the system makes decisions based on its fault detection to ensure reliable operation.

a) Pump Start Failure:

- **Description:** The system checks if the pump turns on after receiving power, whether manually or automatically. If the pump does not turn on, it indicates a problem with the pump start mechanism.
- **Indicators:**
 - **OLED Display:** "PUMP START ERROR"
 - **Blynk App:** "PUMP START ERROR"
 - **Notification:** Users will be informed via email.

b) Tank Switch Malfunction:

- **Description:** If a pump is running and the water tank is full, but the tank full switch fails to stop the pump, the microcontroller will forcefully stop the pump after a few minutes.
- **Indicators:**
 - **OLED Display:** "PUMP STOP ERROR"
 - **Blynk App:** "TANK SWITCH ERROR"
 - **Notification:** Users will be informed via email.
- **Impact:** Pump automation will be disabled until the issue is resolved.

c) **Pump Motor Spin Fault:**

- **Description:** If a pump is on and receiving electricity but the motor is not spinning, the microcontroller will stop the pump after 4 seconds to prevent damage.
- **Indicators:**
 - **OLED Display:** "PUMP SPINNING ERROR"
 - **Blynk App:** "PUMP NOT SPINNING"
 - **Notification:** Users will be informed via email.
- **Impact:** Only the faulty pump will be disabled; the other pump will continue operating normally.

d) **Dry Run Detection:**

- **Description:** If a pump is running but the water level in the tank does not rise or decreases slowly over 15 minutes, indicating a dry run, the microcontroller will immediately stop the pump.
- **Indicators:**
 - **OLED Display:** "PUMP DRY RUN"
 - **Blynk App:** "PUMP DRY RUN"
 - **Notification:** Users will be informed via email.
- **Impact:** Only the faulty pump will be disabled; the other pump will continue operating normally.

e) **Sensor Fault:**

- **Description:** If the system cannot accurately read the water level from the tank, it indicates a fault in the water level sensors.
- **Indicators:**
 - **OLED Display:** "LEVEL SENSOR ERROR"
 - **Blynk App:** "LEVEL SENSOR ERROR"
 - **Notification:** Users will be informed via email.
- **Impact:** Pump automation will be disabled until the issue is resolved.

f) Water Level Wire Error:

- **Description:** If the water level sensor wire becomes disconnected, it indicates a wiring issue.
- **Indicators:**
 - **OLED Display:** "LEVEL WIRE ERROR"
 - **Blynk App:** "LEVEL WIRE ERROR"
 - **Notification:** Users will be informed via email.
- **Handling Procedure:**
 - **Active Pump:** If a pump is active, the microcontroller will use the last known water level to determine how long to keep the pump running.
 - **Operation:** The pump will continue operating until the water level reaches the desired level. If the level wire issue persists after reaching this level, the microcontroller will forcefully stop the pump.
 - **Monitoring:** The microcontroller will repeatedly attempt to check the water level. If it successfully retrieves the water level again, the pump will resume normal operation.

g) Water Level Sensor Power Supply Failure:

- **Description:** If the separate power supply used to measure the water level is not functioning, this indicates a failure in the water level sensor's power source.
- **Indicators:**
 - **OLED Display:** "WATER ADAPTER ERROR"
 - **Blynk App:** "LEVEL ADAPTER ERROR"
 - **Notification:** Users will be informed via email.
- **Impact:** Pump automation will be disabled until the issue is resolved.

h) Real-Time Clock (RTC) Failure:

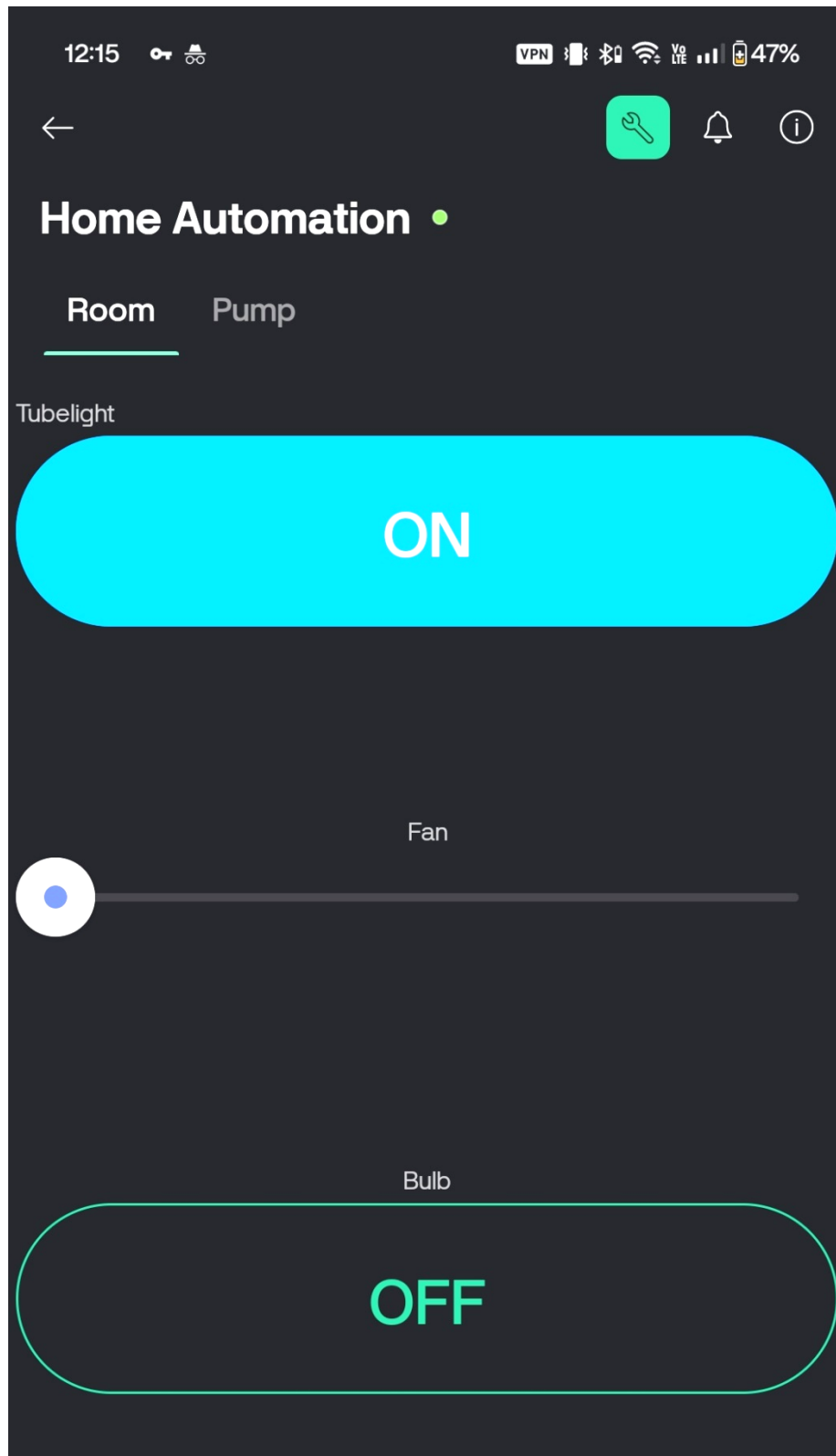
- **Description:** If the DS3231 Real Time Clock Module gets disconnected or fails, this fault will be indicated.
- **Indicators:**
 - **OLED Display:** "CLOCK ERROR"
 - **Blynk App:** "RTC ERROR"
 - **Notification:** Users will be informed via email.
- **Impact:** Pump automation will be disabled until the issue is resolved.

i) GPIO Extender Board Failure:

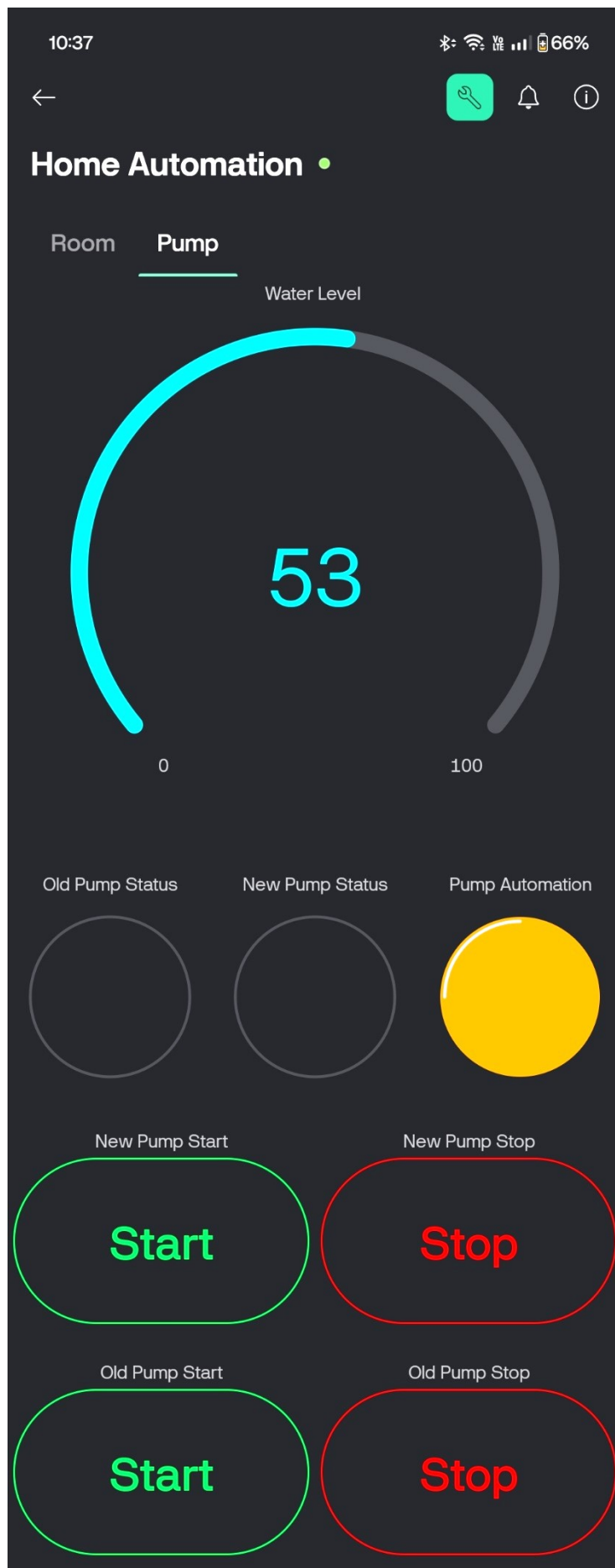
- **Description:** If one or both of the PCF8574 GPIO extender boards get disconnected or faulty, this fault will be indicated.
- **Indicators:**
 - **OLED Display:** "EXP BOARD ERROR"
 - **Blynk App:** "GPIO ERROR"
 - **Notification:** Users will be informed via email.
- **Impact:** Pump automation will be disabled until the issue is resolved.

Blynk App UI Design

1. First tab:



2. Second tab: (Divided into 3)



Level Wire Error



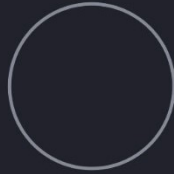
Tank Switch Error



Level Adapter Error



Old Motor Not Spinning



New Motor Not Spinning



Old Pump Dry Run



New Pump Dry Run



Level Sensor Error



Old Pump Start Error



New Pump Start Error



RTC Error

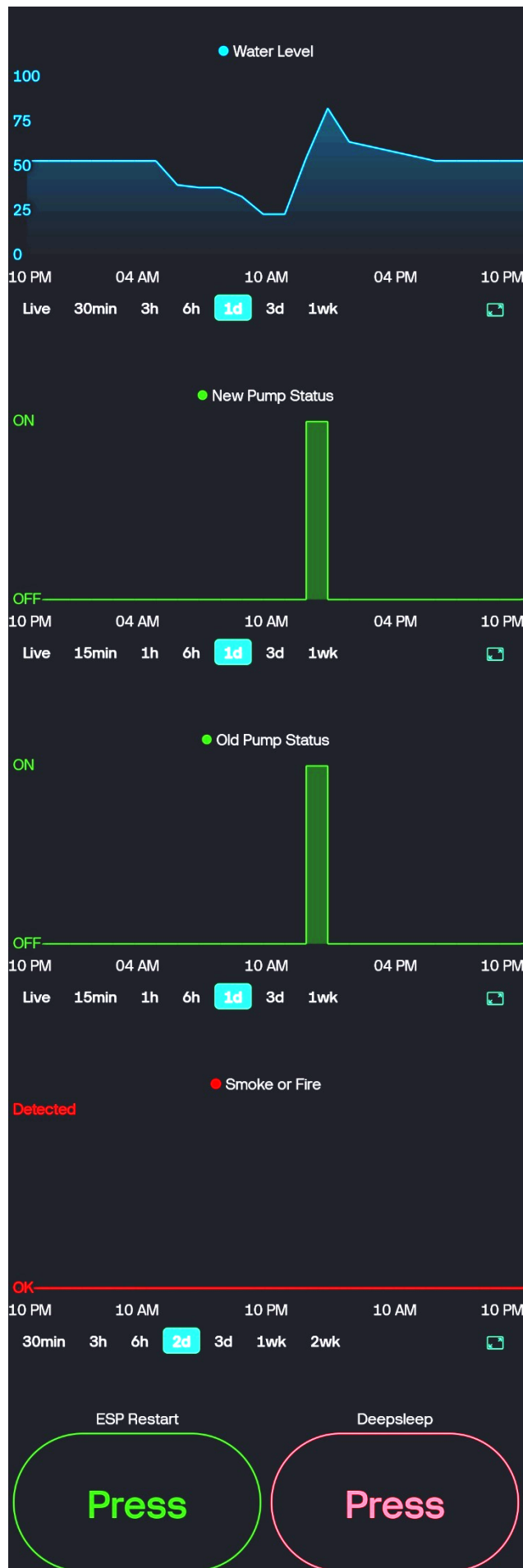


GPIO Error

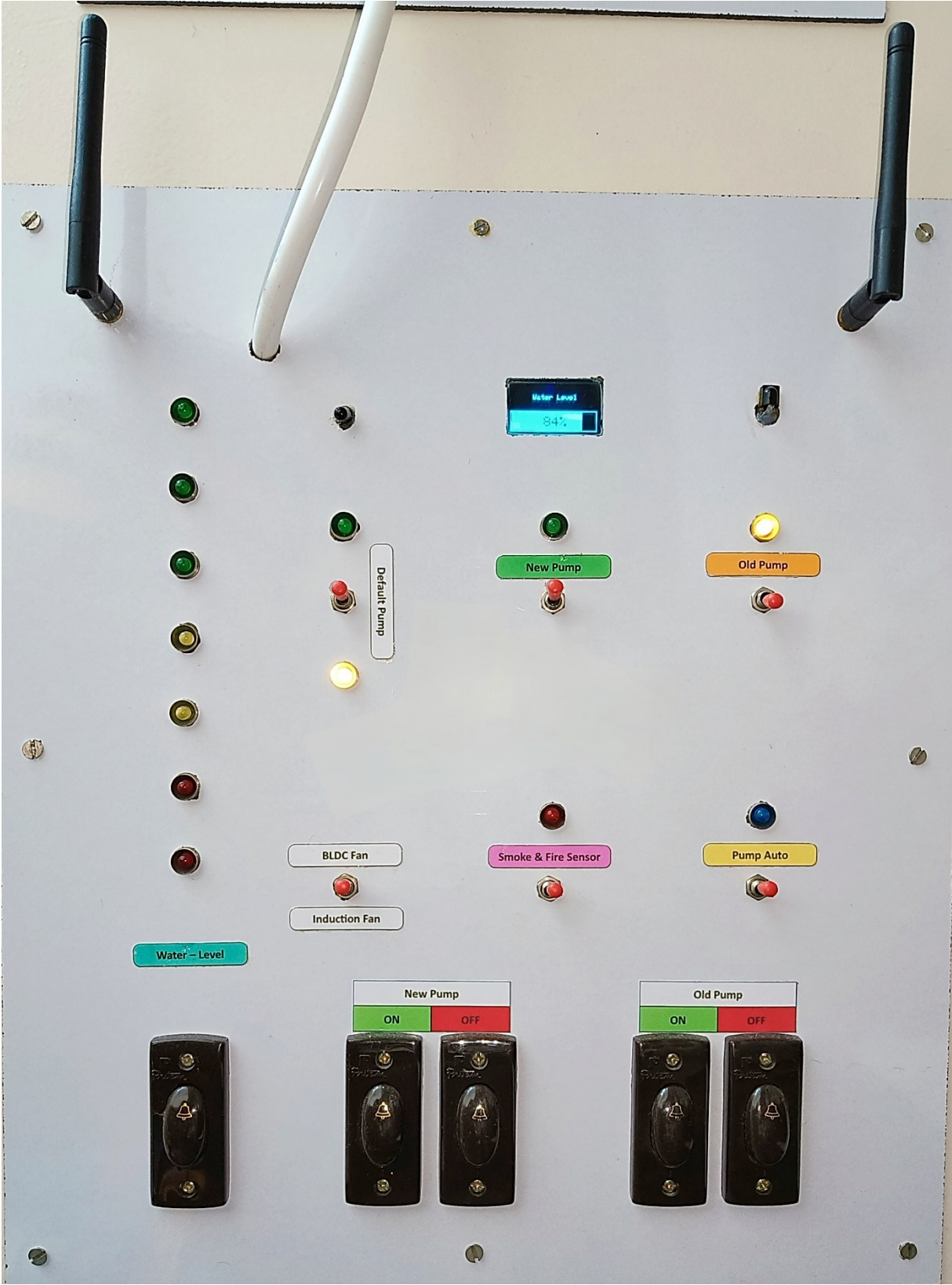


Smoke or Fire

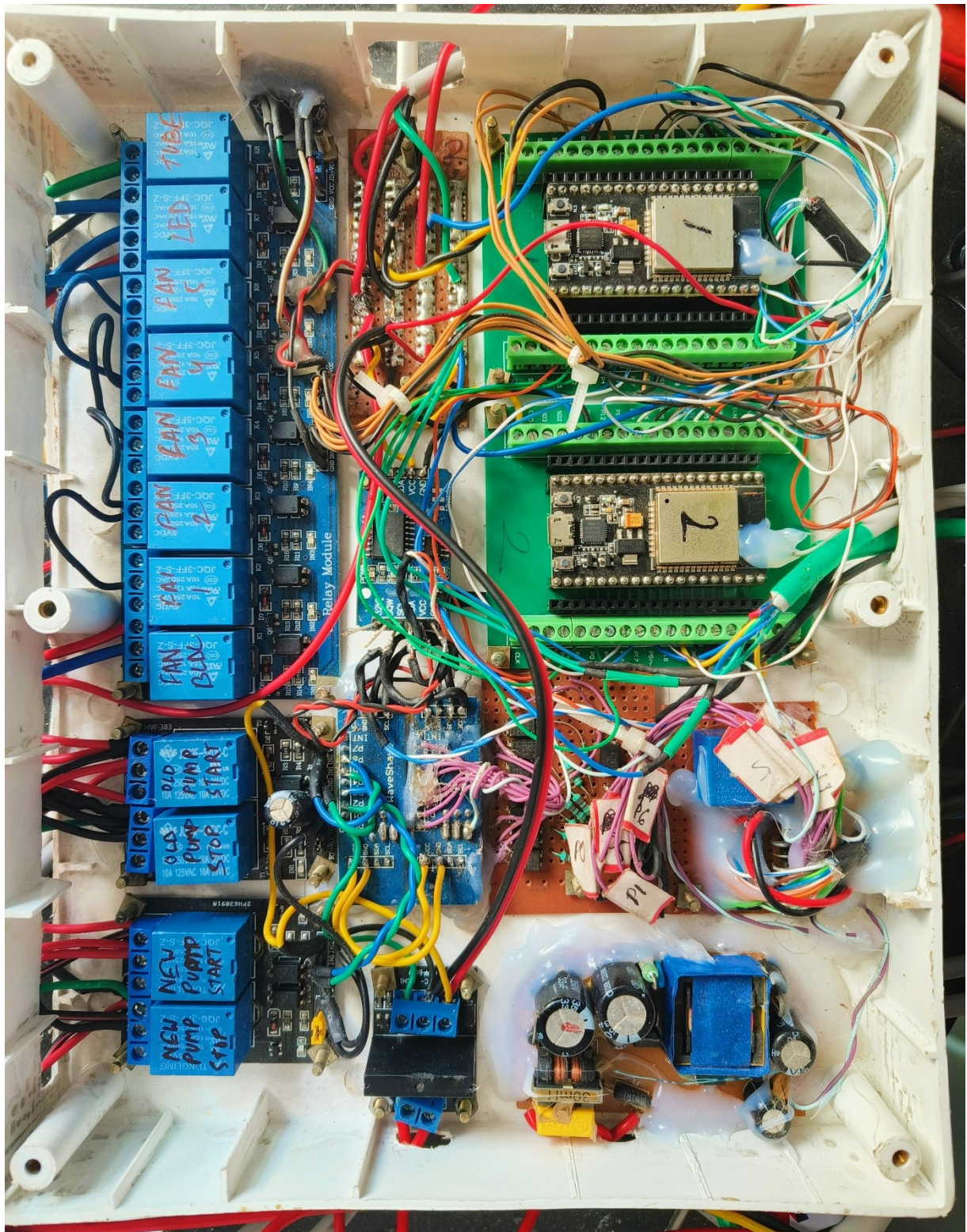




Control Panel



Core Hardware Assembly



Water-Level Sensor Unit



Future Scope

The **Home Automation System** has significant potential for future expansion and improvement. Several features and integrations could enhance its capabilities, including:

- **Smart Assistant Integration:** Adding compatibility with voice-controlled systems like Amazon Alexa and Google Home.
- **Energy Efficiency Monitoring:** Future upgrades could include detailed energy usage tracking for water pumps, lighting, and fans, enabling users to optimize their energy consumption.
- **Expanded Appliance Control:** Future versions of the system could integrate more home appliances, including kitchen devices, HVAC systems, and security systems.
- **Advanced Data Analytics:** Incorporating predictive analytics to forecast water and energy consumption patterns, helping users make informed decisions and optimize their resource usage.

Conclusion

The Home Automation System offers a versatile, intelligent solution designed to meet the demands of modern smart homes. It integrates seamless control over water pumps, lighting, and fans through multiple interfaces, including manual switches, mobile apps, and automated schedules. This ensures not only user convenience but also significant energy savings and efficiency.

Equipped with advanced safety protocols, such as fire and smoke detection, fail-safe pump shutdowns, and intercommunication between microcontrollers, the system actively safeguards the home environment. Its sophisticated fault detection mechanism identifies and addresses issues like pump malfunctions, sensor failures, and motor faults automatically, minimizing risks and preventing damage. Real-time alerts through OLED displays, the Blynk app, and email notifications ensure that users are constantly informed of system status, even when away from home.

The system's modular design, coupled with technologies like ESP-NOW communication, allows for easy expansion and adaptability. This future-proof architecture ensures that it can evolve alongside the growing needs of smart homes, offering a secure, efficient, and intelligent way to manage daily operations.

By blending automation, safety, and scalability, the Home Automation System delivers both peace of mind and modern convenience, making it an indispensable addition to any household.