IoT-ENABLED PLANT MONITORING SYSTEM USING ESP32-S3 AND BLYNK APPLICATION

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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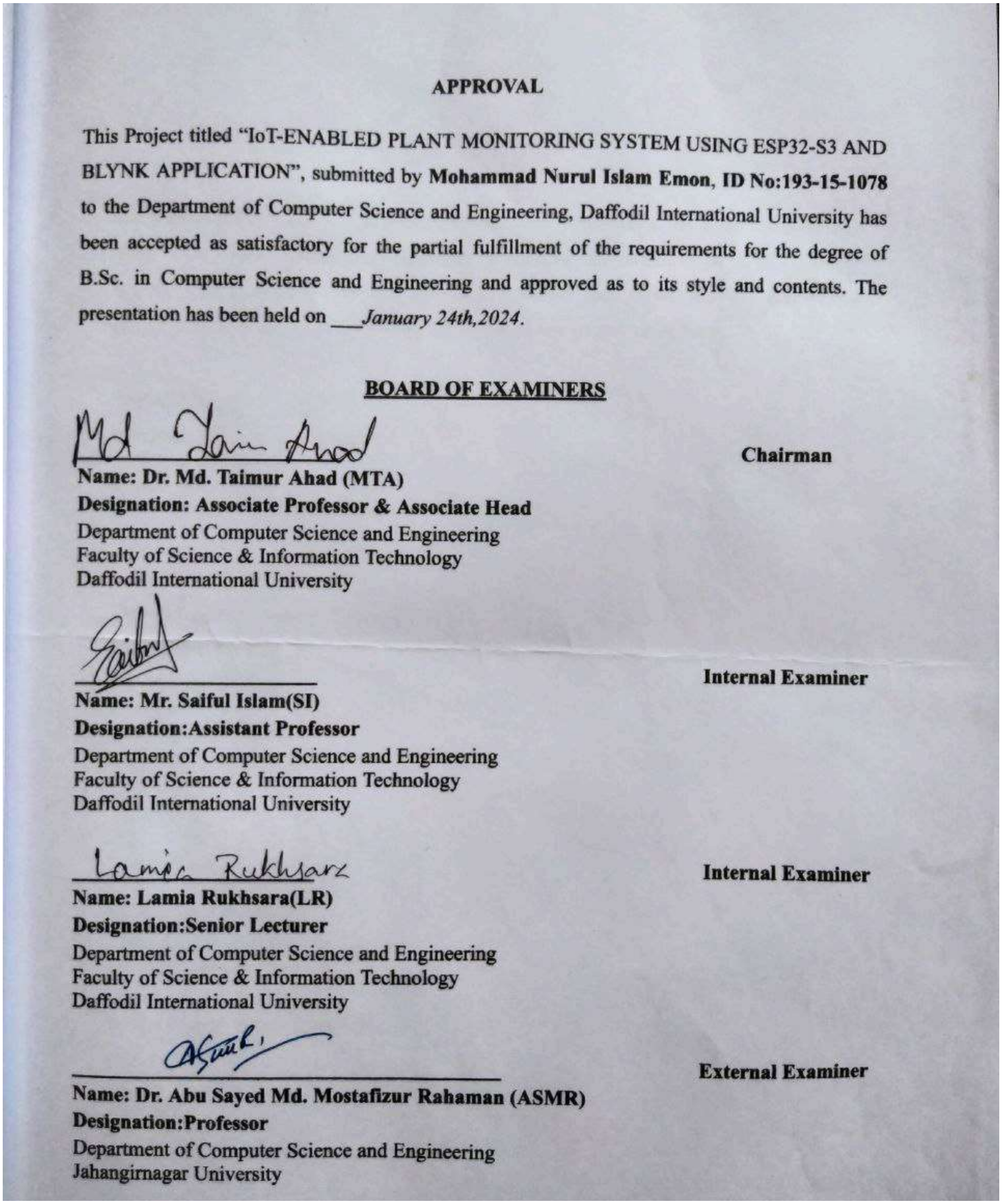
DHAKA, BANGLADESH

JANUARY 2024



APPROVAL

This Project titled "IoT-ENABLED PLANT MONITORING SYSTEM USING ESP32-S3 AND BLYNK APPLICATION", submitted by **Mohammad Nurul Islam Emon**, **ID No:193-15-1078** to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on ___*January 24th,2024*.

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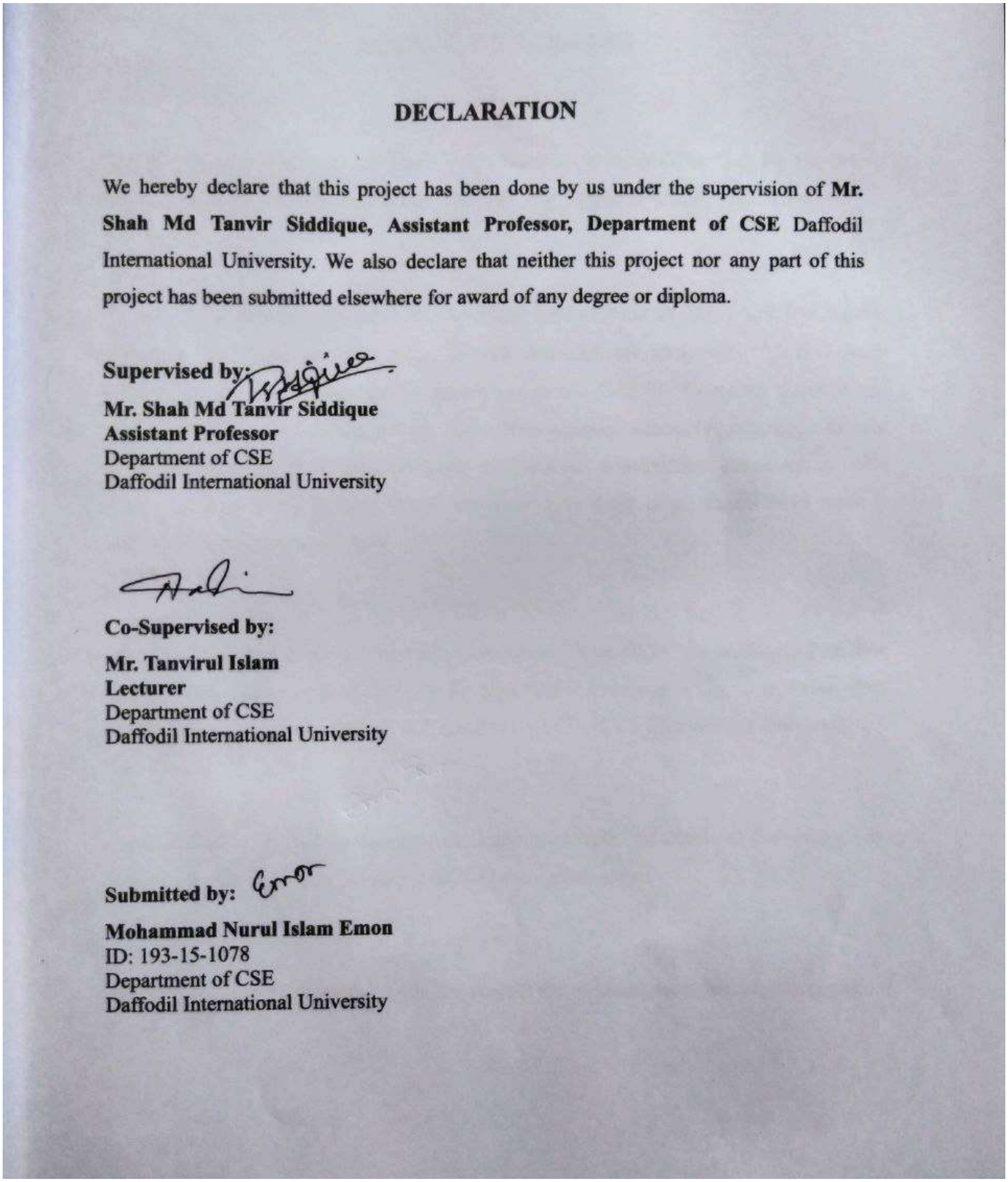

DECLARATION

We hereby declare that this project has been done by us under the supervision of **Mr. Shah Md Tanvir Siddique, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGEMENT

First, we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes it possible to complete the final year project/internship successfully.

We are really grateful and wish our profound indebtedness to **Mr. Shah Md Tanvir Siddique**, **Department of CSE**, Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of “Computer Science and Engineering” to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

We would like to express our heartiest gratitude to Professor **Dr. Sheak Rashed Haider Noori,** Head**,** Department of CSE, for his kind help to finish our project and also to other faculty members and the staff of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discussion while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

We are living in a period of wisdom and technology where we can't indeed suppose a single day without modern technology. This project, titled 'IoT-Enabled Plant Monitoring System Using ESP32-S3 and Blynk Application,' aims to spearhead a technological revolution in precision agriculture. Utilizing the ESP32-S3 microcontroller and seamlessly integrating it with Blynk operations, the system provides real-time monitoring and automated plant care through a network of sensors and actuators.The primary objective of this system is to develop a low-power, efficient embedded system capable of remotely controlling and managing all parameters essential for plant care. Leveraging the Internet, the system integrates with the Firebase database to store sensor raw data for extended periods, facilitating future research. Additionally, the system includes a water level sensor in the main water tank, notifying users via email in case of low water situations.Furthermore, the system accurately detects temperature, moisture, and soil hygrometer humidity, triggering email alerts during extreme weather conditions or low moisture levels. The project addresses the challenges in agriculture by monitoring and controlling environmental conditions such as temperature, relative humidity, and soil moisture. The sensor data is then presented as graphical statistics on a web page accessible from anywhere in the world. By optimizing resource usage and enabling remote monitoring, this project aims to contribute to the adoption of sustainable farming practices, making it possible for users to remotely control and monitor their plants, ensuring their well-being even when they are away from home or town.

Keywords: Smart Agriculture, Smart Garden, IoT(Internet of Things), ESP32-S3, Automation, Energy Efficiency, Real-time service, Blynk control, Firebase Real-time Database

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Technology plays a crucial role in optimizing plant care and monitoring in contemporary agricultural practices. This project introduces a remarkable Plant Monitoring System that utilizes the latest powerful ESP32-S3 microcontroller, along with various sensors and actuators, to provide a comprehensive solution for monitoring and controlling the essential conditions for plant growth.

The Internet of Things (IoT) has transformed the way we interact with the physical modern world by enabling real-time data collection and remote control. This project extends these incredible benefits to plant care, addressing the need for efficient and automated monitoring systems.

1.2 Motivation

The motivation for this project stems from personal experiences where plants faced untimely deaths due to inadequate watering or, conversely, suffered from overwatering during sunlight exposure. Recognizing the critical impact of these issues on plant health, the project aims to provide a solution through a cost-effective and user-friendly plant monitoring system. By enabling remote monitoring and management, the system strives to prevent such incidents by ensuring timely and optimized watering practices, ultimately contributing to the well-being of plants in diverse environmental conditions.

1.3 Objectives

Designing a comprehensive system with the primary goal of delivering instant data on critical parameters—air temperature, humidity percentage, tank water level, and soil moisture percentage. Empowering users to remotely control the water pump based on real-time data for precise plant irrigation, preventing issues of both under-watering and overwatering. Leveraging the user-friendly Blynk 2.0 application, integrated with ESP32-S3, to provide an intuitive interface for efficient system monitoring and control. Additionally, implementing a feature for storing historical data in the Firebase real-time database facilitates thorough analysis and trend identification for continuous improvement.

1.4 Expected output

Upon completion, the project is expected to deliver many things such as a fully functional Plant Monitoring System capable of monitoring and controlling essential parameters like Surrounding temperature, humidity percentage in nearby air, water level and percentage of water in tank, and moisture percentage in soil, beside a responsive and intuitive Blynk 2.0 application interface for remote access and control and data logging functionality to capture and store historical data in firebase Realtime database for further analysis and research.

1.5 Estimated Cost:

Table1.6: Estimated cost

No of Equipment	Name of Equipment	Cost (BDT)
1	ESP32-S3 Wroom-1	1350
2	DHT11	150
3	YL-69 Soil Hygrometer Humidity	120
4	Capacitive Soil Moisture Sensor	280
5	1 channel 5v relay module	70
6	7-segment cathode display	12
7	Ultrasonic Sonar Sensor HC-SO4	93
8	Water pump 4v	150

9	push button	5
10	4-led	20
11	Medium Breadboard	90
12	DC regulator 5v and 3v	100
13	jumper wire-40 pc set	100
14	12v power adapter	500
	Total	**3050**

1.6 Report Layout:

This report is structured to provide a comprehensive understanding of the project. The subsequent chapters are organized as follows:

Chapter 2: background study: A review of relevant literature and existing technologies in the field of IoT-based plant monitoring systems. Chapter 3: System Requirement: Detailed explanation of the hardware and software architecture of the plant monitoring system. Chapter 4: Design: A step-by-step guide to the development process, including component selection, integration, and programming. Chapter 5: Implementation and Results: Presentation and analysis of the results obtained from the implemented system.
Chapter 6: Impact on society, environment, and ethical aspects of this project. Chapter 7: Conclusion: Summarization of key findings, lessons learned, and recommendations for future improvements. Appendix: Supplementary materials, such as code snippets, circuit diagrams, and additional documentation.

CHAPTER 2

BACKGROUND STUDY

2.1 Preliminaries

2.1.1 Internet of Things (IoT)

The Internet of Things, or IoT for short, is all about connecting everyday objects. By adding sensors, actuators, and communication capabilities to these objects, they can collect and share data. And in our project, we're using IoT to monitor and control a plant monitoring system in real time.

2.1.2 ESP32-S3 WROOM1 Microcontroller

Now, let's talk about the nifty little device at the heart of our plant monitoring system: the ESP32-S3 which is an upgraded and newer variant of the ESP32 series, and it features a RISC-V processor core, featuring a more powerful CPU and additional peripherals. This microcontroller is like the brain of the operation, with built-in Wi-Fi and Bluetooth capabilities.

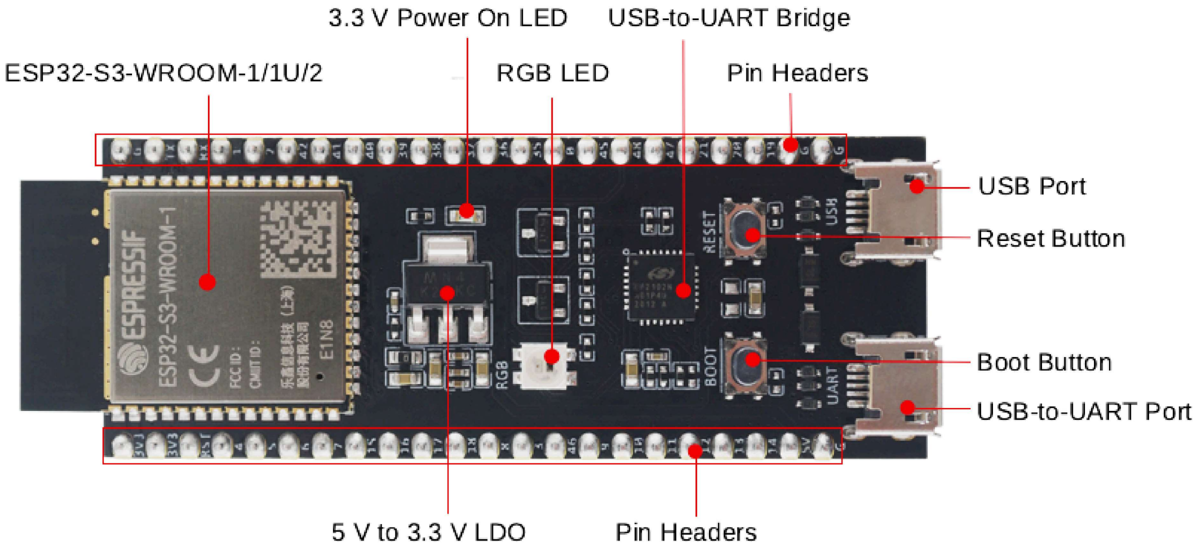


fig2.1: ESP32-S3 component overview

The ESP32-S3 microcontroller showcases an impressive array of features within its CPU and On-Chip Memory, bolstering the system's processing capabilities.

1. **Microprocessor:**

Within the ESP32-S3 series, lies a dual-core 32-bit LX7 microprocessor. It comes embedded with a single-precision FPU, ensuring efficient processing and responsiveness. Operating at speeds of up to 240 MHz.

2. **ROM (Read-Only Memory):**

To sustain vital firmware and core system functionalities, the microcontroller encompasses 384 KB of ROM. This storage capacity is crucial for seamless operations.

3. **SRAM (Static Random-Access Memory):**

With a robust 512 KB of SRAM, the ESP32-S3 proves invaluable as it facilitates swift and efficient data access during runtime.

4. **RTC SRAM:**

In a bid to promote low-power operation and data retention during power-off periods, an additional 16 KB of SRAM has been exclusively allocated to the Real-Time Clock (RTC) module.

5. **PSRAM (Pseudo-Static RAM):**

When it comes to demanding data-intensive applications, the ESP32-S3 emerges triumphant with its support for up to 16 MB of PSRAM.

6. **Wi-Fi Standard:**

Compliant with 802.11 b/g/n Wi-Fi standards, the ESP32-S3 opens up possibilities for wireless connectivity, facilitating seamless data exchange and remote-control functionalities. With bit rates reaching up to 150 Mbps for 802.11n, swift data transmission is guaranteed. Operating within the frequency range of 2412 to 2484 MHz, the Wi-Fi channel remains dependable and efficient.

7. **Bluetooth LE:**

One of the standout features of the microcontroller is its compatibility with Bluetooth Low Energy (Bluetooth 5) and Bluetooth mesh, enabling optimized wireless communication.Bluetooth communication speeds range from 125 Kbps to 2 Mbps.

8. Power Supply:

Operating seamlessly within the voltage range of 3.0 to 3.6 V, the ESP32-S3 offers reliability and ease of use.

9. Operating Temperature:

Designed to excel in diverse environments, the ESP32-S3 thrives in temperatures ranging from -40 to 65 °C, making it versatile and adaptable.

10. Board Pin:

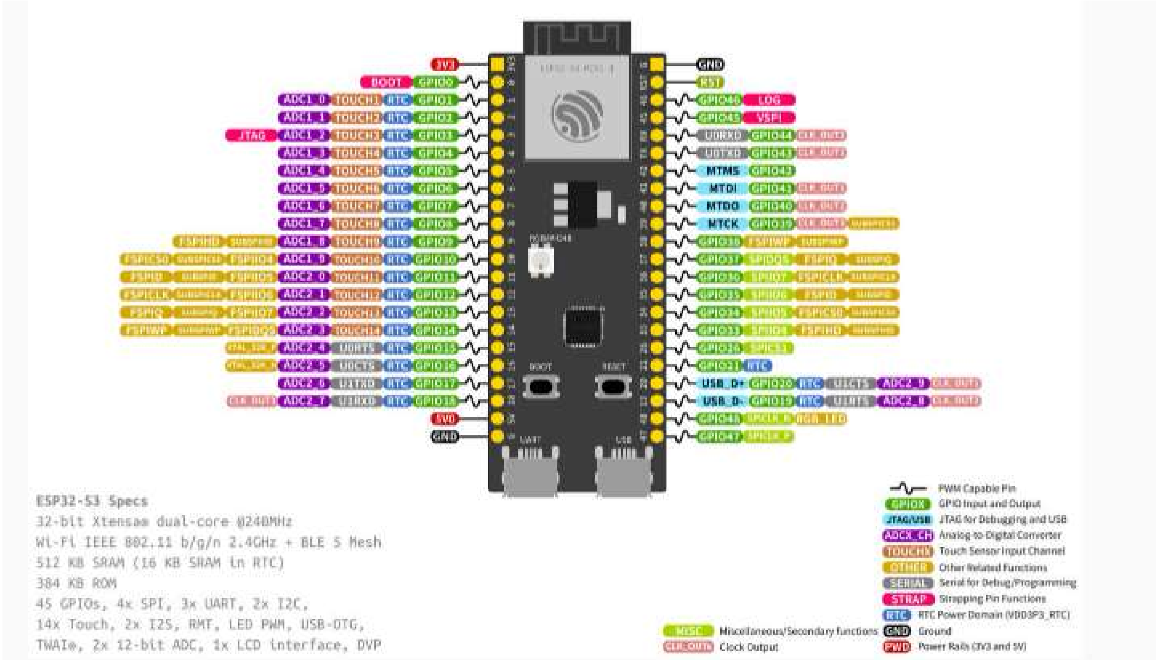


fig2.1: ESP32S3 pin layout

Facilitating smooth integration with external components, the ESP32S3-WROOM1 board boasts a comprehensive layout incorporating 44 pins. This ample quantity of pins presents an ideal opportunity to effortlessly incorporate multiple sensors and actuators into the projects.

2.1.3 Blynk Application

The monitoring and control of our plant monitoring system is a crucial task. And this is where the Blynk application comes into play. Blynk is a user-friendly platform that allows us to create customized IoT applications. In our specific case, we utilize Blynk to remotely monitor and control our plant monitoring system, alongside receiving triggered notifications. Blynk offers us convenient quick-start templates and even customizable templates for our plant monitoring project. The user interface it provides is simple and ensures an easy demonstration of our project.

2.1.4 Firebase Realtime Database

Firebase Realtime Database plays a crucial role in enhancing the functionality and capabilities of the smart plant monitoring system. By incorporating this technology, the system gains the ability to effectively manage and store data. The integration of the Firebase Realtime Database facilitates the real-time storage, retrieval, and synchronization of vital environmental data collected by the system's sensors. This entails the collection and recording of real-time data from a variety of sensors, such as those measuring soil moisture, temperature, and humidity. Through this integration, users can access the most recent and relevant data about their plants.

2.2 Related Works

- This project addresses prevalent challenges including unpredictable weather conditions, a shortage of labor, and the impact of global warming on crop production. The project recognizes the need for a comprehensive system to monitor crucial environmental factors such as air humidity, temperature, air quality index, and soil moisture using ESP8266. [1].

- The project aims to implement a state-of-the-art and cost-effective approach to remotely monitor solar plant performance using IoT. The system facilitates plant maintenance, problem diagnostics, and real-time monitoring to enhance the overall efficiency of solar energy production using microcontroller Arduino Atmega. [2].

- The proposed work focuses on remotely controlling applications located away from the central control station. Leveraging the internet and the Blynk server, the design establishes a sensor-based monitoring station near the electrical device. [3].

- The system focus is on monitoring and maintaining plant health by analyzing environmental factors using IoT technology. The paper proposes the integration of sensors, including DHT-11 and soil moisture sensors, to measure climatic conditions. Additionally, the system provides a nutrient solution to support plant growth by sprinkling water via a relay and solenoid valve, aligning with basic plant requirements using the Blynk IoT platform through the ESP-8266 Wi-Fi.[4].

2.3 Comparative Analysis

All projects share a common focus on utilizing IoT technologies for monitoring and control in different domains, including agriculture, solar energy, and remote device control.Different microcontrollers (ESP8266, Arduino Atmega) are used based on the project's requirements.On the other hand uniquely Highlighted the challenges of plant deaths due to both lack of timely watering and overwatering, emphasizing the optimization of plant care practices. Integration with Firebase for long-term data storage sets your project apart, facilitating future research purposes and trend analysis.The use of the ESP32-S3 microcontroller and the emphasis on a low-power embedded system adds uniqueness to your project's technical aspects**.**

2.4 Scope of the Problem

Now, let's talk about why we embarked on this project in the first place. Traditional plant monitoring methods have their limitations. They often lack real-time data, remote accessibility, and automated control features. Our IoT-enabled Plant Monitoring System is here to save the day. It provides an integrated and intelligent solution that takes care of all these limitations of traditional plant monitoring systems. Our proposed system is a very power efficient, low-cost system and remote monitoring and control as well save data for future research.

2.4 Challenges

2.4.1 Microcontroller Header pin

At first, the pins on the board were not soldered detachable as a result loose connections happen all the time. Moreover, without any reason certain pins on the board consistently remain in a high state. Specifically, pins 37, 38, 40, and 8 are affected.

2.4.2 Power Efficiency

One of the main challenges we faced was to ensure that our plant monitoring system consumed power efficiently. We had to think creatively and explore different strategies to optimize power usage, ensuring the system's longevity and durability.

2.4.3 Loose Wiring Connection Problems

Implementing the hardware components had its own share of challenges, particularly concerning loose wiring connections.

2.4.4 Lack of Resources

The adoption of the ESP32-S3 microcontroller, while offering advanced features, posed challenges in terms of resource availability. We needed to be resourceful and adapt to emerging technologies, acquiring comprehensive documentation, community support, and troubleshooting guidance for a relatively new microcontroller.

2.4.5 Lack of Suitable Library for ESP32-S3

ESP32S3 was released in October 2021 which is an upgraded variant of ESP32. It’s still in the development phase. So, the existing libraries designed for other ESP32 models may not be fully compatible with the ESP32-S3. This may result from potential variations in terms of hardware configurations and functionalities. Consequently, the smooth integration of sensors and components into the project can be hindered. Somehow, it’s perfectly run with the library made for ESP8266, an older variant.

CHAPTER 3

REQUIREMENT SPECIFICATION

3.1 Block Diagram

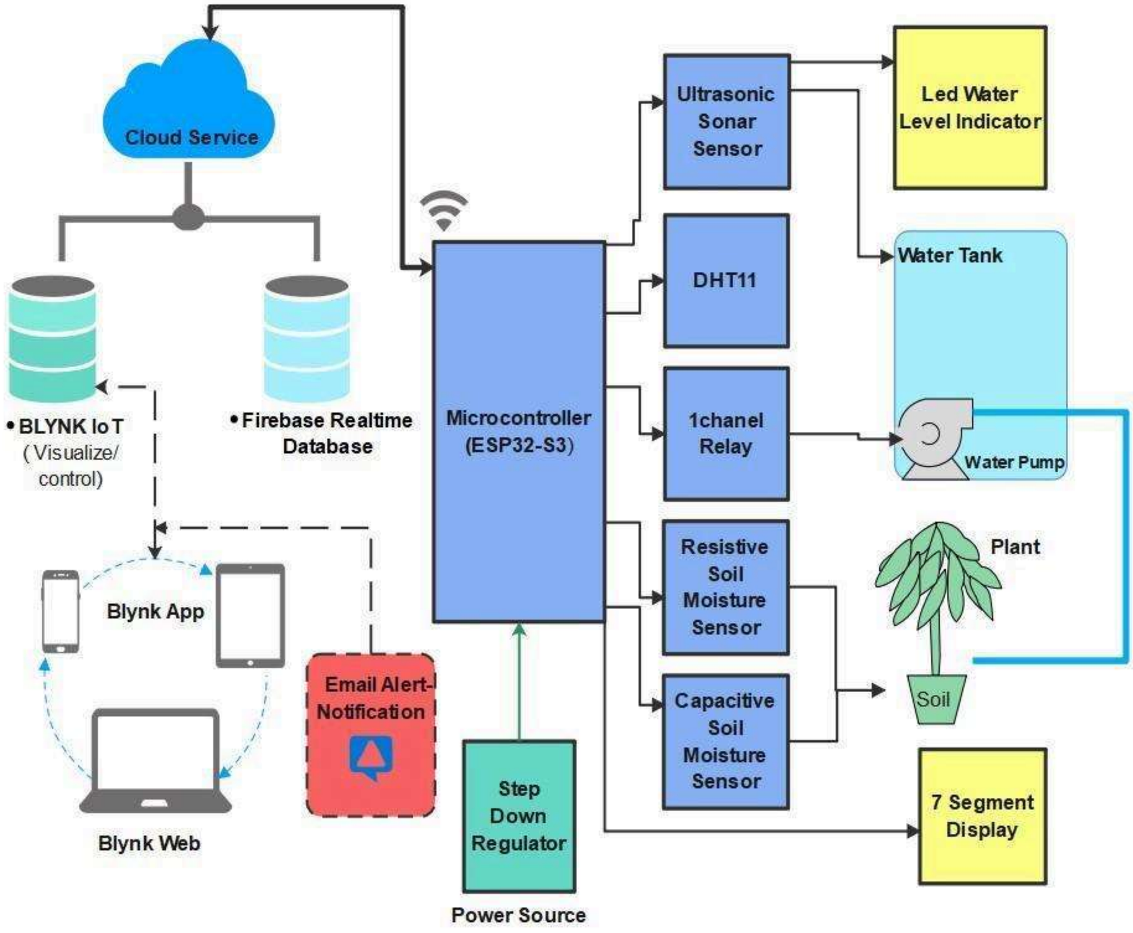


fig 3.1: Block diagram with ESP32-S3

3.2 Block diagram description

The ESP32-S3 collects data from various sensors, including soil moisture, temperature, and humidity sensors. Sensor data acquisition occurs at predefined intervals to ensure accurate and timely readings. The ESP32-S3 processes raw sensor data to derive meaningful insights into soil conditions and plant environment. Algorithms are implemented to analyze the data and identify patterns or anomalies. Processed data is prepared for transmission to the Blynk application and Firebase real-time database. Processed data is transmitted securely from the ESP32-S3 to the Blynk application through Wi-Fi connectivity. Data packets include real-time information on soil moisture levels, temperature, and Humidity. Users interact with the Blynk application through a customized dashboard. The dashboard displays real-time data visualizations, historical trends, and control options for irrigation systems. Based on user input and predefined thresholds, the system triggers responses such as automated irrigation or alerts. Responses are designed to optimize plant conditions and facilitate remote control.

3.3 Flowchart Diagram

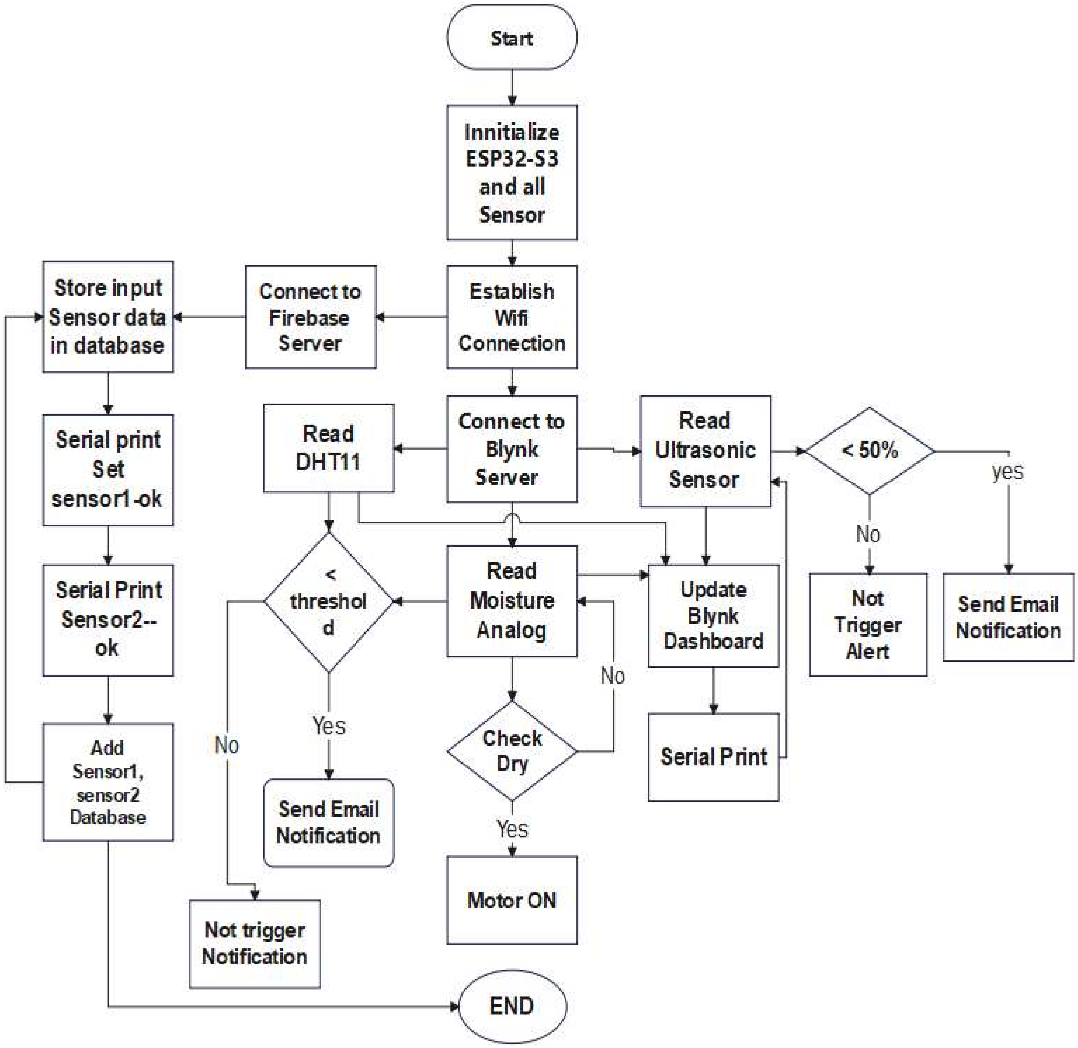


fig 3.3: Flowchart of the proposed system

3.4 Requirement Collection and Analysis

Table 3.4: List of required hardware components

No of Equipment	Hardware components
1	ESP32-S3 wroom1 Microcontroller
2	dht11
3	resistive soil moisture sensor
4	Ultrasonic Distance Sensor
5	5v and 3.3v step-down regulator
6	Water Tank
7	Soldering iron
8	Water Pump
9	Bread Board
10	7-Segment cathode Display
11	12V power adaptor
12	Internet Connection (Wi-Fi)
13	Blynk-Compatible Device
14	Masking tape
15	capacitive soil moisture sensor
16	Mini wire cutter
17	Jumper Wire
19	Screwdriver
20	Data Cable

3.5 Details of Hardware Component

3.5.1 Bread Board

A breadboard typically consists of a plastic board with a grid of holes into which electronic components, such as resistors, capacitors, and integrated circuits, can be inserted. The holes are connected internally in a specific pattern, allowing easy connection and testing of different components without the need for soldering. For this reason, we have used this as our board has a detachable header pin.

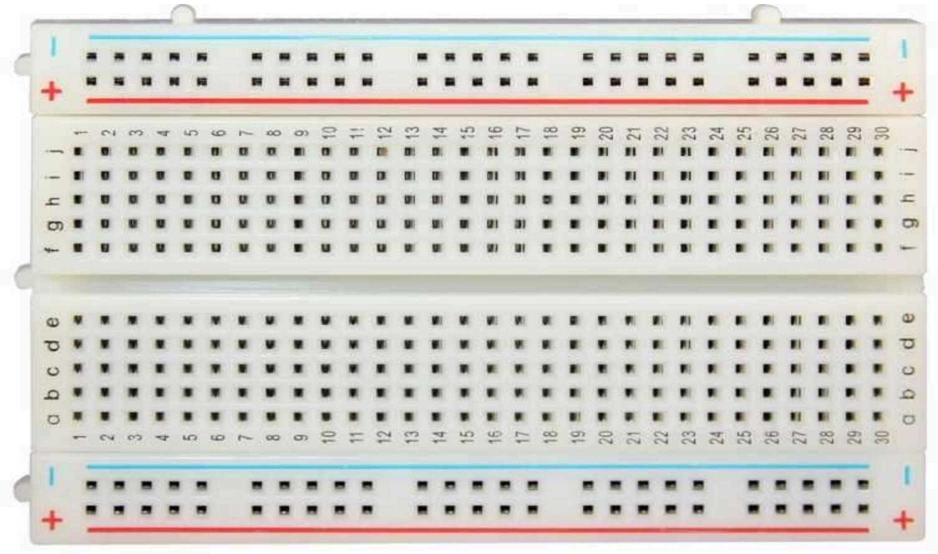


fig 3.5: Breadboard

3.5.2 Capacitive soil moisture sensor

A capacitive soil moisture sensor is a device designed to measure the moisture content in the soil in our project. It typically consists of two electrodes that are inserted into the soil. The sensor operates on the principle that the capacitance between the electrodes changes with variations in soil moisture levels. As the soil moisture increases, the capacitance also increases. It requires very low power to operate which is 3.3V to 5V.

fig 3.5: Capacitive soil moisture sensor

3.5.3 Ultrasonic Distance Sensor

An ultrasonic sensor is a device that uses ultrasonic sound waves for distance measurement which is used in our project to measure the water level in a tank. It typically consists of a transmitter and a receiver. The transmitter emits ultrasonic waves, which travel through the air and bounce off an object. The receiver then detects the reflected waves, and the time taken for the waves to return is used to calculate the distance to the object. It requires very low power to operate which is 5v and a max range of 40-50cm.

fig 3.5: Ultrasonic Distance Sensor

3.5.4 Resistive soil moisture sensor

A resistive soil sensor is a type of soil moisture sensor that measures the moisture content in soil based on its electrical conductivity. This sensor typically consists of two or more metal electrodes that are inserted into the soil. The electrical resistance between these electrodes changes with variations in soil moisture**.**

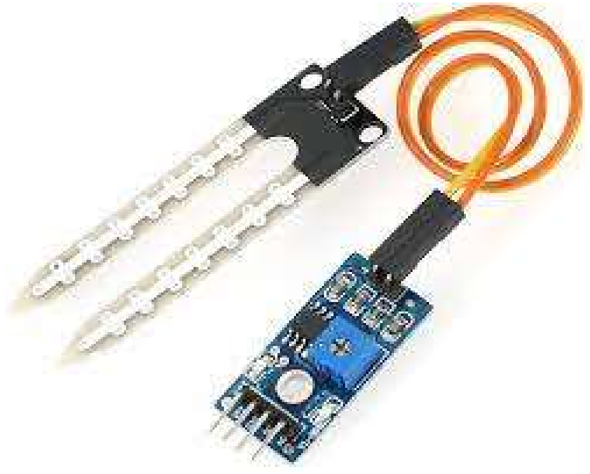


fig 3.5: Resistive soil moisture sensor

3.5.5 DHT11

The DHT11 is a low-cost digital temperature and humidity sensor used in our project for measuring environmental conditions. The DHT11 sensor includes a thermistor for temperature measurement and a humidity-sensing component. The humidity measuring range is 20-80 percent. The temperature measuring range is 0 to 50 degrees Celsius. Input supply voltage 3V to operate this module.

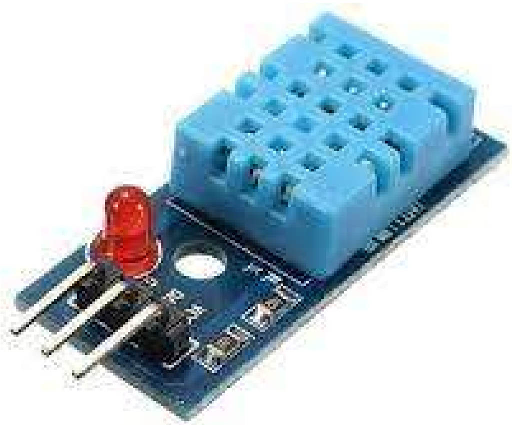


fig 3.5: DHT11

3.6 Use Case Modeling and Description

3.6.1 Use Case Diagram:

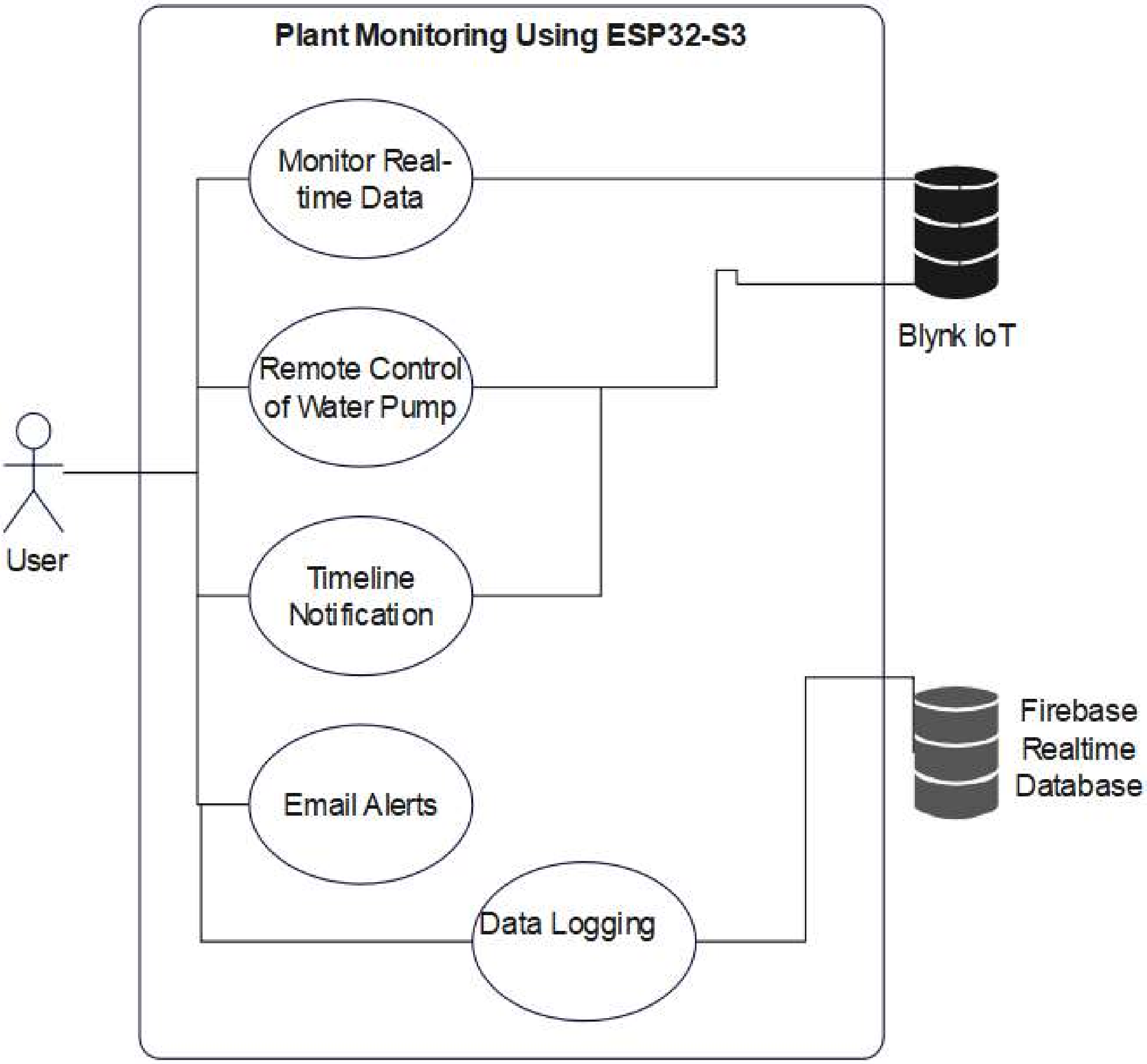


fig 3.6: Use Case Diagram of proposed System

Use Case 1: Monitor Real-time Data

Actors: User, Sensor

Description: The user interacts with the Blynk mobile application to monitor real-time data. The system fetches sensor readings (soil moisture, temperature, humidity,water level) and displays them on the Blynk web dashboard and app dashboard.

Use Case 2: Remote Control of Water Pump

Actors: User, Water Pump

Description: The user utilizes the Blynk mobile application to remotely control a water pump connected to the system. The system activates or deactivates the water pump based on soil moisture level.

Use Case 3: Email Alerts

Actors: User, Sensor

Description: The system monitors threshold values set by the user for soil moisture ,temperature and water level. If a threshold is breached, the system sends an alert to the user through the Blynk app and also sends real-time notification messages via e-mail.

Use Case 4: Data Logging to Firebase

Actors: Sensor, Firebase

Description: The system logs sensor data to the Firebase Realtime Database for historical analysis. Data is organized based on timestamps and specific sensor identifiers.

Use Case 5: Timeline Notification

Actors: User, Blynk

Description: The system logs sensor data to Blynk and illustrates and triggers alert notifications if the water in the tank is below 50 percent. If the temperature rises above 30 degree Celsius. Show real-time notification of login and logout and active time of prototype model project.

CHAPTER 4

DESIGN SPECIFICATION

4.1 Hardware Configuration

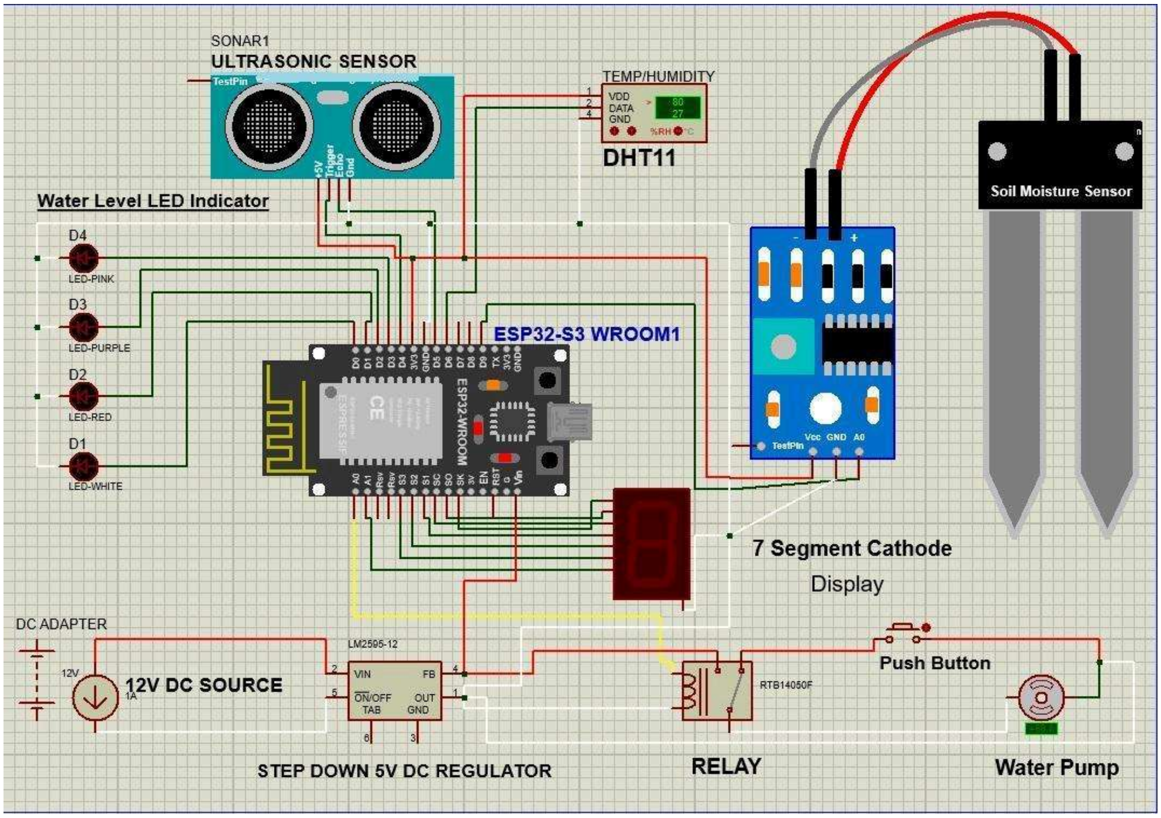
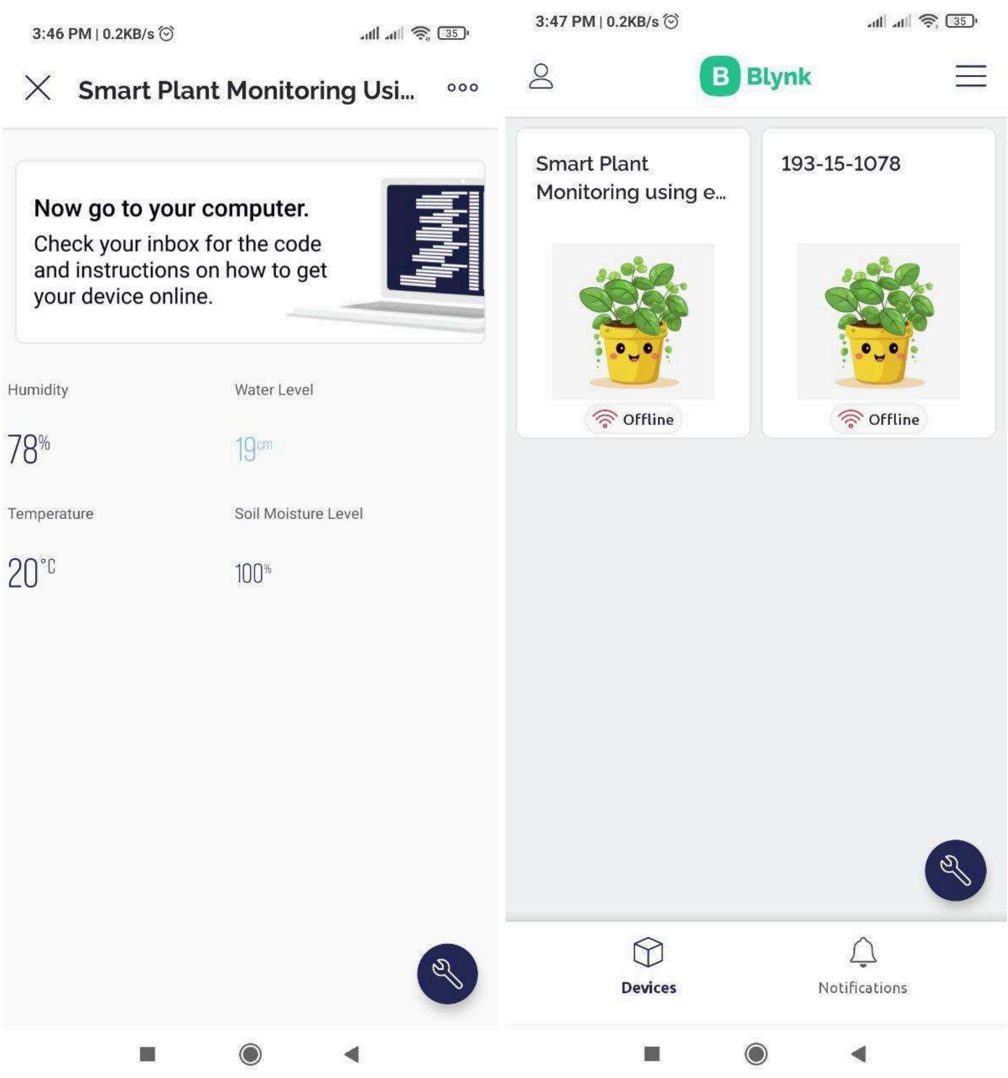


fig4.1: Circuit Diagram with ESP32-S3 wroom1

4.2 Front-end Design

The web and mobile applications of Blynk are used as user interfaces. The following process to design of Blynk application for both mobile and web version are shown below:

fig4.2: Blynk Design Process



Now go to your computer.

Check your inbox for the code and instructions on how to get your device online.

Humidity 78%

Water Level 19cm

Temperature 20°C

Soil Moisture Level 100%

Smart Plant Monitoring using e...

Offline

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Offline

fig4.2: Blynk App Gui

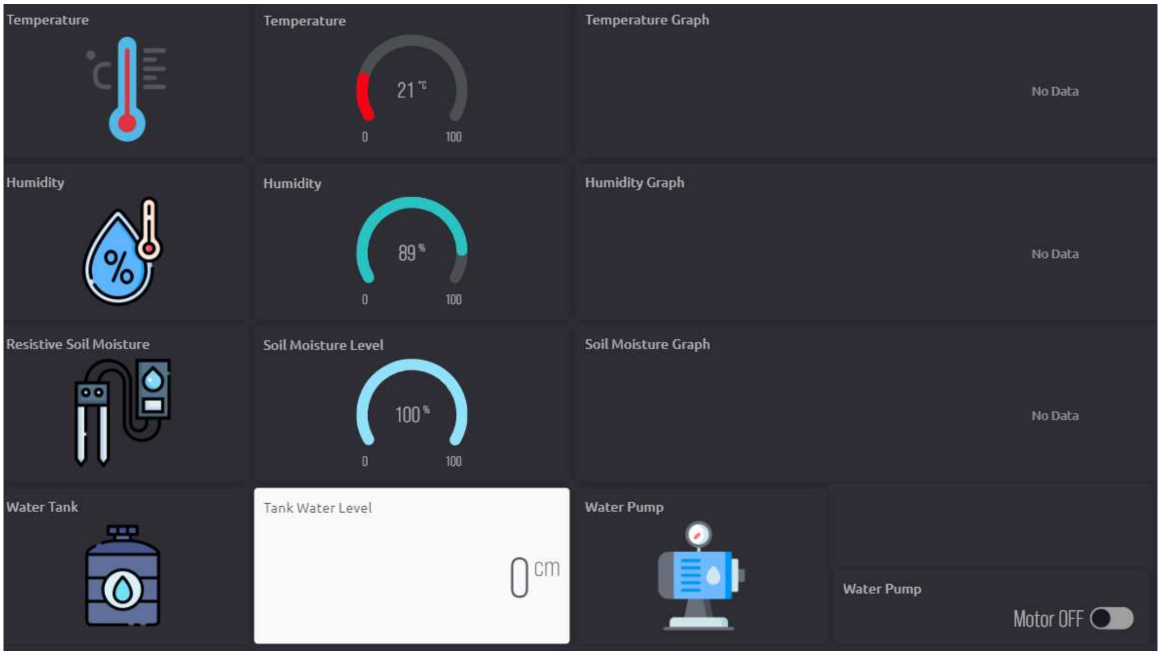


fig4.2: Blynk Web Dashboard

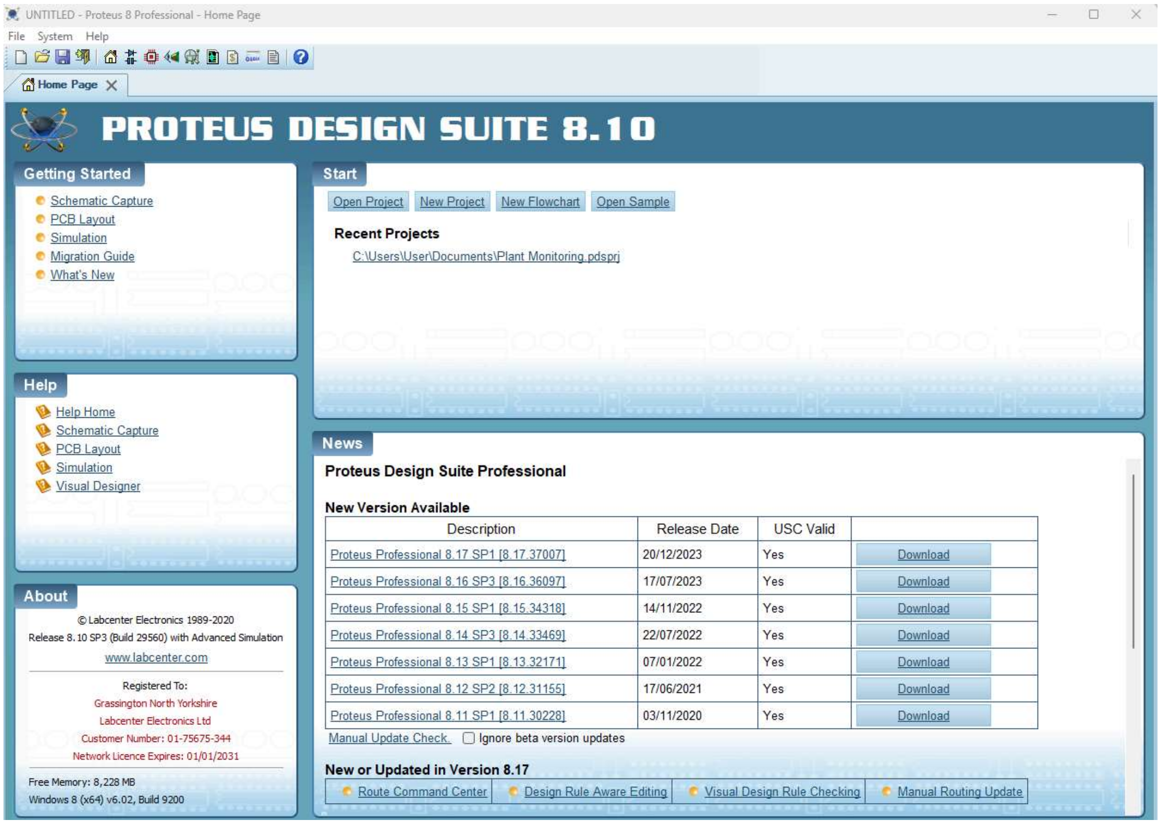
4.3 Implementation Requirements:

These software tools collectively contribute to the seamless development, simulation, and deployment of the smart plant monitoring system

4.3.1 Proteus Design Suite:

This software is mainly used for Electronic Design and Automation in these projects.

Description: Proteus 8.1 is a comprehensive design suite that aids in electronic circuit simulation, PCB layout, and microcontroller programming. It allows for the virtual testing of the system before physical implementation.



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Proteus Design Suite Professional

New Version Available

Description	Release Date	USC Valid	
Proteus Professional 8.17 SP1 [8.17.37007]	20/12/2023	Yes	Download
Proteus Professional 8.16 SP3 [8.16.36097]	17/07/2023	Yes	Download
Proteus Professional 8.15 SP1 [8.15.34318]	14/11/2022	Yes	Download
Proteus Professional 8.14 SP3 [8.14.33469]	22/07/2022	Yes	Download
Proteus Professional 8.13 SP1 [8.13.32171]	07/01/2022	Yes	Download
Proteus Professional 8.12 SP2 [8.12.31155]	17/06/2021	Yes	Download
Proteus Professional 8.11 SP1 [8.11.30228]	03/11/2020	Yes	Download

New or Updated in Version 8.17

fig4.3: proteus suit GUI

4.3.2 Edraw Max:

Purpose: Circuit Diagram, Block Diagram, UML Diagram Design etc.

Description: Edraw Max is a versatile diagramming tool used for creating circuit diagrams, block diagrams, UML diagrams, and various other visual representations. It facilitates the clear illustration of system components and their interconnections.

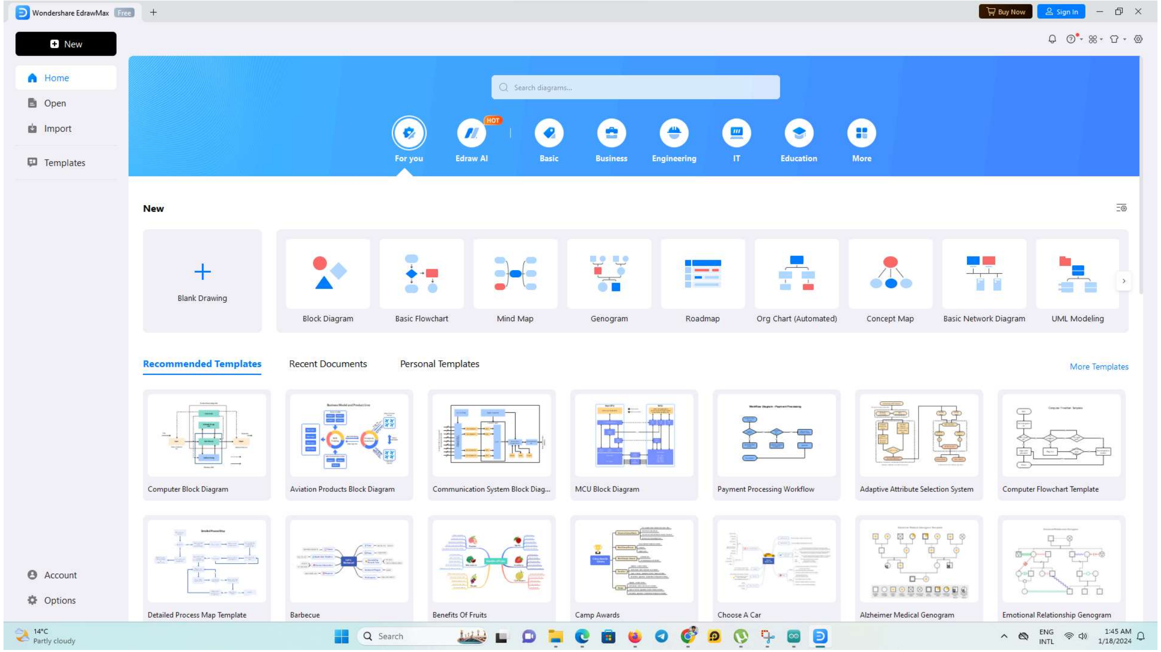
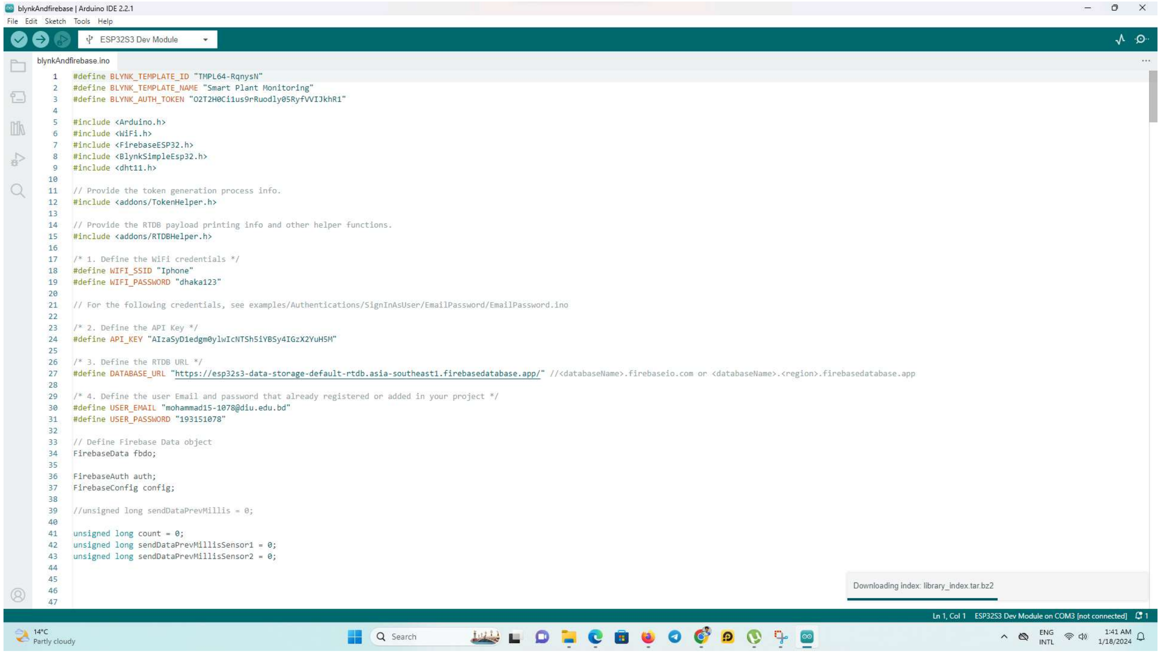


fig4.3: EDraw Max GUI

4.3.3 Arduino IDE 2.2.1:

Arduino Integrated Development Environment (IDE) is the primary software for programming the ESP32-S3 microcontroller. It supports the development and uploading of code for the smart plant monitoring system.



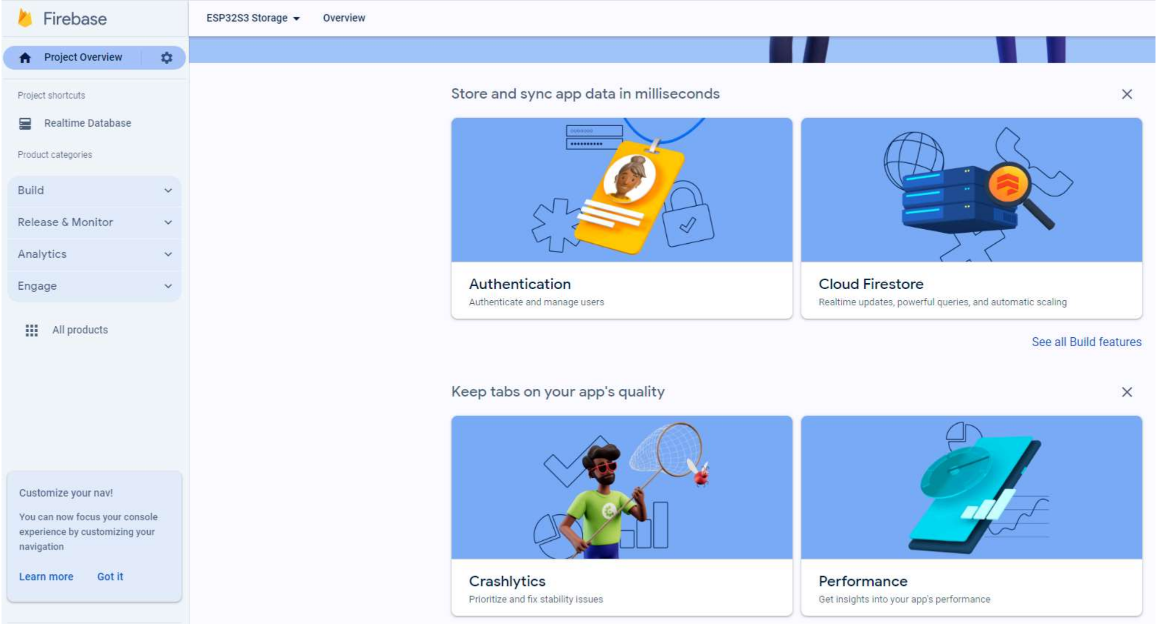
```
#define BLYNK_TEMPLATE_ID "TMPL64-RqnysN"
#define BLYNK_TEMPLATE_NAME "Smart Plant Monitoring"
#define BLYNK_AUTH_TOKEN "O2T2H0Ci1us9rRuodly05RyfVVIJkhR1"

#include <Arduino.h>
#include <WiFi.h>
#include <FirebaseESP32.h>
#include <BlynkSimpleEsp32.h>
#include <dht11.h>

// Provide the token generation process info.
#include <addons/TokenHelper.h>

// Provide the RTDB payload printing info and other helper functions.
#include <addons/RTDBHelper.h>

/* 1. Define the WiFi credentials */
#define WIFI_SSID "Iphone"
#define WIFI_PASSWORD "dhaka123"

// For the following credentials, see examples/Authentications/SignInAsUser/EmailPassword/EmailPassword.ino

/* 2. Define the API Key */
#define API_KEY "AIzaSyD1edgm0ylwIcNTSh5iYBSy4IGzX2YuH5M"

/* 3. Define the RTDB URL */
#define DATABASE_URL "https://esp32s3-data-storage-default-rtdb.asia-southeast1.firebasedatabase.app/" //<databaseName>.firebaseio.com or <databaseName>.<region>.firebasedatabase.app

/* 4. Define the user Email and password that already registered or added in your project */
#define USER_EMAIL "mohammad15-1078@diu.edu.bd"
#define USER_PASSWORD "193151078"

// Define Firebase Data object
FirebaseData fbdo;

FirebaseAuth auth;
FirebaseConfig config;

//unsigned long sendDataPrevMillis = 0;

unsigned long count = 0;
unsigned long sendDataPrevMillisSensor1 = 0;
unsigned long sendDataPrevMillisSensor2 = 0;
```

Fig4.3: Arduino IDE GUI

4.3.4 Realtime Firebase Database:

Purpose: Data Storage and Retrieval

Description: Firebase Realtime Database is employed for storing and retrieving real-time data generated by the smart plant monitoring system. It enables historical data logging, allowing users to analyze trends over time.



Customize your nav!

You can now focus your console experience by customizing your navigation

fig4.3: Real-time Firebase Database

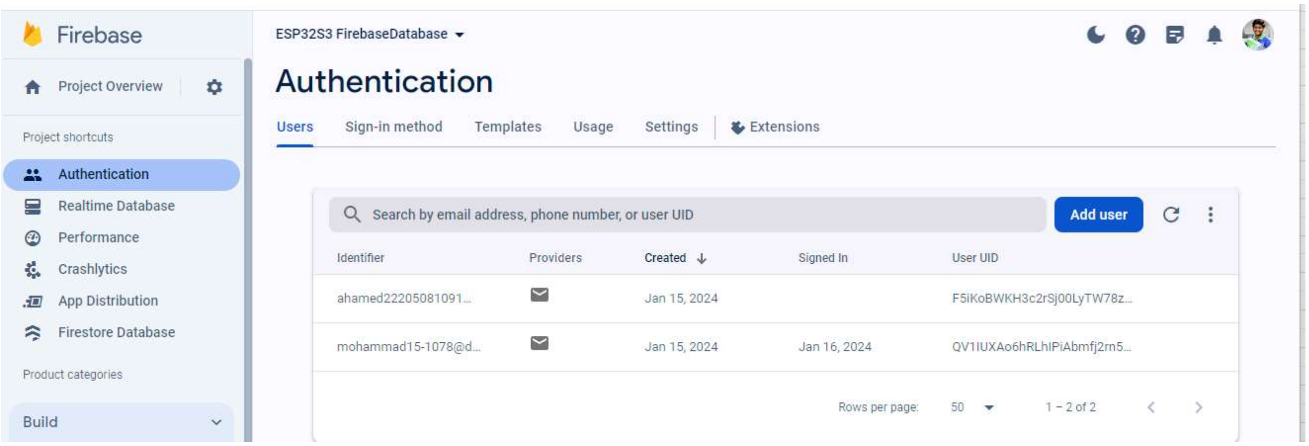
4.3.5 Blynk Application:

The main purpose of Blynk is to Remote Monitoring and Control. The Blynk application serves as the user interface for remote monitoring and control. It allows users to visualize real-time data, set thresholds, and intervene manually if necessary. Besides, it gives various pre-built templates for the design purpose of a project. These applications have both web applications and app applications which are very useful and easy to use from anywhere in the world.

CHAPTER 5

IMPLEMENTATION AND TESTING

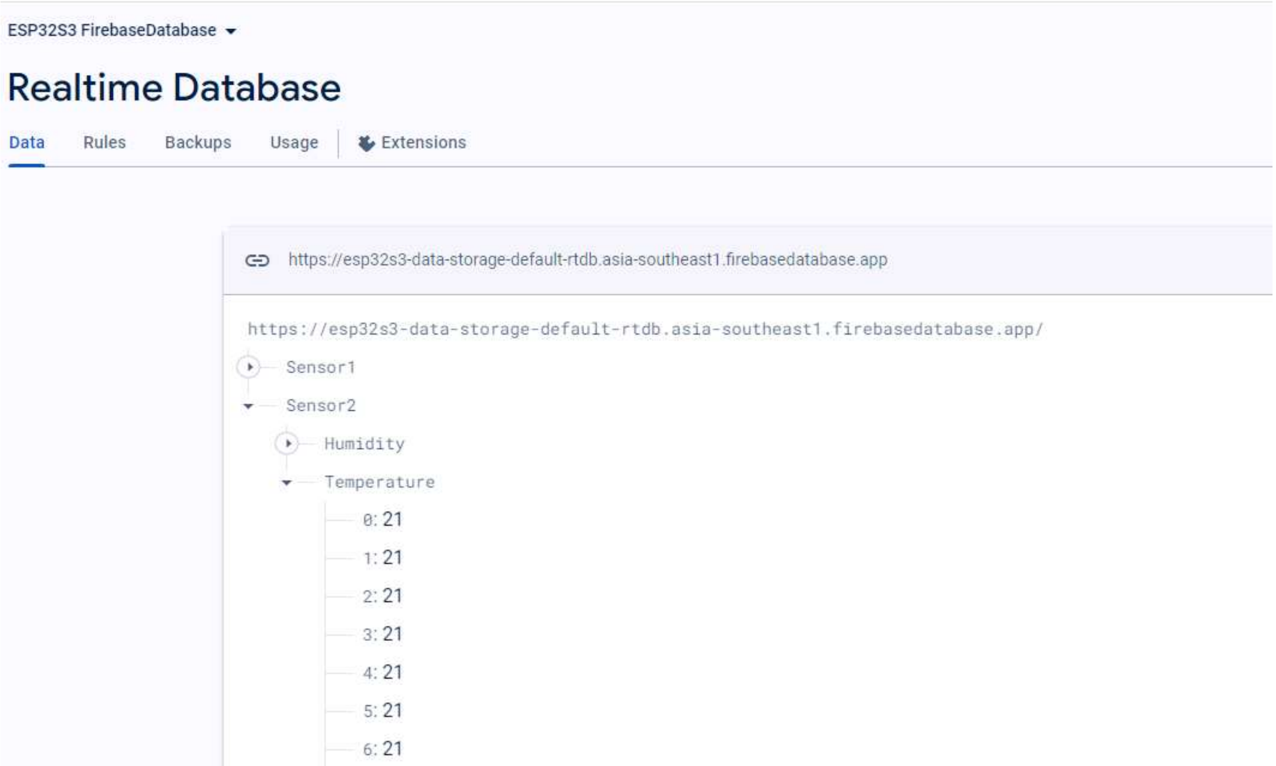
5.1 Implementation of Database



Identifier	Providers	Created ↓	Signed In	User UID
ahamed22205081091…	✉	Jan 15, 2024		F5iKoBWKH3c2rSj00LyTW78z…
mohammad15-1078@d…	✉	Jan 15, 2024	Jan 16, 2024	QV1IUXAo6hRLhIPiAbmfj2rn5…

Rows per page: 50 1 – 2 of 2

fig 5.1:user authentication of firebase



https://esp32s3-data-storage-default-rtdb.asia-southeast1.firebasedatabase.app

```
https://esp32s3-data-storage-default-rtdb.asia-southeast1.firebasedatabase.app/
  Sensor1
  Sensor2
    Humidity
    Temperature
      0: 21
      1: 21
      2: 21
      3: 21
      4: 21
      5: 21
      6: 21
```

fig 5.1: Real Time sensor data in firebase

The Figure 5.1 firebase authentication section is basically used to login. in the above figure we can see our device last sign in jan 16,2024. and next figure show where all the input sensor data are saved. Sensor1 shows the moisture sensor raw data save as JSON format in database which can be collect or download anytime needed. Then similarly in sensor 2 section temperature and humidity data are saved as Json format. these can convert into any other format for any research purpose.

5.2 Implementation of Front-end Design

5.2.1 Blynk Application Interface:

fig 5.2: Blynk interface for plant monitoring

a. Dashboard Layout: The Blynk application features a customizable dashboard, allowing users to arrange widgets and prioritize parameters based on project requirements.

b. Real-time Data Visualization: Widgets display real-time data in visually informative formats, ensuring a user-friendly and intuitive experience.

5.3. Implementation of hardware

The hardware implementation involves ESP32-S3 microcontroller which serves as the central processing unit, responsible for data acquisition, processing, and communication.

Then, Sensors working as input of the system, such as the DHT11 sensor that captures temperature and humidity data, the soil moisture sensor measures resistive moisture and capacitive moisture in the soil, and an ultrasonic distance sensor monitors water levels in the tank. Actuators work as output in this system such as a relay module controlling the water pump based on system logic. LED indicators provide visual feedback on system status. A 7-segment display communicates real-time soil moisture levels. As user Interface push buttons enable manual control of the water pump on/off. Moreover, the Blynk-compatible mobile device serves as remote monitoring and control. A power supply 12v adapter and step down regulator circuit ensures the necessary voltage and current for reliable operation.

Final Prototype model of the system

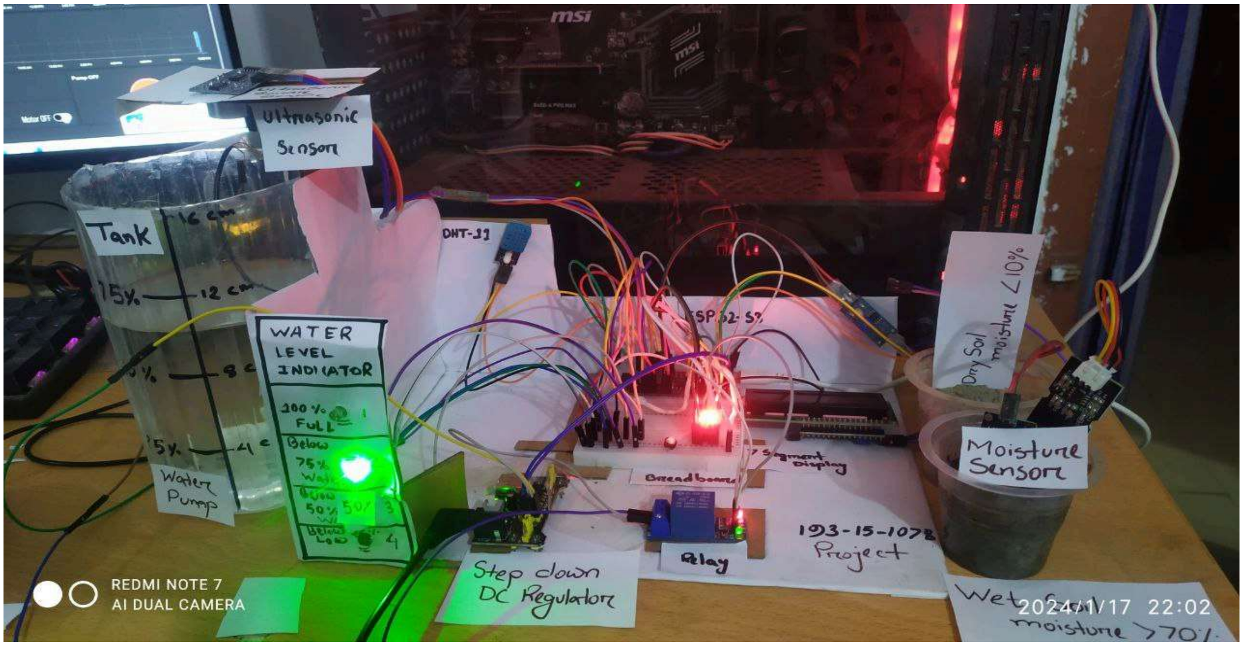


fig 5.3: System Prototype Hardware Circuit

5.4 Test Results and Reports

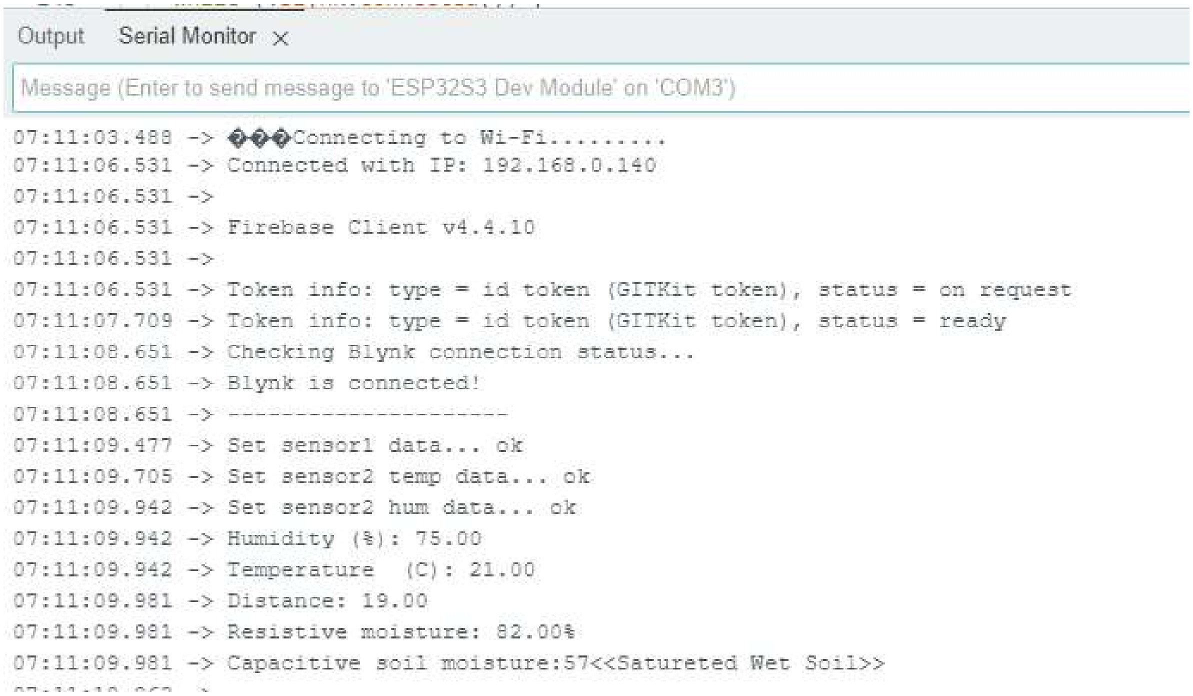
5.4.1 24-hour Real Time Experimental Result:

fig 5.4: 24-hour real time experimental result

The chart from the Blynk dashboard above illustrates the results for three key parameters: temperature, humidity, and soil moisture. At the initial observation at 6 AM, the soil moisture level of the plant registered at 84%. This level remained consistent until 11 AM, concurrent with a stable temperature of 21 degrees Celsius, indicative of a winter season. Subsequently, after 11 AM, there was a marginal 2% decline in the moisture level, reaching a concluding value of 70% by the end of the 24-hour period.

5.4.2 Serial Monitor result:

The serial monitor shows us whether it is connected to the Wi-Fi server or not. Then show which IP address. Then connect with the firebase database and show the Firebase client version and token mode. then it shows whether the Blynk application is connected or not. then it sends data of sensor1 as humidity data to firebase database and sensor 2 as dht11 data to firebase server. and it prints all the sensor values every 2 seconds.

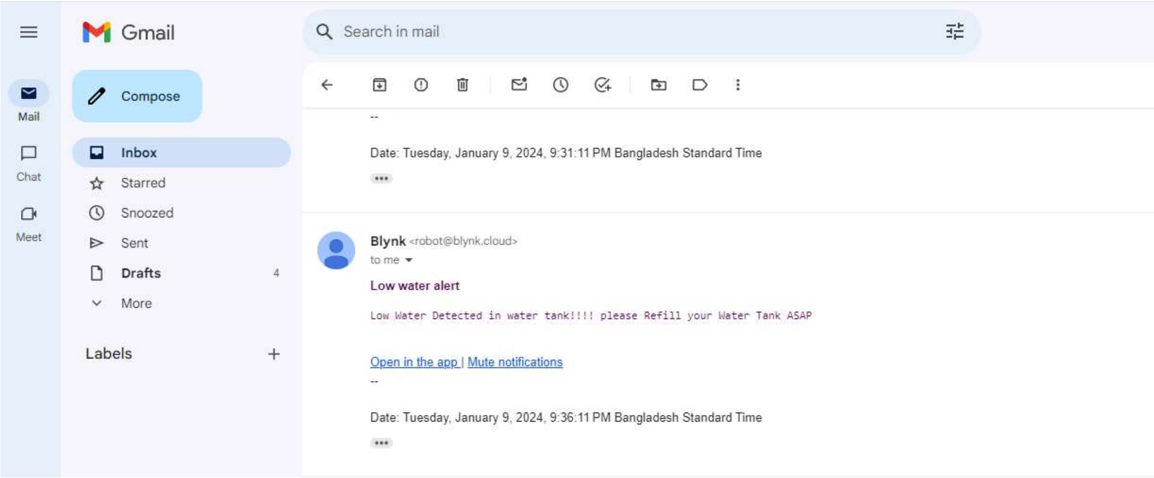


```
07:11:03.488 -> ���Connecting to Wi-Fi.........
07:11:06.531 -> Connected with IP: 192.168.0.140
07:11:06.531 ->
07:11:06.531 -> Firebase Client v4.4.10
07:11:06.531 ->
07:11:06.531 -> Token info: type = id token (GITKit token), status = on request
07:11:07.709 -> Token info: type = id token (GITKit token), status = ready
07:11:08.651 -> Checking Blynk connection status...
07:11:08.651 -> Blynk is connected!
07:11:08.651 -> --------------------
07:11:09.477 -> Set sensor1 data... ok
07:11:09.705 -> Set sensor2 temp data... ok
07:11:09.942 -> Set sensor2 hum data... ok
07:11:09.942 -> Humidity (%): 75.00
07:11:09.942 -> Temperature  (C): 21.00
07:11:09.981 -> Distance: 19.00
07:11:09.981 -> Resistive moisture: 82.00%
07:11:09.981 -> Capacitive soil moisture:57<<Satureted Wet Soil>>
```

fig 5.4: Serial Monitor output

5.4.3 Email Notification Alert:

Receive instant email notifications for crucial plant care updates, including low water levels, extreme weather conditions, and soil moisture alerts, through our IoT-Enabled Plant Monitoring System.



--

Date: Tuesday, January 9, 2024, 9:31:11 PM Bangladesh Standard Time

Blynk <robot@blynk.cloud>
to me

Low water alert

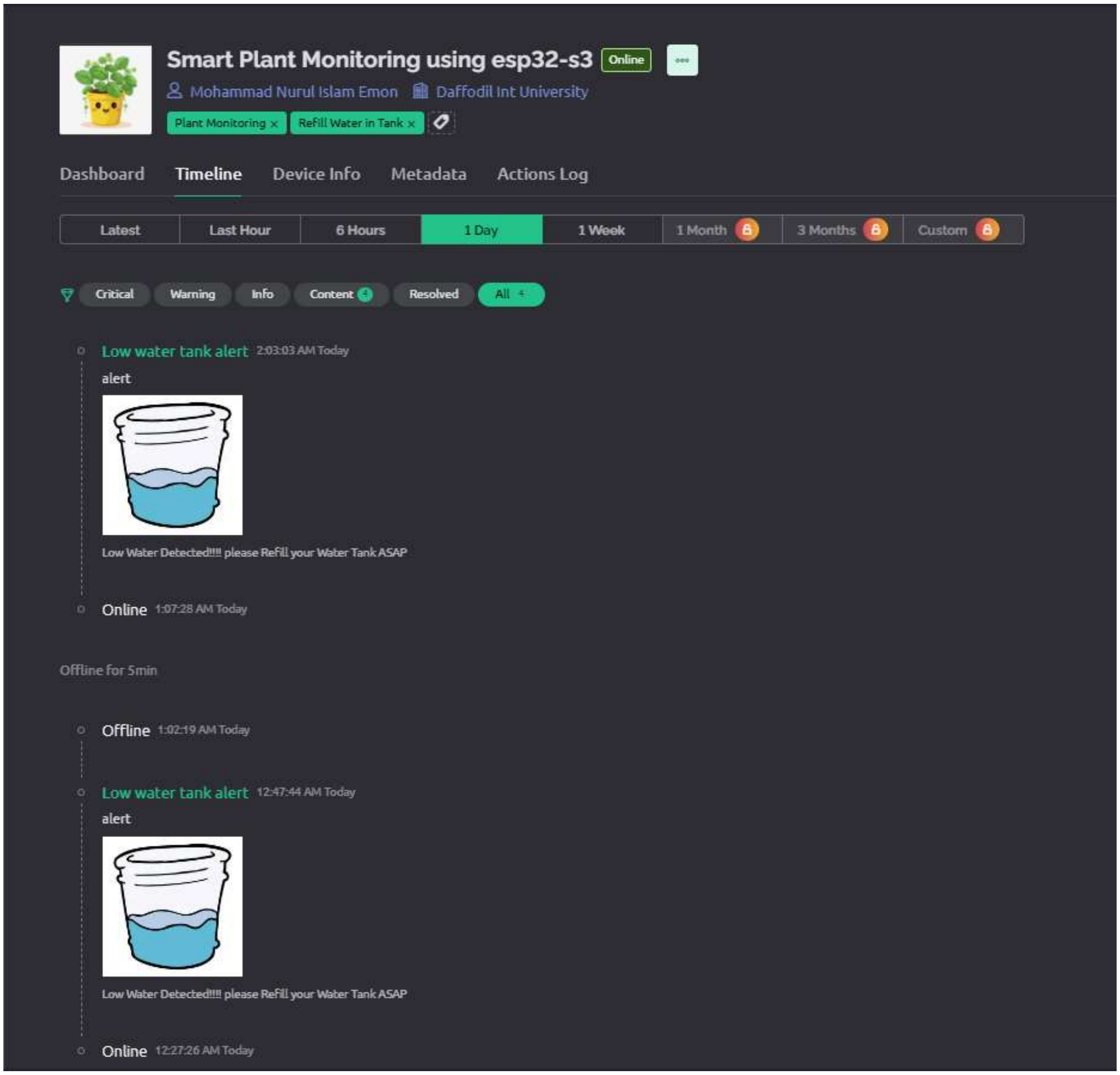
Low Water Detected in water tank!!!! please Refill your Water Tank ASAP

Open in the app | Mute notifications
--

Date: Tuesday, January 9, 2024, 9:36:11 PM Bangladesh Standard Time

fig 5.4: Email Notification Alert

5.4.5 Blynk Timeline Notification Alert:



Smart Plant Monitoring using esp32-s3

Mohammad Nurul Islam Emon Daffodil Int University

Low water tank alert 2:03:03 AM Today

alert

Low Water Detected!!!! please Refill your Water Tank ASAP

Online 1:07:28 AM Today

Offline for 5min

Offline 1:02:19 AM Today

Low water tank alert 12:47:44 AM Today

alert

Low Water Detected!!!! please Refill your Water Tank ASAP

Online 12:27:26 AM Today

Fig 5.4: Blynk Timeline Notification

From the figure 5.4.3 we can see it receive instant Timeline notifications Alert for low water levels, extreme weather conditions, and soil moisture alerts, through our IoT-Enabled Plant Monitoring System.

5.4.6 User Feedback:

Early user feedback suggests satisfaction with the user-friendly interface and customization options. Users appreciate the system's reliability in providing accurate real-time data and responsive controls.

Chapter 6: Impact on Society, Environment and Sustainability

6.1 Impact on Society

The societal impact of the smart plant monitoring system is broadened through the promotion of responsible agriculture and environmental awareness. By equipping individuals with an instinctive tool for effective plant care, the system empowers both gardening enthusiasts and agricultural experts. The functionality of real-time monitoring and control ensures that users can adequately nurture their plants, contributing to the expansion of green areas and the enhancement of ecosystems. Furthermore, the system's educational aspect encourages the sharing of knowledge within communities, advocating for sustainable practices and responsible management of resources.

6.2 Impact on Environment

The impact of the smart plant monitoring system on the environment is noteworthy due to its capacity to optimize water usage and minimize resource wastage. By precisely regulating the water pump based on soil moisture levels, the system reduces unnecessary water consumption, actively supporting water conservation endeavors. The monitoring of temperature and humidity also facilitates the creation of a plant-friendly environment without excessive energy utilization. Overall, the system aligns with eco-friendly practices, endorsing a greener and more sustainable approach to plant care.

6.3 Ethical Aspects

Ethical considerations play a crucial role in the development and deployment of the smart plant monitoring system. The system advocates for responsible resource management by averting overwatering, effectively embodying both economic and environmental ethics. The system's inherent transparency and user control features uphold the ethical principle of user autonomy, granting individuals the ability to make well-informed decisions regarding their plant care practices. Additionally, the system ensures privacy by securely storing user data and refraining from sharing it without explicit consent.

6.4 Sustainability Plan

The sustainability plan for the smart plant monitoring system revolves around continuous efforts to enhance efficiency and minimize environmental impact. Ongoing updates to the system's firmware and software will be implemented to improve functionality and compatibility with emerging technologies. Furthermore, research and development initiatives will prioritize the integration of more sustainable materials in the hardware components, resulting in a reduced environmental footprint during the manufacturing process. Optimizing the system's scalability will also promote sustainable farming practices on a larger scale.

Chapter 7: Conclusion and Future Scope

7.1 Discussion and Conclusion

The utilization of the ESP32-S3 microcontroller and the IoT Blynk application in a Plant Monitoring System has brought about a notable advancement in precision agriculture. The focus of the study was to develop and implement a system that seamlessly integrates sensor data, real-time monitoring, and user-friendly controls in order to enhance plant cultivation practices. The key components of this system include the versatile ESP32-S3 microcontroller, various soil condition monitoring sensors, and the Blynk application for user interaction.The study establishes that the implementation of the IoT-enabled Plant Monitoring System, combining the ESP32-S3 and Blynk application, effectively overcomes significant challenges faced in traditional agriculture.

The following conclusions can be drawn:

- **Real-time Monitoring and Control:** The system enables farmers to access real-time information on soil moisture, temperature, and light intensity, facilitating proactive decision-making and precise control over irrigation.
- **User-friendly Interface:** The user-friendly interface of the Blynk application ensures accessibility for users with varying technical expertise, contributing to widespread adoption within the agricultural community.
- **Scalability and Adaptability:** The system displays scalability, accommodating different field sizes, and adapting to environmental changes, making it suitable for diverse agricultural settings.
- **Energy Efficiency:** Power consumption optimizations, including sleep modes, result in extended battery life, ensuring uninterrupted system operation even in remote locations.
- **Data Security and Privacy:** Robust encryption measures have been implemented to secure communication between the ESP32-S3 and the Blynk application, effectively addressing concerns regarding data security and privacy.

7.2 Scope for Further Developments

The current study has established a strong foundation for the implementation of IoT-enabled plant monitoring in agriculture. However, there are several avenues for future research and improvement, which are as follows:

1. Integration of Additional Sensors:

   Future studies may explore the incorporation of supplementary sensors, such as nutrient level sensors or disease detection sensors. This integration can provide a more comprehensive understanding of the overall health of the plants.

2. Integration of Additional Actuators:

   Future studies may explore the incorporation of supplementary actuators like motors to make shade to save trees from heavy rainfall or moving devices to check various places and check many trees surrounding parameters..

3. Machine Learning Applications:

   By implementing machine learning algorithms, the system's predictive capabilities can be enhanced. This improvement would enable more accurate forecasting of plant conditions and resource requirements, facilitating how much and amount required can be predicted which leads to more efficient agricultural practices.

4. Remote Communication Protocols:

   It is essential to investigate alternative communication protocols for areas with limited internet connectivity.

5. Community-based Deployments:

   Assessing the impact of this implementation on communal agricultural practices would provide valuable insights and foster sustainable agricultural development .

6. Long-term Field Studies:

   Conducting extended field studies to evaluate the system's performance across multiple growing seasons and diverse crops is crucial. This approach would yield valuable insights into the long-term effectiveness and potential challenges of the system.

7. User Adoption and Behavior Studies:

   Research focusing on user adoption patterns and behavioral studies can offer valuable feedback for refining the system's design and user interface. Understanding user preferences and needs is essential for optimizing the system's usability and effectiveness.

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Mohammad Nurul Islam Emon

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