KLE Technological University

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Dr. M. S. Sheshgiri Campus, Belagavi

Department of Electronics and Communication Engineering

Mini Project Report on

Solar Powered Wireless Weather Station

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that the project entitled **"Solar Powered Wireless Weather Station"** is a bonafide work carried out by the student team of **"Diya Revankar (02FE22BEC026), Kalashri Gomannache (02FE22BEC034), Pruthviraj Nesarikar (02FE22BEC057), Radhesh Patil (02FE22BEC059)"**. The project report has been approved as it satisfies the requirements with respect to the Mini project work prescribed by the university curriculum for B.E. (V Semester) in the Department of Electronics and Communication Engineering of KLE Technological University, Dr. M. S. Sheshgiri Belagavi campus, for the academic year 2024-2025.

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1.	
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-The project team

Abstract

”Solar Powered Wireless Weather Station” presents the design and implementation of a self-sustaining weather station. The system is designed to address the growing need for real-time environmental monitoring in remote and off-grid locations. By leveraging a NodeMCU microcontroller, the station collects crucial weather parameters, including temperature, humidity, atmospheric pressure, and light intensity, through highly accurate sensors. The collected data is wirelessly transmitted to the cloud via Wi-Fi, where it is integrated with the ThingSpeak platform for real-time visualization, analysis, and long-term storage.

The use of solar energy as the primary power source ensures continuous, low-maintenance operation, even in areas with limited access to conventional power supplies. The system's portability and renewable energy dependence make it an ideal solution for monitoring environmental conditions in remote areas, agricultural fields, or disaster-prone regions.

This report provides a comprehensive overview of the project's hardware and software design. It details the selection and integration of components, including sensors, power management modules, and communication interfaces, ensuring an efficient and reliable system. Additionally, the implementation of ThingSpeak facilitates user-friendly data access and analysis, enabling informed decision-making for environmental research, resource planning, and weather-related risk management.

The project emphasizes sustainability, cost-effectiveness, and practicality, showcasing potential applications in agriculture, urban planning, and climate studies. This weather station serves as a scalable and adaptable solution, promoting the integration of renewable energy in technological advancements while addressing critical challenges in environmental monitoring.

Contents

List of Figures

Chapter 1

Introduction

The increasing demand for real-time weather monitoring and data analysis has driven the development of wireless weather stations. However, many existing systems rely on external power sources and wired connections, limiting their flexibility and sustainability, especially in remote or off-grid locations. To address these challenges, this project aims to design and implement a solar-powered, Wi-Fi-enabled weather station. By integrating a NodeMCU microcontroller with sensors for temperature, humidity, and atmospheric pressure, the system will collect real-time weather data. The data will then be transmitted wirelessly to the ThingSpeak platform, enabling remote monitoring and analysis. The solar power component ensures that the system operates autonomously, making it an ideal solution for areas with limited or no access to conventional power sources. This project not only promotes energy efficiency but also contributes to sustainable, off-grid weather monitoring solutions.

Chapter 2

Literature Survey

In this section, we review several studies related to solar-powered weather stations, focusing on their objectives, methodologies, and limitations.
1. **Cloud Computing's IoT-Based ThingSpeak, NodeMCU for Weather Monitoring** This study aimed to develop a real-time weather monitoring system using IoT and cloud computing. Data was collected and sent to the ThingSpeak cloud platform, relying on Wi-Fi provided by ESP32 for real-time data upload and visualization. However, the system faced challenges related to scalability and adaptability under different environmental conditions. Additionally, it incurred high initial costs and power consumption.
2. **Efficient IoT-Based Weather Station** The objective of this research was to design an efficient, portable IoT weather station capable of providing real-time weather updates. The system employed a NodeMCU board, the Blynk app for user interaction, and sensors for temperature, pressure, humidity, and rainfall. Despite its efficiency, the station was limited in scalability due to its reliance on specific hardware and might lack precision in extreme climatic conditions.
3. **Low-Cost IoT-Enabled Weather Station** This paper focused on creating an affordable weather monitoring system for localized weather tracking with IoT integration. The system utilized a NodeMCU microcontroller along with various sensors, such as those for wind speed and humidity, with data transmitted to the ThingSpeak cloud platform. While cost-effective, the system exhibited limitations in data precision and was constrained by the basic capabilities of the cloud platform for advanced data analysis.
4. **Cloud-Based Weather Station Using IoT Devices** This study aimed to develop a cloud-based weather station for real-time monitoring with IoT integration. A Raspberry Pi was used alongside sensors, cloud storage, and a Django-based web application for real-time monitoring. However, the system's dependence on internet and cloud services rendered it less suitable for remote areas lacking reliable connectivity.
These studies highlight the potential of IoT-enabled weather stations while emphasizing challenges like scalability, precision, cost, and dependency on cloud services.

Chapter 3

Project Planning

3.1 Explanation of Figures

3.1.1 Gantt Chart

The Gantt chart in Figure 3.1 provides a timeline for the development stages of the project titled *Solar-Powered Wi-Fi Weather Station*. The project is divided into five main tasks, with their durations and statuses clearly marked using color codes:

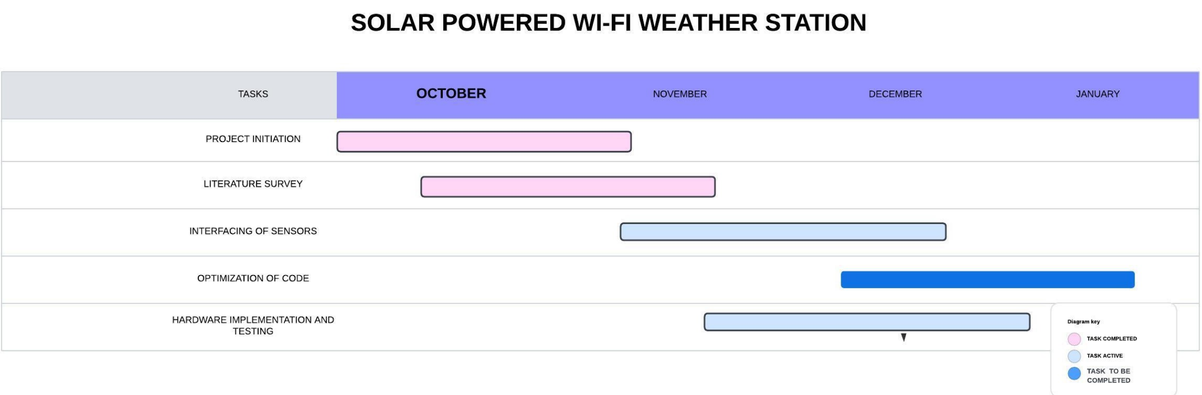


Figure 3.1: Gantt Chart: Timeline for the *Solar-Powered Wi-Fi Weather Station* project.

3.1.2 Work Breakdown Structure (WBS)

The Work Breakdown Structure (WBS) shown in Figure 3.2 divides the project into manageable components, categorizing work into distinct areas to ensure systematic execution:

- **Initiation:**
  - Identifying objectives of the project.
  - Determining stakeholders involved.
  - Setting up a detailed schedule for task execution.
- **Hardware Acquisition:**

  - Selecting and procuring the NodeMCU ESP8266 microcontroller.
  - Gathering sensors like DHT11 (temperature and humidity sensor), BMP280 (pressure sensor), and rain sensors for environmental data collection.

- **Software Development:**
  - Using Arduino IDE to write and upload code to the ESP8266.
  - Setting up ThingSpeak for cloud-based data visualization and analysis.

- **ESP8266 Integration:**
  - Configuring sensors to read environmental data and transmit it through the ESP8266 module.

- **ThingSpeak Integration:**
  - Integrating the ESP8266 module with ThingSpeak for seamless data transmission and visualization.

- **User Interface (UI):**
  - Designing the UI on the ThingSpeak platform to display weather parameters.
  - Connecting the UI to the ThingSpeak database for real-time data updates.

- **Testing:**
  - Testing the system to ensure proper functionality, accuracy, and reliability under real-world conditions.

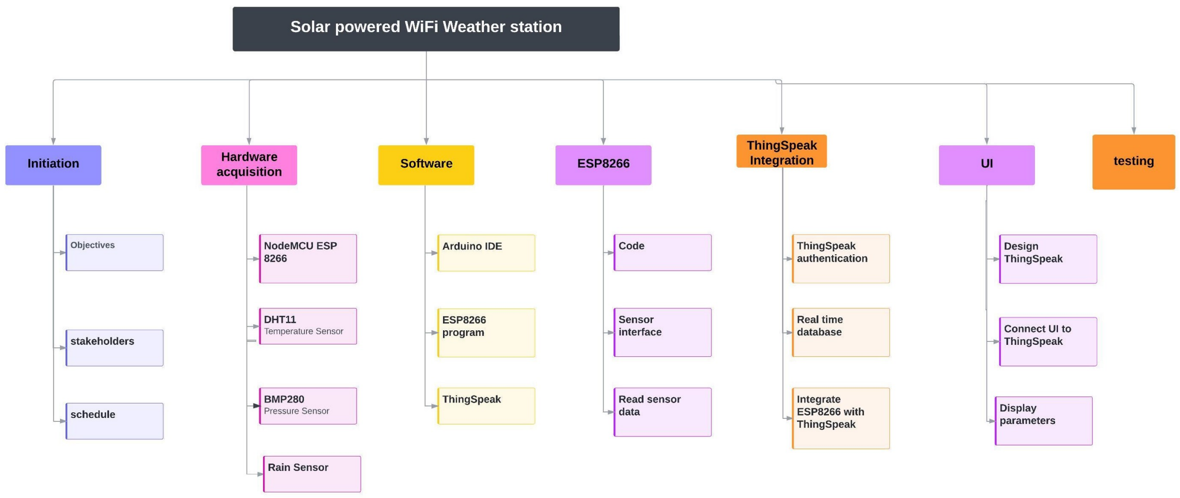


Figure 3.2: Work Breakdown Structure (WBS): Tasks and Deliverables for the *Solar-Powered Wi-Fi Weather Station* project.

Chapter 4

Methodology

4.1 System Overview

The system consists of the following major components:

- **Sensors:** DHT11 (for temperature and humidity), BMP280 (for barometric pressure), and a rain sensor.
- **Microcontroller:** NodeMCU (ESP8266) is used for processing and wireless communication.
- **Power Supply:** Solar power setup, including a solar panel and a Li-Ion battery, ensures the system is energy-efficient and sustainable.
- **IoT Analytics and Data Visualization:** Data is sent to ThingSpeak for IoT analytics and MATLAB for visualization and analysis.

4.2 System Design

- **Power Management:** A solar panel charges the Li-Ion battery, which powers the NodeMCU and connected sensors. A voltage regulator ensures a stable power supply to the components.
- **Sensors Integration:**
  - **DHT11:** Measures temperature and humidity.
  - **BMP280:** Measures barometric pressure and altitude.
  - **Rain Sensor:** Detects precipitation levels.
- **Microcontroller:** The NodeMCU (ESP8266) collects sensor data and transmits it wirelessly to the cloud.

4.3 Implementation Steps

1. **Solar Power Setup:**

- Connect the solar panel to the Li-Ion battery with a charge controller to prevent overcharging.
- Use a DC-DC converter to provide the required voltage levels for the NodeMCU and sensors.

2. **Sensors Configuration:**
   - Connect the DHT11, BMP280, and rain sensor to the NodeMCU.
   - Write Arduino code to read data from these sensors.
3. **Data Transmission Using NodeMCU:**
   - Configure the NodeMCU for Wi-Fi connectivity.
   - Program the microcontroller to send data to ThingSpeak using its API for IoT analytics.
4. **IoT Analytics with MATLAB:**
   - Analyze data in ThingSpeak.
5. **Data Visualization:**
   - Visualize data on parameters like temperature, humidity, pressure, and rain levels on dashboards.

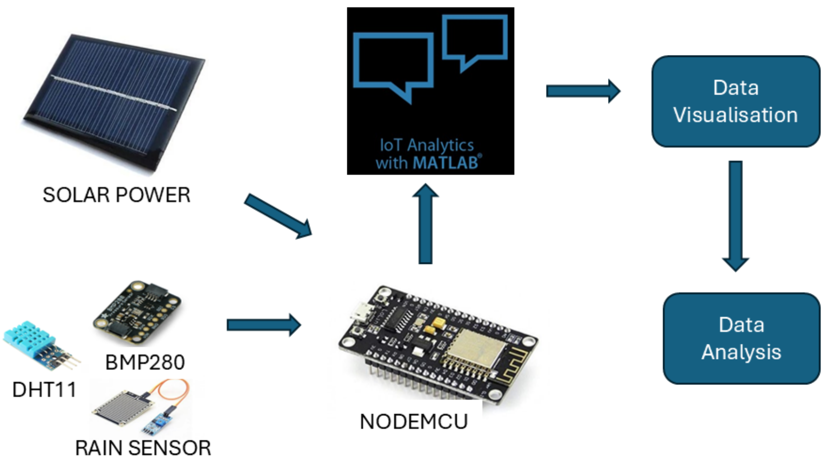


Figure 4.1: Implementation figure

Chapter 5

Block Diagram and Simulation

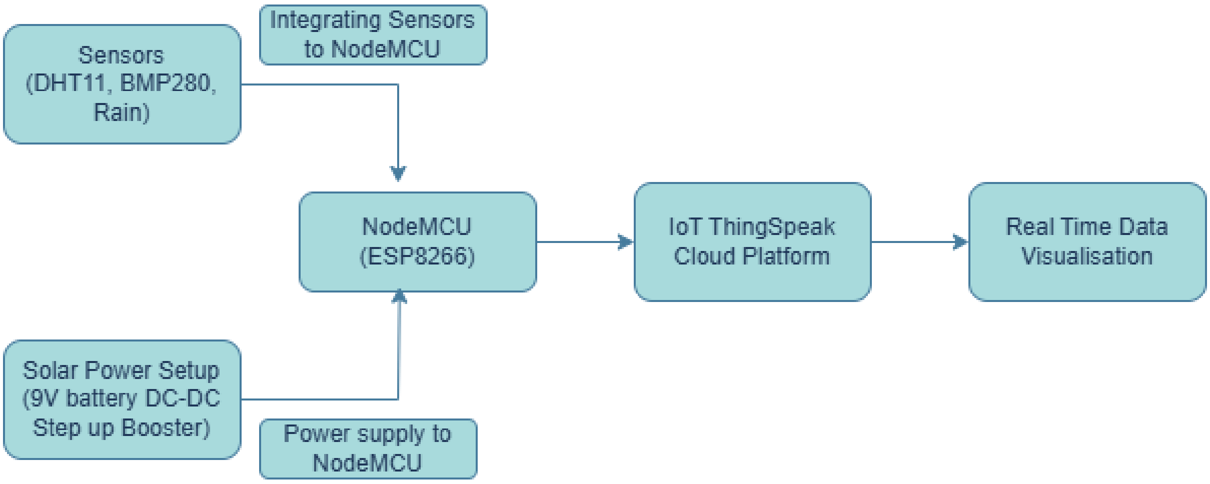


Figure 5.1: System Block Diagram

Block Diagram Description

The block diagram above illustrates the complete system architecture. It integrates sensors, a microcontroller, a solar power setup, and IoT analytics for environmental monitoring and data analysis.

Explanation

The system is divided into the following components:

- **Sensors:** The system utilizes three sensors:
  - *DHT11:* Measures temperature and humidity.
  - *BMP280:* Measures atmospheric pressure.
  - *Rain Sensor:* Detects rainfall intensity.

- **Solar Power Setup:** A solar panel, coupled with a Li-ion battery, powers the system, ensuring energy efficiency and sustainability.
- **Microcontroller (NodeMCU ESP8266):** The NodeMCU collects data from the sensors and transmits it to the cloud via Wi-Fi.
- **IoT Analytics with MATLAB (ThingSpeak):** Sensor data is uploaded to ThingSpeak for IoT analytics and processed using MATLAB.

Simulation:

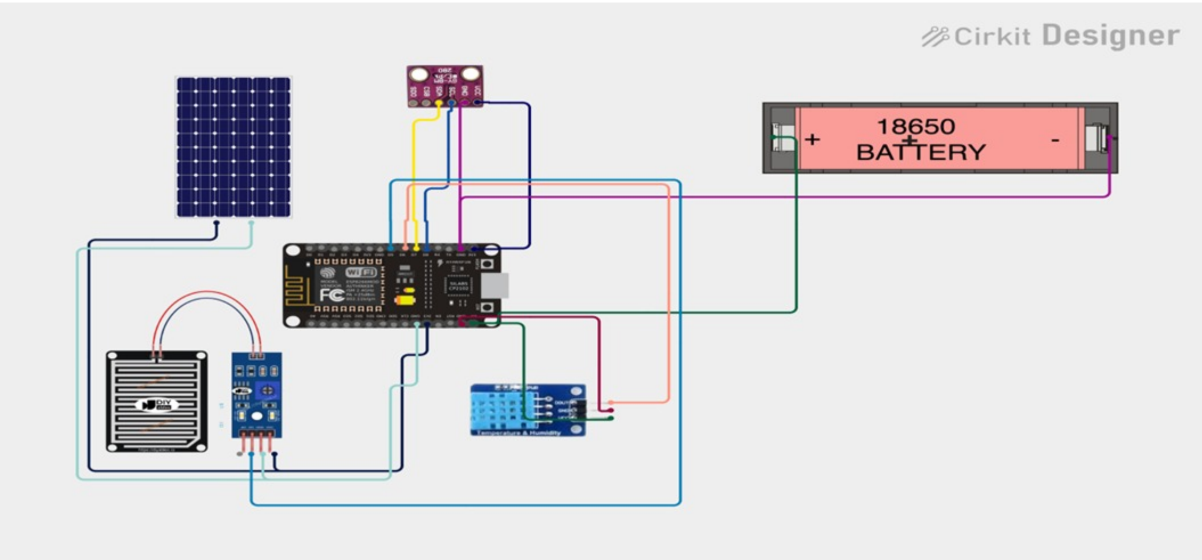


Figure 5.2: Simulation

Chapter 6

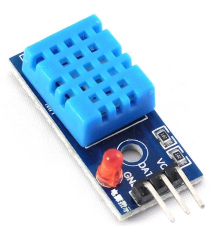
Design Specifications

6.1 Input Specifications

The project uses the following key components:

- **NodeMCU ESP8266:** A low-cost, Wi-Fi-enabled microcontroller ideal for IoT applications. It is responsible for collecting sensor data and transmitting it to the cloud.

- **DHT11 Sensor:** This sensor measures temperature and humidity with decent accuracy, making it suitable for weather monitoring applications.

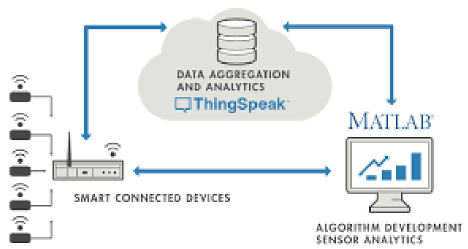


- **BMP280 Sensor:** A barometric pressure sensor used to measure atmospheric pressure and altitude, providing critical weather data.

- **Rain Sensor:** A simple module to detect the presence of rainfall and measure precipitation intensity.

6.2 Output Specifications

We have used ThingSpeak IoT Platform to display the real time data collected through the sensors.



ThingSpeak is a cloud-based IoT platform that enables real-time data collection, storage, analysis, and visualization from connected devices. It supports seamless integration with popular IoT hardware like ESP8266, Arduino, and Raspberry Pi. ThingSpeak offers user-friendly APIs, customizable dashboards, and powerful MATLAB integration for advanced data analysis. It is widely used for applications like weather monitoring, home automation, energy management, and predictive maintenance. While its free version has data upload limits, the platform remains ideal for IoT projects requiring efficient and scalable solutions.

6.3 List of Components

Sr. No.	Name of Component	Specification	Quantity
1	Solar Panel	6V, 5W	1
2	DHT11 Sensor	Temperature and Humidity Sensor	1
3	BMP280 Sensor	Barometric Pressure Sensor	1
4	Li-Ion Battery	3.7V, 2200mAh	1
5	Breadboard	830 Tie Points	1
6	Rain Sensor	Raindrop Detection Module	1
7	1N4007 Diode	General-Purpose Rectifier Diode	1
8	NodeMCU ESP8266	Wi-Fi Microcontroller	1
9	DC-DC Step-Up Booster	Voltage Boost Converter (5V to 12V)	1
10	TP4056 Module	Li-Ion Battery Charger Module	1

Table 6.1: List of Components Required for the Project

Chapter 7

Applications, Advantages, and Future Scope

Applications

- **Weather Monitoring:** The system can be deployed in remote or urban areas to monitor temperature, humidity, rainfall, and barometric pressure in real time.
- **Agriculture:** Useful for farmers to track weather conditions and make informed decisions about irrigation, crop selection, and pest control.
- **Smart Cities:** Integrates with IoT-based smart city infrastructure for environmental monitoring and data-driven urban planning.

Advantages

- **Energy Efficiency:** The use of solar power makes the system self-sustaining and reduces dependency on external power sources.
- **Cost-Effective:** Solar power and low-cost microcontrollers and sensors make the system economical for large-scale deployment.
- **Wireless Communication:** NodeMCU ensures seamless wireless data transmission, eliminating the need for physical connectivity.
- **Scalability:** Additional sensors can be integrated to measure more parameters such as wind speed or air quality.
- **Remote Accessibility:** Weather data can be accessed from anywhere through the ThingSpeak platform, ensuring flexibility and convenience.

Future Scope

- **Integration with AI/ML:** Incorporate machine learning algorithms to predict weather patterns and provide actionable insights.
- **Expanded Parameter Monitoring:** Add sensors for air quality, UV index, and wind speed for comprehensive environmental analysis.

- **Advanced Power Management:** Improve solar power efficiency by incorporating Maximum Power Point Tracking (MPPT) and larger batteries.
- **Global Connectivity:** Extend data transmission capabilities using LoRaWAN or satellite communication for remote areas without Wi-Fi access.
- **Industrial Applications:** Customize the system for specific industries like logistics or energy to monitor environmental conditions affecting operations.
- **Open-Source Platform:** Develop open-source hardware and software versions to encourage community-driven innovation and collaboration.

Chapter 8

Results

The figure below showcases a dashboard displaying real-time monitoring of temperature and humidity using gauge widgets. The temperature is recorded as 29.9°C, and the humidity is at 41. This setup provides an intuitive visual representation of environmental conditions, useful for quick assessments in IoT-based monitoring systems.

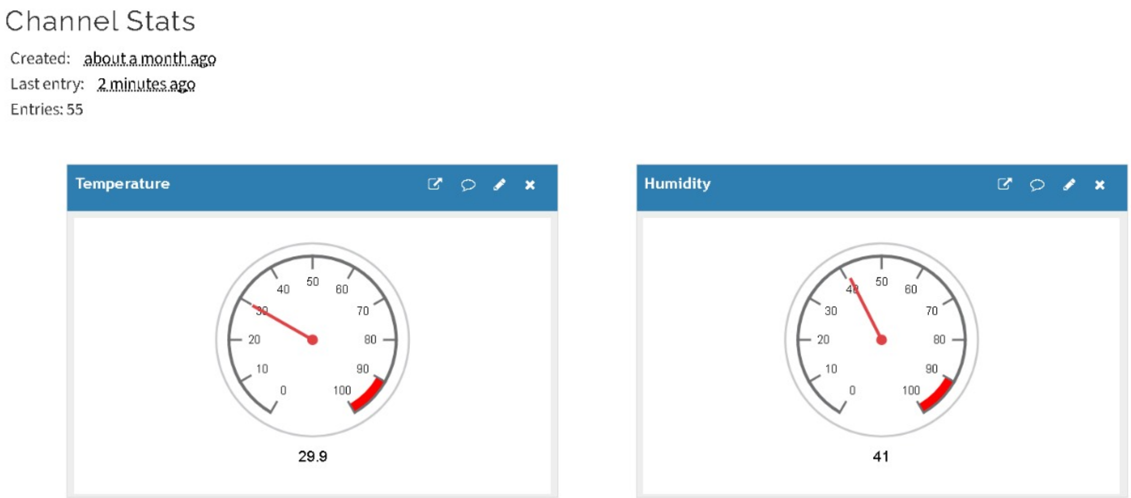


Figure 8.1: ThingSpeak Results

The below figure highlights a time-series analysis of weather parameters, including humidity and rainfall, over a specific period. The graph shows the trend of humidity, ranging from a maximum of 95% on December 10th to a minimum of 37% on December 30th. Additionally, the rainfall data indicates a peak value of 604 units on December 10th and a current value of 81.52 units on December 24th. This visualization is ideal for identifying trends and anomalies in weather monitoring applications.

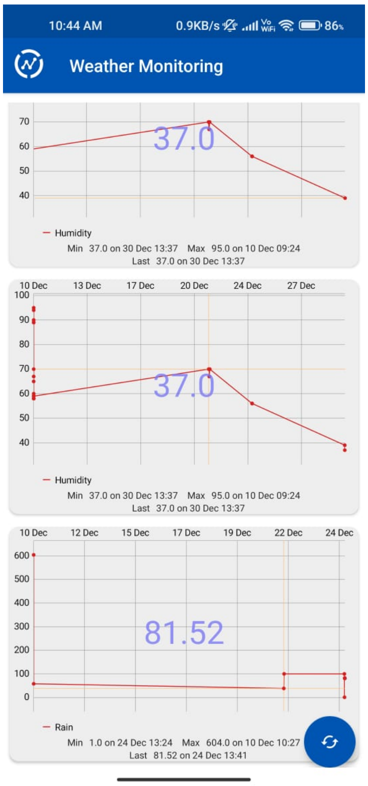


Figure 8.2: ThingSpeak Results in Mobile App

The below figure is our final Model. This project is successfully implemented as per the requirement using the sensors mentioned and the visualisation of real time data on ThingSpeak dashboard is done.

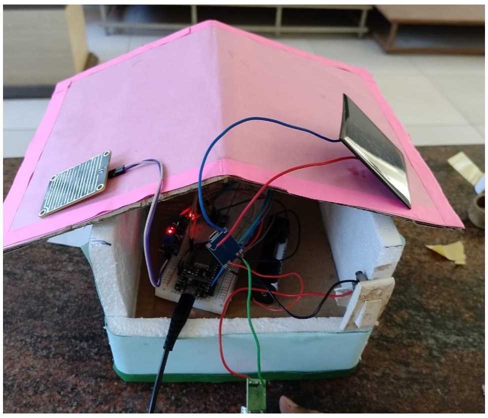


Figure 8.3: Model

Chapter 9

Optimisation

Table 9.1: Optimization Comparison: Pre vs Post Solar Power Implementation

Parameter	**Pre-Optimization**	**Post-Optimization**
Time to Obtain Real-Time Data	20 ms	15 ms
Power Source	External Power (Non-sustainable)	Solar Power (Sustainable)
System Efficiency	Less efficient	More efficient
Sustainability	Not sustainable	Sustainable (Aligns with SDGs 9 & 11)

Chapter 10

Conclusion

The solar-powered wireless weather station effectively combines the principles of renewable energy with advanced Internet of Things (IoT) technologies, presenting an innovative solution for real-time weather monitoring. By harnessing solar energy, the system operates independently of traditional power grids, making it an eco-friendly and sustainable option for diverse applications. Its wireless capability ensures seamless data collection and transmission, which is particularly beneficial for both urban areas with high connectivity demands and remote regions where conventional power and communication infrastructure might be limited.

This project underscores the potential of integrating renewable energy sources with IoT to address modern challenges in environmental monitoring. The real-time weather data collected can be used in various domains, including agriculture, disaster management, urban planning, and climate research.

Future developments could focus on expanding the system's capabilities, such as incorporating advanced sensors for additional parameters like air quality, UV radiation, and soil moisture. Enhancements to the wireless communication range would further extend its usability, allowing deployment in even more remote and challenging terrains. Additionally, implementing machine learning algorithms for predictive analysis and anomaly detection could significantly increase the value of the data generated, offering actionable insights for decision-makers.

In conclusion, the solar-powered wireless weather station serves as a scalable, eco-friendly, and cost-effective framework for monitoring and analyzing environmental conditions, paving the way for smarter, more sustainable solutions in the realm of IoT and renewable energy integration.

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