RENEWABLE ENERGY POWERED WEATHER MONITORING SYSTEM USING IoT

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BACHELOR OF TECHNOLOGY

IN

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CANDIDATE'S DECLARATION

We, Shivam Kaushik (2K19/EE/234), Shresth Srivastava (2K19/EE/238) and Rahul (2K19/EE/197), students of B.Tech (Electrical Engineering), hereby declare that the project Dissertation titled - "Renewable Energy Powered Weather Monitoring System Using IoT", which is submitted by us to the Department of Electrical Engineering, Delhi Technological University, New Delhi in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

Place: New Delhi
Date:

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CERTIFICATE

We, hereby certify that the Project Dissertation titled – "Renewable Energy Powered Weather Monitoring System Using IoT", submitted by Shivam Kaushik (2K19/EE/234), Shresth Srivastava (2K19/EE/238) and Rahul (2K19/EE/197) to the Department of Electrical Engineering, Delhi Technological University, New Delhi in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: New Delhi

Date:

Prof. Radheshyam Saha
(Supervisor)

Mr. Krishna Dutt
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ABSTRACT

Weather estimation plays a crucial role in our daily lives, particularly in the field of agriculture. While national weather data provides general information, it may not be precise for specific locations as it relies on data from the nearest weather station. This project aims to develop a weather station powered by renewable energy sources, allowing for accurate monitoring of weather parameters. The station incorporates various sensors for detecting temperature, air quality, humidity, raindrop, carbon monoxide, smoke, and barometric pressure.

The Arduino microcontroller is used to collect data from these sensors, which is then transmitted to mobile applications via Bluetooth. Real-time monitoring of weather parameters is possible through the mobile application, and in case of critical weather conditions, warning indications and alerts are provided to ensure safety and precautionary measures. The project's objective is to enhance weather monitoring capabilities and provide valuable information for decision-making in various sectors.

ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to all the individuals and organizations who have contributed to the successful completion of our project titled **"Renewable Energy Powered Weather Monitoring System Using IoT"**. This journey has been incredibly enlightening and rewarding for us, and we owe our gratitude to the following individuals and entities.

First and foremost, we extend our sincere thanks to DTU (Delhi Technological University) for providing us with the platform and resources to undertake this project. We are particularly grateful to Prof. Radheshyam Saha & Mr. Krishna Dutt, our Faculty Advisors, for their invaluable guidance, constant supervision, and support throughout the project. Their expertises and insights have been instrumental in shaping the project's direction and ensuring its successful execution.

Furthermore, we express our gratitude to the researchers, authors, and organizations whose work in the field of renewable energy, IoT, and weather monitoring has served as a source of inspiration and knowledge for our project. Their groundbreaking studies and innovative ideas have paved the way for the development of our system.
Lastly, we would like to acknowledge the support and encouragement received from our friends and family throughout this project. Their unwavering belief in our abilities and constant motivation have been invaluable.

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CHAPTER 1

RENEWABLE ENERGY POWERED WEATHER MONITORING SYSTEM :AN INTRODUCTION

1.1 Introduction to Renewable Energy and Weather Monitoring

Weather monitoring plays a crucial role in numerous industries and sectors. In agriculture, accurate and timely weather data is essential for optimizing crop yield and quality, determining irrigation schedules, and managing pest control. It also aids in assessing climate change impacts, enabling researchers and policymakers to develop strategies for sustainable agricultural practices. In the aviation industry, real-time weather updates are vital for ensuring flight safety and minimizing disruptions caused by adverse weather conditions. Additionally, weather monitoring is crucial for effective urban planning, disaster preparedness, and response.

The benefits of weather monitoring extend beyond specific industries. Accurate and up-to-date weather information enables individuals to make informed decisions about daily activities, travel plans, and outdoor events. It enhances public safety by providing timely warnings and alerts for severe weather conditions such as storms, hurricanes, and heatwaves. Furthermore, weather monitoring contributes to scientific research and climate studies, helping scientists gain insights into long-term climate patterns, climate change, and its impact on ecosystems. By collecting and analyzing comprehensive weather data, we can improve our understanding of the Earth's climate system and develop strategies for mitigating the effects of climate change.

Renewable energy-powered weather monitoring systems using IoT have emerged as a popular and environmentally friendly approach in recent years. These systems rely on sensor technology to gather crucial information on various meteorological factors. One notable advantage of employing sources of renewable energy, such as solar and wind power, to operate these systems is their capability to function in remote and off-grid areas. This attribute proves particularly advantageous in regions with limited access to conventional power sources or where reliable weather data is indispensable for agricultural, aviation, or other specific applications.

The integration of IoT technology enables real-time data collection and transmission from these sensors to a centralized platform. This platform facilitates data analysis and utilization for making informed decisions. It empowers users to predict weather patterns, optimize agricultural practices, and improve disaster response strategies. By harnessing renewable energy sources and integrating IoT technology, we can revolutionize weather monitoring systems, making them more sustainable, efficient, and accessible to a wide range of users.

In summary, weather monitoring serves as a foundation for informed decision-making in various sectors and daily life. Its significance lies in its ability to provide accurate, real-time information about weather conditions and trends, enabling us to enhance productivity, safety, and resilience in the face of changing weather patterns. By harnessing renewable energy sources and integrating IoT technology, we can revolutionize weather monitoring systems, making them more sustainable, efficient, and accessible to a wide range of users.

1.2 Problem Statement

The lack of an efficient weather monitoring system poses challenges for individuals and organizations in understanding and responding to weather conditions. Currently, there are limited means for users to access accurate and real-time weather data, including temperature, humidity, and air quality index, which are crucial for making informed decisions and taking appropriate actions.

Without a reliable weather monitoring system, users remain unaware of severe weather phenomena such as strong winds, heatwaves, or other emergencies, putting their safety and well-being at risk. Additionally, the absence of comprehensive weather data hinders accurate weather forecasting, making it difficult for users to plan and prepare for future weather conditions.Furthermore, the inability to access historical weather data prevents users from identifying and analyzing long-term weather patterns and trends. This hampers their ability to make effective assessments and predictions based on past weather measurements.

Therefore, there is a pressing need to develop an advanced weather monitoring system that provides users with real-time weather data, enables accurate weather forecasting, and facilitates the analysis of historical weather patterns. Such a system would empower users to make informed decisions, enhance safety measures, and optimize their activities based on reliable and comprehensive weather information.

1.3 Proposed Methodology

The project's suggested technique involves the development of a renewable energy-powered weather monitoring system using IoT. The system aims to provide real-time weather data without human intervention by utilizing wireless technology.The system will incorporate sensors to measure various weather characteristics such as barometric pressure, temperature, humidity, and rainfall amount. These sensors will be strategically placed in the targeted area of a city or village, allowing for comprehensive weather monitoring.

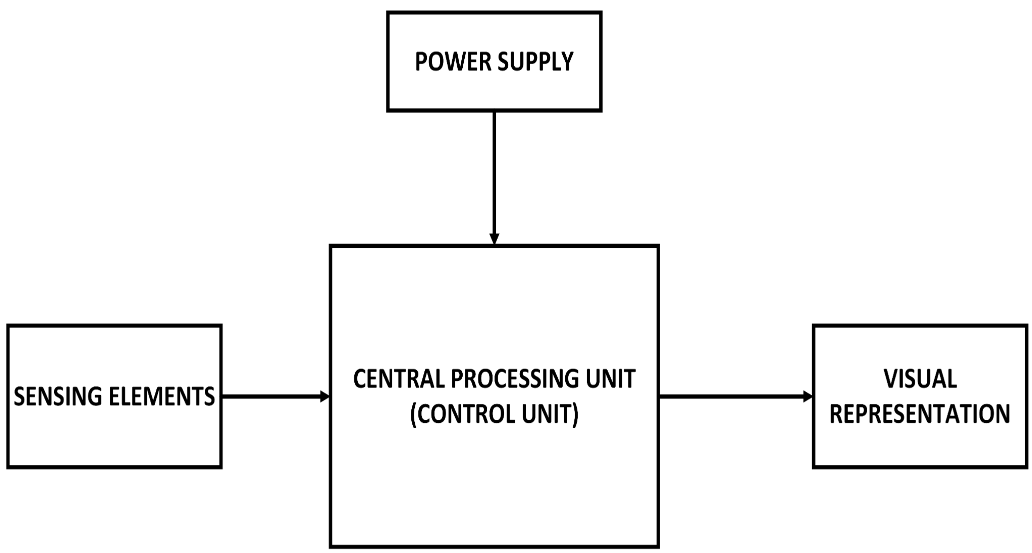

Fig 1.1 Block Diagram of Generic Proposed Weather Monitoring System

To enable easy access to the collected data, the system will transmit the sensor readings to an Android mobile application through a serial Bluetooth terminal window. Users will be able to view the real-time weather information directly on their mobile devices or in the display screen..The implementation of the system will involve the utilization of a microcontroller, which will gather the data from the sensors, that will act as the central hub for data collection and transmission.The renewable energy aspect of the system will be achieved by incorporating solar or wind power sources to provide the necessary energy for the operation of the weather monitoring system. This will enable the system to function in remote areas or locations with limited access to conventional power sources.

By implementing this proposed methodology, the project aims to develop an efficient and reliable weather monitoring system that harnesses renewable energy and utilizes IoT technology. The system will enable users to access accurate and real-time weather data, facilitating better decision-making, improved safety measures, and enhanced agricultural practices.

1.4 Objectives of Renewable Energy Powered Weather Monitoring System

The following are the project's goals:

- To create and implement a weather monitoring system that is powered by renewable energy sources, specifically solar energy, to ensure sustainable and environmentally-friendly operation.
- Implement a number of sensors, including temperature, humidity, air pressure, noise level, and air quality sensors, to collect comprehensive weather data.
- To establish a wireless communication network for seamless transmission of weather data from the sensors to an online database.
- To ensure the reliability and accuracy of the weather monitoring system by conducting a comparison analysis between the collected data and national weather data, evaluating the deviation percentage for temperature, humidity, and barometric pressure.
- Exploring the potential applications of the weather monitoring system, such as weather forecasting, agricultural planning, and environmental monitoring, to highlight its practical value and impact.
- Providing insights and recommendations for future improvements and enhancements of the weather monitoring system, considering factors such as additional sensor integration, scalability, and data visualization options.

1.5 Features of Renewable Energy Powered Weather Monitoring System

The Weather Monitoring System offers several key features. Firstly, it requires low maintenance for end users, ensuring convenience and ease of use. Additionally, it provides real-time weather information and data access through the web, allowing users to stay updated with current conditions. The system boasts high accuracy in its measurements, ensuring reliable and precise data. Moreover, it utilizes renewable energy sources, such as solar panels, for charging the battery, making it environmentally friendly and sustainable.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The field of weather monitoring has witnessed significant advancements in recent years, with a particular focus on utilizing Internet of Things (IoT) technology to enhance data collection and analysis. This literature review aims to provide an overview of various research studies and their contributions in the domain of IoT-based weather monitoring systems. The selected papers cover a range of topics including the design and implementation of weather stations, wireless sensor networks, and cloud-based infrastructure for managing environmental resources.

Weather monitoring systems play a crucial role in various industries by integrating diverse environmental parameters and actuators to modify settings. Accurate weather data is essential for agriculture, packaging industries, and environmental monitoring. However, traditional weather forecasting methods face challenges, highlighting the need for automated systems to improve accuracy and efficiency. In this chapter, literature review of research papers[1-14] has been carried out and illustrated below.

2.2 Weather Stations and Sensor Integration

A weather station is an instrument that provides information about temperature, barometric pressure, humidity, and other weather parameters. It uses sensors to measure these parameters, including temperature, humidity, light intensity, and rain value. The prototype utilizes an ESP8266-based Wi-Fi module, and when values exceed set thresholds, alerts are sent via SMS, email, and social media [1].

An IoT-based weather information prototype is presented, utilizing the WeMos platform for weather monitoring. The prototype demonstrates the integration of IoT technologies for real-time weather data collection and monitoring. By utilizing the WeMos platform, it showcases the potential of IoT in enhancing weather information systems for improved accuracy and accessibility. The system offers opportunities for applications in various fields such as agriculture, aviation, and environmental monitoring [9].

2.3 Real-time Weather Reporting and Data Collection

Introduction of an IoT-based Weather Reporting System designed to determine dynamic climatic parameters. By leveraging IoT technology, real-time weather data is collected and analyzed, contributing to efficient weather monitoring. The research focuses on the integration of IoT for enhanced weather reporting capabilities [3].

The design and implementation of a Weather Monitoring and Controlling System was presented. The system aims to monitor weather conditions and control environmental factors such as temperature, humidity, and lighting. It discusses the hardware and software components used in the system and highlights its potential applications in various settings [4].

2.4 Wireless Communication and Connectivity

It introduces a wireless sensor network-based environmental monitoring system. The system utilizes wireless connectivity to establish communication between sensor nodes and a central monitoring station. It enables real-time monitoring of various environmental parameters such as temperature, humidity, air quality, and noise levels [5].

An IoT-based data logger system for weather monitoring using wireless sensor networks was presented, emphasizing the role of sensor nodes in data collection. The research emphasizes the advantages of wireless connections in providing flexibility, scalability, and easy deployment for efficient environmental monitoring applications [6].

They contained discussion regarding weather monitoring using wireless sensor networks based on Iot. The paper also explores the relationship between climate change, agriculture, and developing countries, focusing on the importance of adaptation [7].

The system utilizes wireless technologies such as Zigbee or Bluetooth to establish communication between sensor nodes and a central monitoring unit. It enables real-time monitoring and data collection of environmental parameters such as temperature, humidity, and air pollution levels. The research highlights the benefits of wireless communication in enabling remote and flexible environmental monitoring, making it suitable for various applications such as smart cities and industrial environments [8].

2.5 Integration of Actuators for Weather Modification

The authors emphasize the significance of integrating temperature, lighting, and humidity monitoring into a single system with actuators to modify these conditions. Discussion regarding distinguishing between weather and climate, highlighting the potential of actuators in modifying weather settings takes place [10].

The potential benefits and challenges associated with using actuators for weather modification, emphasizing their role in influencing and manipulating weather patterns. The paper sheds light on the advancements in actuator technology and its applications in weather modification for various sectors such as agriculture, aviation, and climate research.It also discusses the challenges of manual data collection in surface weather observations, emphasizing the need for automated techniques [13].

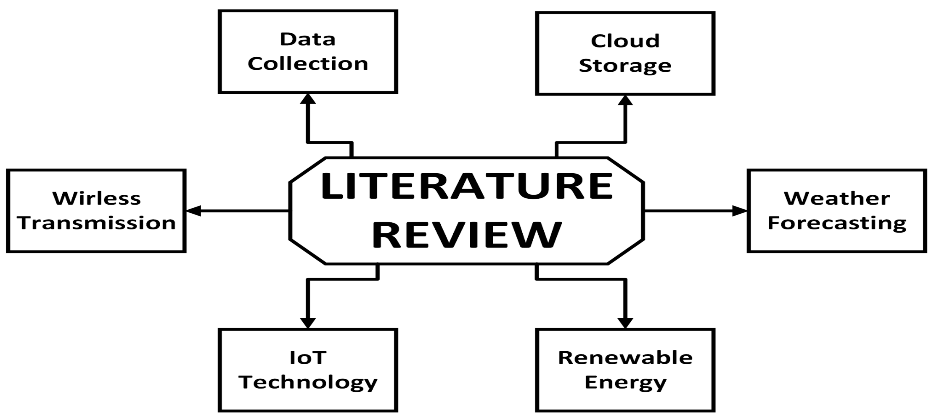

Fig 2.1 Overview of Literature Review

2.6 Weather Monitoring in Industries

The research proposes a weather monitoring system for environmental pollution examination in the packaging industry using Cloud Computing and DHT sensors [4]. Someone introduced a new paradigm for integrated environmental monitoring, focusing on temperature, lighting, and humidity. These studies highlight the importance of weather monitoring in industries [9].

2.7 Advances in Weather Forecasting

The research discusses traditional weather forecasting methods based on observed patterns and experience. They underscore the significance of barometric pressure measurements in forecasting. These advancements emphasize the need for more accurate and automated weather monitoring systems [2].

2.8 Cloud-based Infrastructure for Environmental Resource Management

A cloud-based infrastructure for managing environmental resources, providing scalability and accessibility. Papers also discussed the combination of cloud computing and wireless sensor networks, highlighting the advantages of this integration. Also explored the potential of IoT and cloud computing in environmental monitoring [11].

Integration of various data sources, such as remote sensing and IoT devices, into the cloud platform for real-time data collection and analysis. It emphasizes the benefits of cloud-based solutions, including scalability, cost-effectiveness, and accessibility, in improving environmental resource management practices. The paper showcases the potential of cloud-based infrastructure for enhancing decision-making processes and promoting sustainable resource utilization [14].

2.9 Summary

The literature review highlights the importance of integrating various weather parameters into a comprehensive monitoring system. The lack of research on actuators for modifying temperature, lighting, and humidity settings indicates a gap in current knowledge. The literature also emphasizes the need for automated systems to improve weather forecasting accuracy and efficiency. This literature review also highlights the advancements in IoT-based weather monitoring systems, emphasizing sensor integration, real-time data collection, wireless communication, and the integration of actuators. It showcases the importance of weather monitoring in industries and the need for accurate forecasting. The studies presented contribute to the development

The findings from this review provide a foundation for the development of a robust weather monitoring system capable of accurately forecasting weather conditions and facilitating decision-making in various industries.

2.10 Proposed System

The proposed system incorporates a range of sensors and components to create a comprehensive and sustainable solution. The sensors utilized include the BMP280 for precise temperature and barometric pressure measurement, the MQ135 for air quality detection, the DHT11 for monitoring temperature and humidity levels, and the raindrop sensor for rain detection. These sensors collectively enable real-time environmental monitoring.In addition to the sensor array, the system incorporates a Bluetooth module, specifically the HC-05, which facilitates wireless communication and data transfer. A 16x4 display serves as the primary visual interface, providing clear and concise information. Furthermore, the system leverages mobile display capabilities, allowing users to access and monitor data remotely via their smartphones.

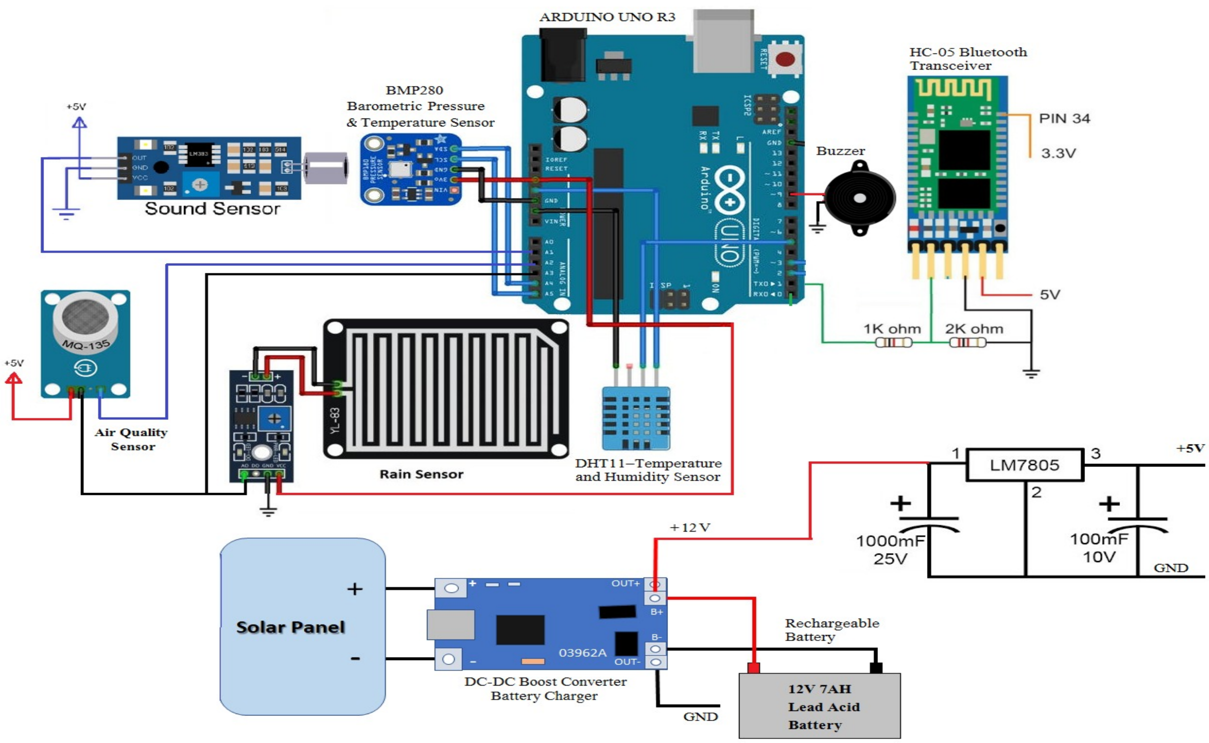

Fig 2.2. Circuit Diagram of Proposed Weather Monitoring System

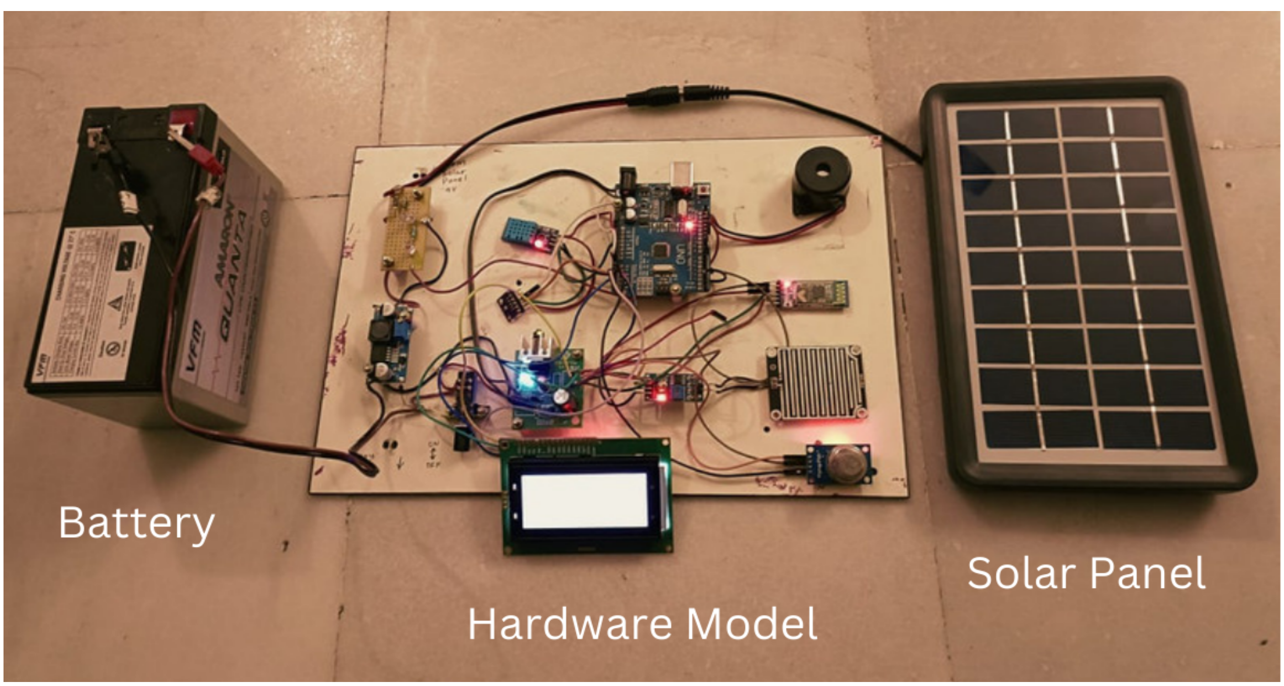

Fig 2.3. Proposed Weather Monitoring System

CHAPTER 3

RENEWABLE ENERGY POWERED WEATHER MONITORING SYSTEM : HARDWARE DESIGN

3.1 Introduction

This chapter describes the hardware layout of the weather monitoring system that runs on renewable energy. The goal is to create a system that can automatically monitor meteorological parameters such as temperature, humidity, barometric pressure, and rainfall. The system utilizes wireless technology to transmit real-time data to an android mobile application, providing users with immediate access to weather readings through a serial Bluetooth terminal window.

The hardware design focuses on selecting and integrating the necessary components to ensure accurate and reliable data collection. Special attention is given to the use of renewable energy sources, such as solar power, to power the system and enable its operation in remote and off-grid locations. By harnessing renewable energy, the Weather Monitoring System can overcome limitations associated with traditional power sources and provide continuous monitoring capabilities.

3.2 Monitoring Parameters

The Weather Monitoring System is designed to capture and monitor key weather parameters essential for accurate weather forecasting. These parameters include temperature, which provides insights into the thermal conditions of the environment; humidity, which measures the moisture content in the air; barometric pressure, which indicates atmospheric pressure variations; and rainfall amount, which tracks precipitation levels. By tracking these parameters in real time, the system can generate comprehensive and up-to-date weather data.

3.3 Data Transmission and Display

To ensure convenient access to the collected weather data, the system incorporates wireless technology for data transmission. The collected readings are transmitted wirelessly to an android mobile application. Through a serial Bluetooth terminal window, users can view the real-time weather data on their mobile devices. Also the weather data can be checked on a 16 x 4 LCD display connected with the arduino.This allows for seamless monitoring of weather conditions and enables users to make informed decisions based on the current environmental conditions.

3.4 Renewable Energy Power Source

A key aspect of the hardware design is the utilization of renewable energy sources to power the Weather Monitoring System. Solar power is particularly harnessed, as it provides a sustainable and reliable energy supply. The integration of solar panels and energy storage systems ensures continuous operation, even in areas with limited access to conventional power sources. This makes the system suitable for deployment in remote locations where weather data is crucial, such as agricultural fields, aviation zones, and environmental monitoring sites.

Moreover, the utilization of renewable energy sources aligns with the global shift towards sustainable practices and the adoption of clean technologies. It not only ensures the continuous operation of the system but also promotes environmental conservation and minimizes reliance on traditional energy grids.By incorporating renewable energy power sources into the Weather Monitoring System, researchers and stakeholders can gather accurate and real-time weather data while embracing environmentally friendly solutions. This integration further enhances the system's versatility and makes it adaptable to various geographical locations and weather conditions.

3.5 Block Diagram

The main controller for the Weather Monitoring System, The Arduino Uno R3 utilizes the ATMega328 microcontroller as its core component. This microcontroller is responsible for receiving inputs from the sensors and facilitating data communication with the wireless monitoring station via Bluetooth. To ensure continuous operation, a battery bank supplies power to the entire system. The battery bank is charged by a solar panel, harnessing renewable energy as a sustainable power source.

Various sensors are employed to gather data for weather prediction. These include a temperature sensor, humidity sensor, air quality sensor, barometric pressure sensor, and raindrop sensor. By collecting data from these sensors, the system can analyze and interpret weather conditions. If any weather parameter exceeds the normal range, an alarm warning sound is generated through a buzzer to alert individuals. The battery stores the power produced by the solar panel. using a DC-DC boost converter-based charger. This ensures efficient energy utilization and maintains power supply to the system.

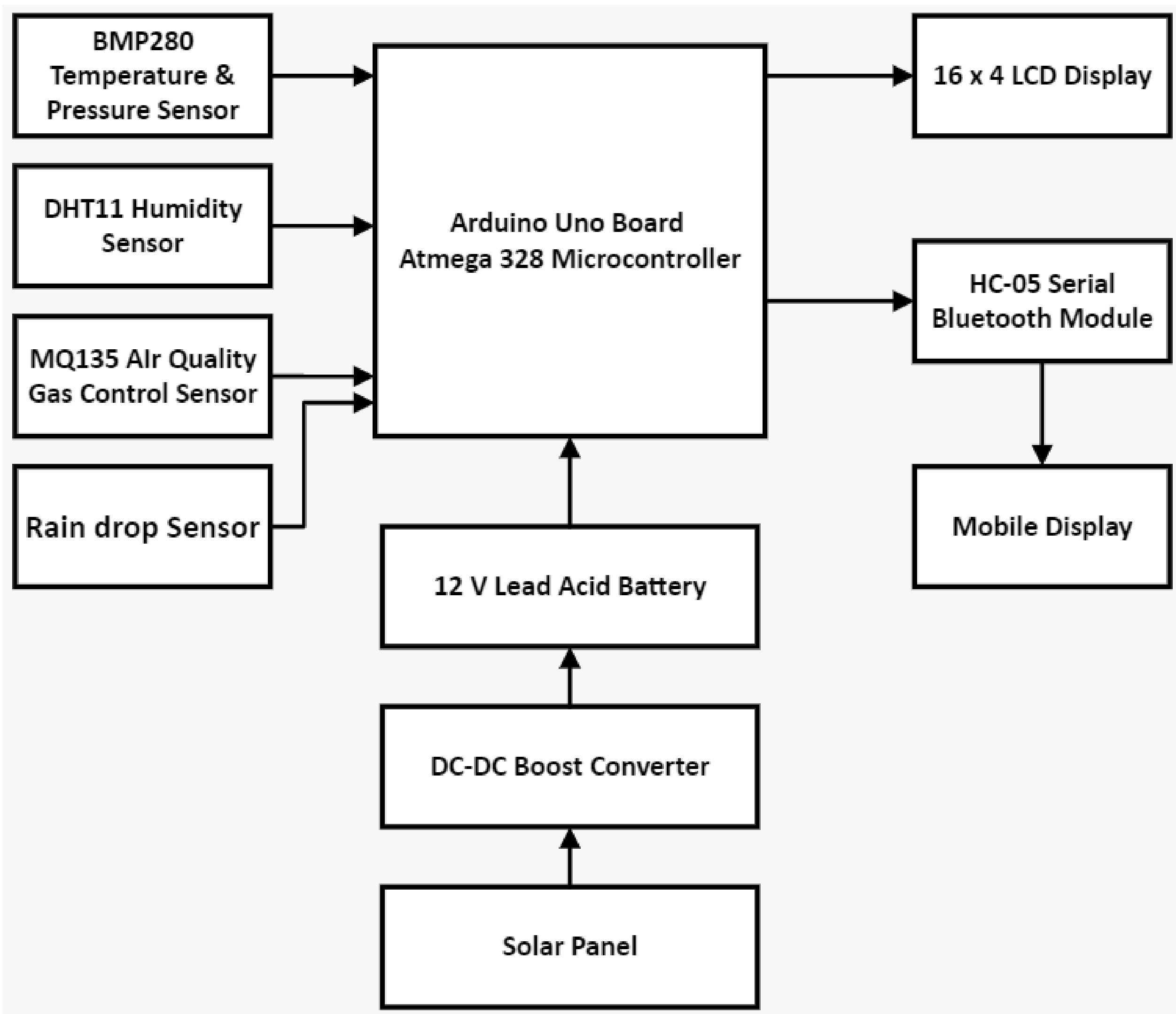

Fig 3.1. Block Diagram of Weather Monitoring System

To provide real-time updates, weather data is transmitted wirelessly to an Android mobile device. This is achieved through the use of a serial Bluetooth terminal application, allowing users to monitor weather conditions remotely and stay informed about any changes or abnormalities.The hardware design of the Weather Monitoring System integrates these components and functionalities to enable accurate data collection, wireless communication, and sustainable operation. The following sections will further elaborate on the specific technical details and implementation of each component.

3.6 Components

In the hardware design of the Weather Monitoring System, various components are utilized to ensure accurate data collection, wireless communication, and sustainable operation. The following components play crucial roles in the system:

1. Sensors :

The following sensors have been used in our hardware model.

- **DHT11 Humidity and Temperature Sensor:** The DHT11 sensor plays a significant role in the system employed to quantify humidity and temperature levels in the environment. It provides reliable and accurate data for monitoring weather conditions.

- **BMP280 Barometric Pressure and Altitude Sensor:** The BMP280 sensor is utilized to measure barometric pressure and altitude. It enables the system to monitor changes in atmospheric pressure, which is essential for weather forecasting and analysis.

- **Rain Drop Sensor:** The raindrop sensor is designed to detect rainfall. It acts as a switch when raindrops fall on the sensor, providing valuable data on precipitation levels.

- **MQ135 Air Quality Gas Control Sensor:** The MQ135 sensor is responsible for detecting harmful gases and monitoring air quality. It enables the system to measure gases such as ammonia, benzene vapor, and smoke, ensuring comprehensive environmental monitoring.

2. HC-05 Serial Bluetooth Module: The HC-05 module serves as a wireless communication interface. It allows the system to transmit data to a remote monitoring station or an Android mobile application for real-time updates and analysis.

3. Arduino Uno: The Arduino Uno acts as the main controller in the system. It incorporates the ATmega328 microcontroller, which gathers input from the sensors and facilitates communication with the wireless monitoring station through Bluetooth.

4. Battery:A battery is used to supply power to the Weather Monitoring System. It ensures uninterrupted operation, even in the absence of conventional power sources.

5. DC-DC Boost Converter: The DC-DC boost converter plays a crucial role in energy management. It efficiently charges the battery using the power generated by the solar panel, optimizing energy utilization and supporting sustainable operation.

6. Solar Panel: The solar panel harnesses renewable energy from the sun and converts it into electrical power. It charges the battery, ensuring a continuous and eco-friendly power supply for the Weather Monitoring System.

7. 16 x 4 LCD Display: The 16 x 4 LCD display provides a visual interface to view and monitor weather data. It allows users to conveniently access information such as temperature, humidity, barometric pressure, and other relevant parameters.

These components work together harmoniously to create an efficient and reliable Weather Monitoring System capable of collecting and analyzing data for accurate weather forecasting and monitoring.

3.6.1 DHT11 Temperature and Humidity Sensor

The DHT11 sensor is a commonly used sensor that provides digital readings for both temperature and humidity.. It incorporates a capacitive humidity sensor and a thermistor to accurately measure the surrounding air conditions. The sensor provides a digital signal on the data pin, eliminating the need for analog input pins. Its compact size and ease of use make it a popular choice for embedded systems.

The DHT11 sensor has the following features:

- **Relative Humidity and Temperature Measurement:** It has a temperature measurement range of 0°C to 50°C with an accuracy of ±2°C. It also measures relative humidity in the range of 20% to 80% with an accuracy of ±5%.
- **Long-Term Stability:** The sensor demonstrates excellent long-term stability, ensuring reliable and consistent performance over time.
- **No Additional Components Required:** Unlike some other sensors, the DHT11 does not require additional components for operation, simplifying the design and reducing costs.
- **Long Transmission Distance:** It can transmit data over a distance of up to 100 meters, making it suitable for applications requiring extended range communication.
- **Low Power Consumption:** The sensor operates with low power consumption, conserving energy and prolonging battery life in battery-powered applications.

The DHT11 sensor employs a technique for digital signal collection and utilizes advanced humidity sensing technology, which contributes to its reliability and stability. Each sensor undergoes temperature compensation and calibration in a precise calibration chamber, ensuring accurate and precise measurements of temperature and humidity, with calibration coefficients stored in the sensor's memory. This allows for accurate humidity measurements and eliminates the need for additional calibration steps.

The compact size, low power consumption, and long transmission distance make the DHT11 sensor suitable for various demanding applications. Its single-wire serial interface facilitates easy integration into existing systems. With its high-quality performance, fast response time, and anti-interference capabilities, it becomes a cost-effective choice for applications requiring temperature and humidity monitoring, making it an ideal component for weather monitoring systems and other applications requiring environmental sensing.

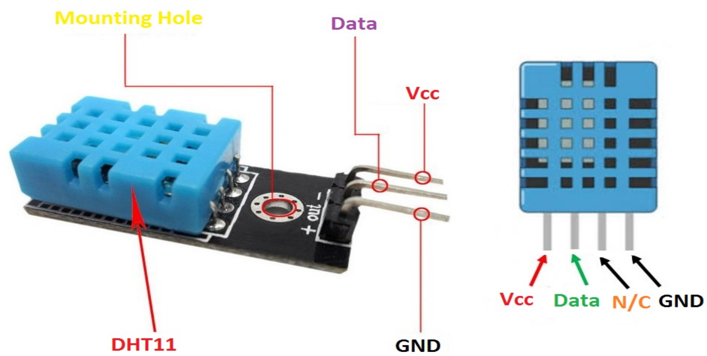

Fig 3.2 DHT11 Pin Diagram

3.6.1.1 DHT11 Pins Description

Pin	Parameters
Pin1 - Vcc	Provides power supply of 3.3V to 5V.
Pin2 - Data	Outputs a digital signal..
Pin3 - N/C	Not Connected.
Pin4 - Ground	Connected to the ground (0V / GND)

Table 3.1. DHT11 Pins Description

3.6.1.2 DHT11 Working Principle

The DHT11 sensor operates based on the following two principles:

1) **Humidity Measurement:**The sensor employs a capacitive humidity sensor comprising two electrodes and a substrate material for accurate humidity measurements.. As the moisture content in the environment changes, it saturates the substrate material. The

resistivity between the electrodes is measured to determine the humidity level. This change in resistivity is then calibrated using the stored humidity coefficient in the sensor's OTP (One-Time Programmable) memory, resulting in the release of the relative humidity value.

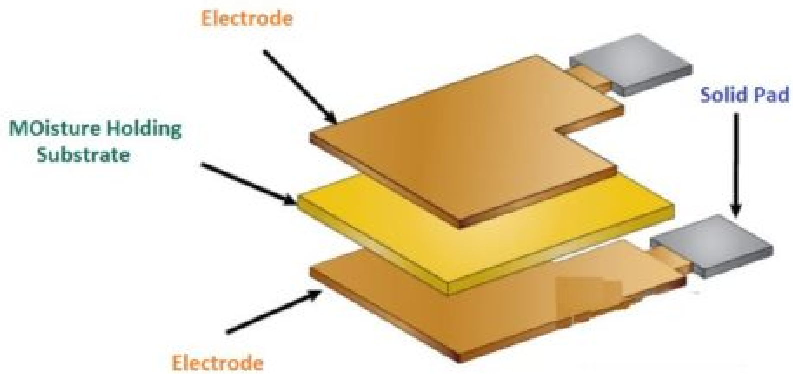

Fig 3.3. DHT11 Humidity measurement part

2) Temperature Sensing

The DHT11 sensor incorporates a thermistor, sometimes referred to as Negative Temperature Coefficient (NTC) temperature sensor. The thermistor is attached to the wall inside the sensor's plastic casing. It exhibits a negative correlation between temperature and resistance, with its resistance decreasing as the surrounding temperature increases. The thermistor is designed with semiconducting materials, including ceramics, polymers, to provide a significant difference in resistance for a slight temperature shift.

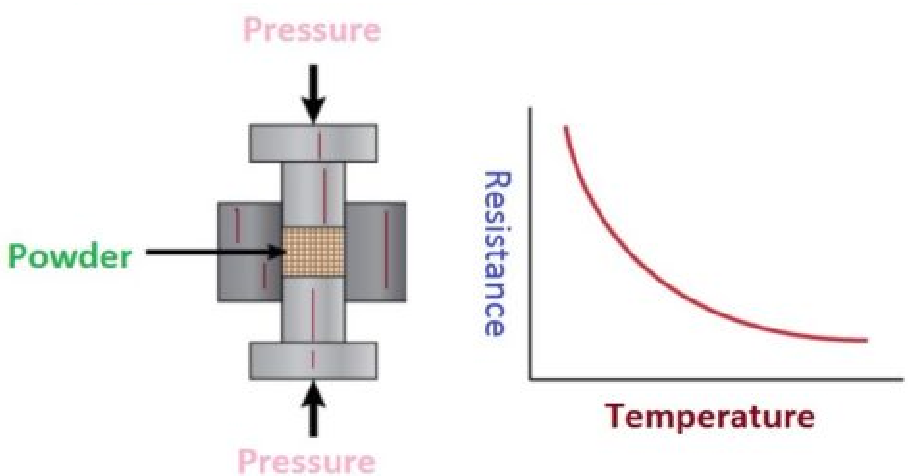

Fig 3.4. Temperature Sensing

3.6.1.3 DHT11 Sensor communication with Microcontroller

When communicating with a microcontroller, the DHT11 sensor follows the following process:

1. The Data Pin of the DHT11 sensor should have a pull-up resistor of 5k ohms.
2. Under normal conditions, the Data Pin of the sensor is maintained at a HIGH voltage level, enabling the sensor to operate in low power consumption mode.
3. To initiate data transmission, the microcontroller must pull the Data Pin low for at least 18 microseconds, allowing the sensor to detect the signal.
4. Once the sensor detects the low signal, it waits for the Data Pin to hit HIGH before switching from low power consumption mode to running mode. again.

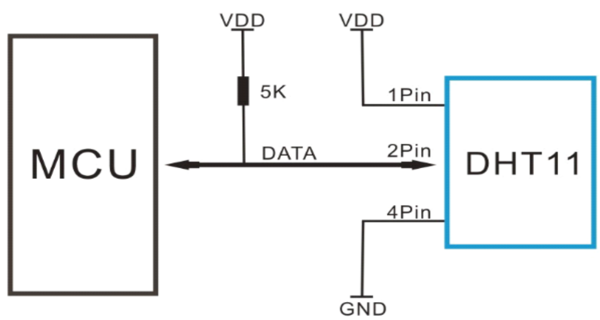

Fig 3.5. DHT11 Communication with Microcontroller

5. When the microcontroller sets the Data Pin to HIGH, the DHT11 sensor sends out the 40-bit calibrated output value in a serial manner.
6. After transmitting the data, the sensor waits for the microcontroller's next command before switching to a low power mode.
7. The microcontroller must wait for 20-40 microseconds to receive a response from the DHT11 sensor.

This communication process enables the microcontroller to retrieve temperature & humidity data from the DHT11 sensor accurately and reliably.

3.6.2 BMP 280 Barometric Pressure And Altitude Sensor

BMP280 Barometric Pressure and Altitude Sensor is a compact and affordable atmospheric sensor breakout. It provides accurate measurements of barometric pressure and temperature while occupying minimal space.The BMP280 is a dependable option whether you need to collect data on atmospheric conditions for navigation, weather forecasting, home automation, or self-health monitoring.

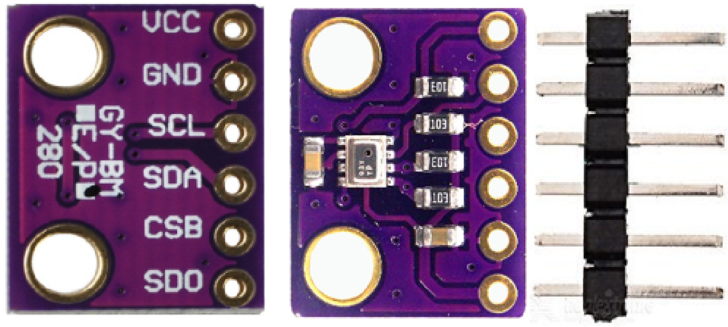

Fig 3.6. BMP280 Barometric Pressure and Altitude Sensor

The BMP280 sensor is specifically designed for mobile applications, making it ideal for integration into gadgets with batteries, including watches, GPS units, and mobile phones. Its small size and low power consumption contribute to its suitability for such devices. Bosch's cutting-edge piezo-resistive pressure sensor technology is used by the sensor to ensure high precision, linearity, long-term stability, and robust EMC performance.With a range of operational options, the BMP280 offers exceptional flexibility. It is optimized to deliver optimal power consumption, resolution, and filter performance.

3.6.2.1 BMP280 Sensor I2C/SPI Module

BMP280 Barometric Pressure & Altitude Sensor I2C/SPI Module is a versatile sensor suitable for various weather sensing applications. It offers compatibility with both I2C and SPI interfaces, providing flexibility in integration. With its high precision and low cost, this sensor is an excellent choice for measuring temperature with a 1.0°C precision and barometric pressure with an absolute accuracy of 1 hPa. (1 hPa = 100Pa)

It is particularly effective in capturing pressure changes with altitude, making it a reliable tool for accurate pressure measurements.

Fig 3.7. BMP280 Module

3.6.2.2 Circuit Diagram of BMP280 Sensor

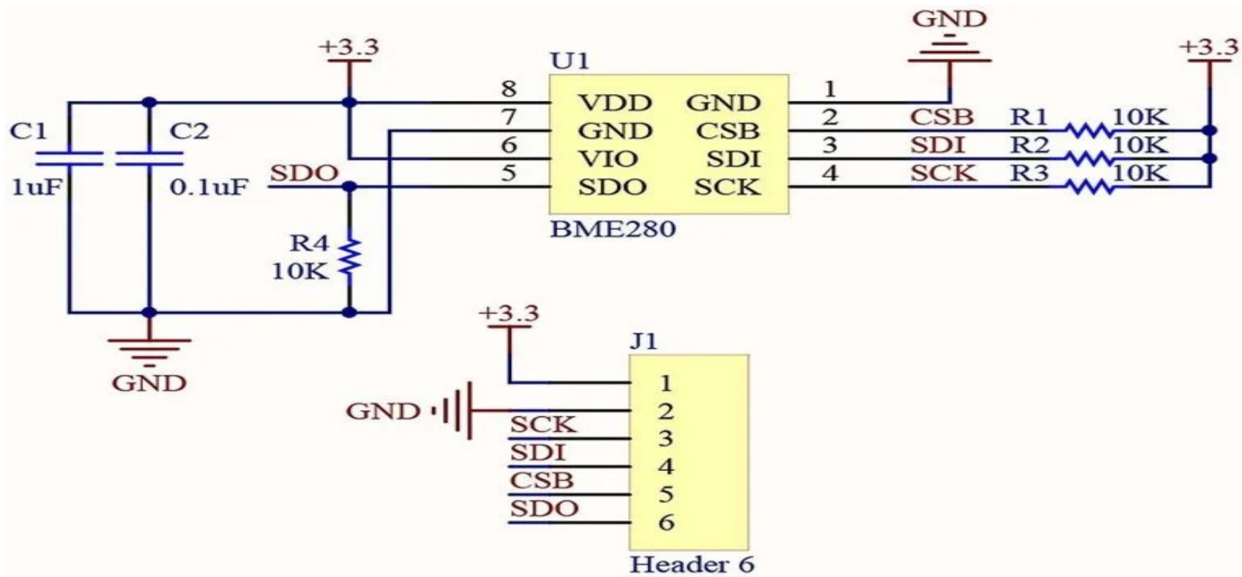

Fig 3.8. Circuit diagram of BMP280 Sensor

3.6.2.3 BMP280 Sensor PINOUT

Six pins make up the BMP280 Digital Pressure Sensor module: VCC, GND, SCL, SDA, CSB, and SDO. Except for VCC and GND, every single pins on this sensor module is of digital type.

- VCC: This pin is the power supply, which can be connected to either 3.3V or 5V. Please note that the analog output may vary depending on the supplied voltage.
- GND: The ground pin of the sensor, which should be connected to the ground pin of the Arduino or the system.
- SCL: Serial Clock, used by the master device to generate clock signals for communication. It pulses this pin at regular intervals.

Fig 3.9. BMP280 Pinout Figure

- SDA: Serial Data, facilitates the exchange of data between two devices.
- CSB: Chip Select pin, utilized for device selection when communicating via SPI. It allows selecting one device if multiple devices are connected on the same bus.
- SDO: Data is transmitted to another SPI device using the Serial Data Out pin, an output signal.

3.6.2.4 BMP280 Sensor Module Parts

It is designed such that the sensor module is user-friendly, requiring only a few readily available parts for operation. The module incorporates a MEMS-based sensor capable of detecting abrupt variations in temperature and barometric pressure. The parts involved in the module are as follows:

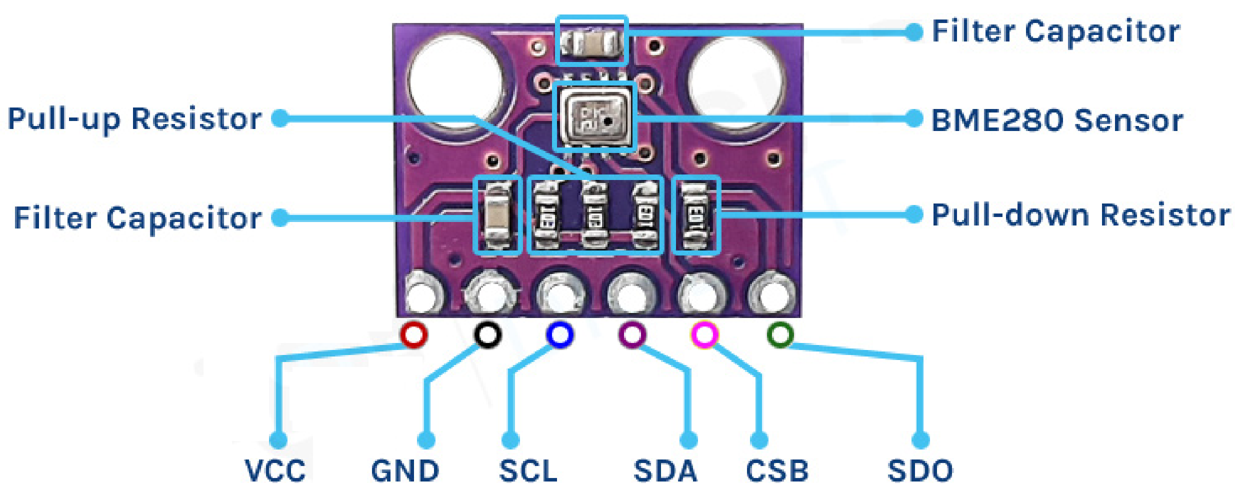

Fig 3.10. BMP280 Digital Pressure Sensor Module Parts

Figure displays the parts used in the BMP280 Digital Pressure Sensor module. Among the six pins, two pins are power pins, VCC & GND, and the remaining are dedicated to data and clock signals, with all four being 5V tolerant. The module also includes two 100nF filter capacitors—one for filtering the analog power line and the other for powering the digital power line. Additionally, there are three pull-up resistors used for SDA, SCL and SDO, as well as one pull-down resistor for SDI. Together, these components form the BMP280 sensor module.

3.6.2.5 BMP280 Voltage and Operating Parameters

When using the BMP280 device, it is important to note that it is not tolerant to 5V and should be operated at 3.3V. The operating parameters for the BMP280 are as follows:

- **Operating Voltage:** The device can operate within the range of 1.8 V to around 3.6 V, but it is usually operated at 3.3V.
- **Operating Temperature:** The BMP280 can function in a temperature range from -40 to +85 degrees Celsius. For full accuracy, the recommended temperature range is between 0 and +65 degrees Celsius.
- **Operating Pressure:** The BMP280 can check pressure within the range of 300 hPa to 1100 hPa.
- **Peak Current:** The device has a peak current of 1.12mA.
- **Accuracy:** The BMP280 provides high accuracy within specific ranges. Between 700 to 900 hPa and 25 to 40 degrees Celsius, the accuracy is ±0.12 hPa and ±1.0 m.

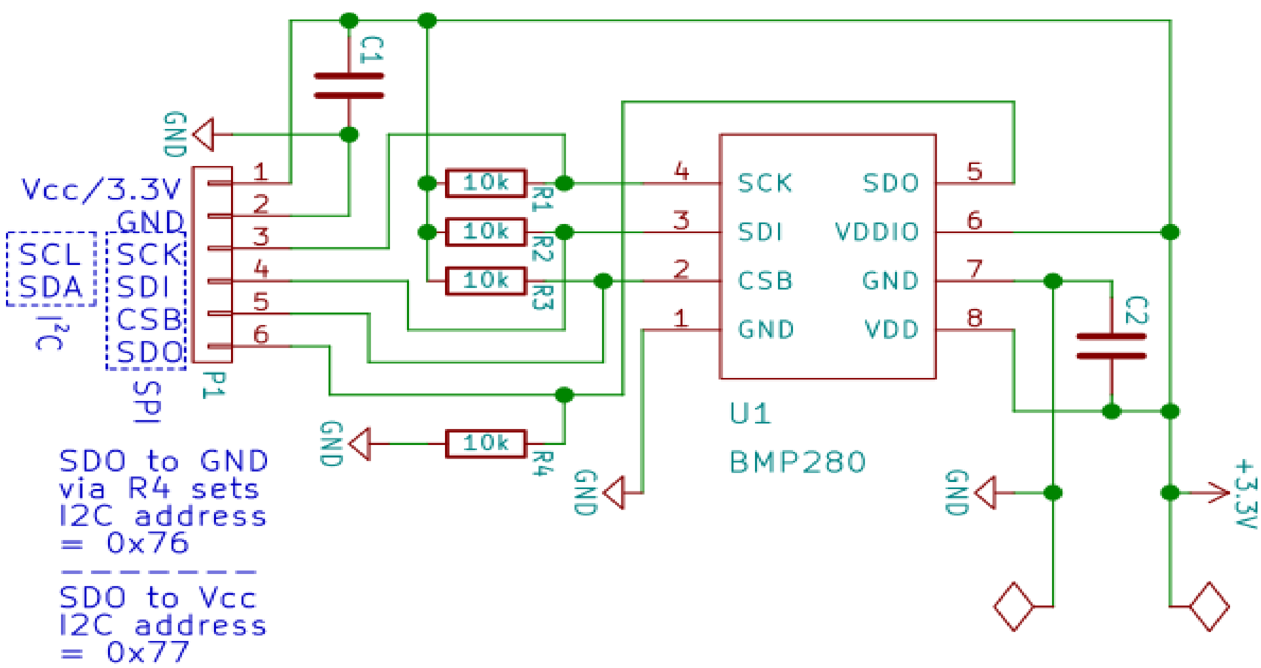

Fig 3.11. BMP280-3.3 Pressure Sensor Module Circuit Diagram

3.6.2.6 BMP280 I2C Configuration

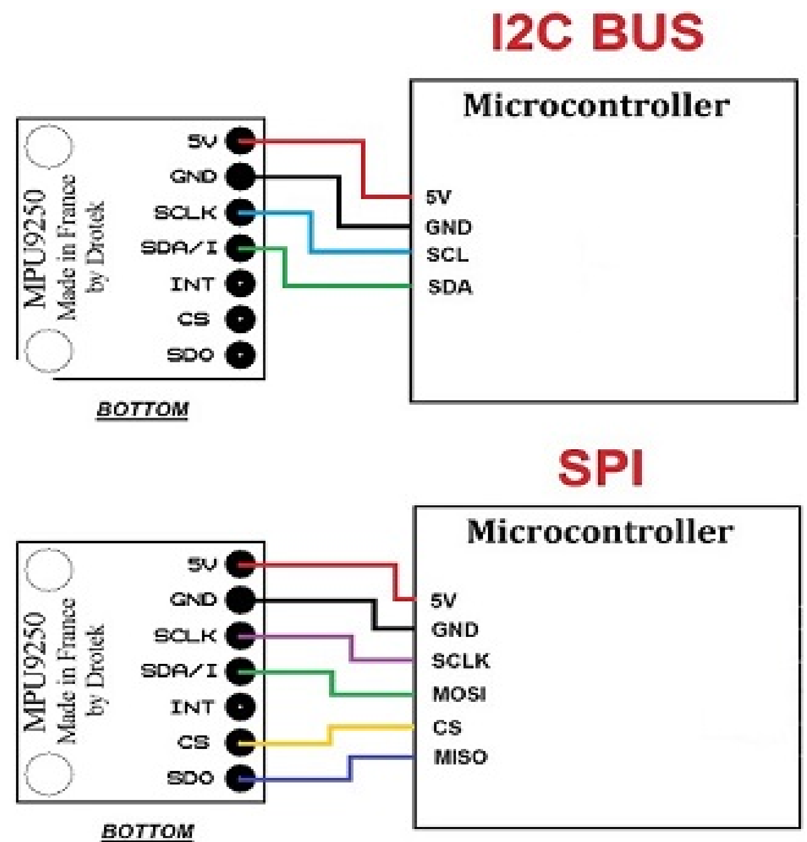

Fig 3.12. BMP280-3.3 I2C and SPI Configuration

There are two ways to set up the module's I2C address. Simply leave pin 6 (SDO) of the module unconnected if you want the address to be set to 0x76. By essentially setting the address to 0x76, the on-board resistor is able to pull the SDO pin low.

The module's pin 6 (SDO), which is ordinarily connected to the 3.3V supply, must be connected to Vcc if you desire the address to be 0x77. The module's pin 5 (CSB), which selects the I2C interface, must be connected to Vcc. When utilizing the I2C interface, however, pin 5 can also be left unconnected because there is an on-board pull-up resistor to handle this. Refer to above figure for a visual representation of the BMP280-3.3 I2C and SPI Configuration.

3.6.2.7 Features of BMP280

The BMP280 sensor offers a range of features that make it a valuable tool for various applications. Its key features include:

- **Precise Measurements:** The BMP280 provides accurate temperature, atmospheric pressure, and approximate altitude data, allowing for more precise readings.
- **GPS Navigation Enhancement:** It enhances GPS navigation systems by improving dead reckoning, time to first fix, and slope detection capabilities.
- **Indoor and Outdoor Navigation:** The sensor is suitable for indoor navigation tasks such as floor detection and elevator detection, as well as outdoor navigation, leisure, and sports applications.
- **Weather Forecasting:** With its ability to measure atmospheric pressure, the BMP280 can contribute to weather forecasting applications.
- **Health Care Applications:** The sensor finds applications in health care, such as spirometry, a medical test that measures lung function.
- **Vertical Velocity Indication:** It can indicate the rise or sink speed in vertical movement scenarios.

In addition to its features, the BMP280 operates within the following specifications:

- **Operating Voltage:** The sensor can operate within a voltage range of 1.71V to 3.6V, with typical operation at 3.3V.
- **Operating Temperature:** It can function in extreme temperature conditions, with an operating range of -40 to +85 degrees Celsius. For optimal accuracy, it is recommended to operate the sensor between 0 and +65 degrees Celsius.
- **Operating Pressure:** The BMP280 can calculate pressure in the range of 300 hPa to 1100 hPa.
- **Peak Current:** The sensor has a peak current of 1.12mA.
- **Accuracy:** For pressure readings between 700 to 900 hPa and temperatures ranging from 25 to 40 degrees Celsius, the BMP280 offers an accuracy of ±0.12 hPa and ±1.0m.

With its wide range of applications and reliable performance, the BMP280 sensor provides valuable data for various projects and systems. The BMP280 sensor is a versatile device used in various applications. It finds use in weather monitoring, altimeters for outdoor activities, indoor navigation systems, IoT devices, drones, automotive systems, and industrial monitoring. It measures temperature and barometric pressure, allowing accurate weather forecasting, altitude measurement, and precise environmental monitoring. With its compact size, low power consumption, and accurate measurements, the BMP280 sensor is integrated into devices like weather stations, smart home systems, wearable devices, and manufacturing processes. Its applications span across weather prediction, navigation, IoT, aviation, automotive, and industrial sectors, making it a valuable tool for environmental sensing and control.

3.6.3 Rain Drop Sensor

The raindrop sensor, also known as a rain detector sensor, is a user-friendly device designed to detect rainfall. It functions as a switch, triggering an action when raindrops come in contact with the sensor. With slight modifications to the code, it can also measure the intensity of rainfall. Additionally, this sensor includes a separate indicator LED and an onboard potentiometer, allowing for sensitivity adjustment of the output digital signal.

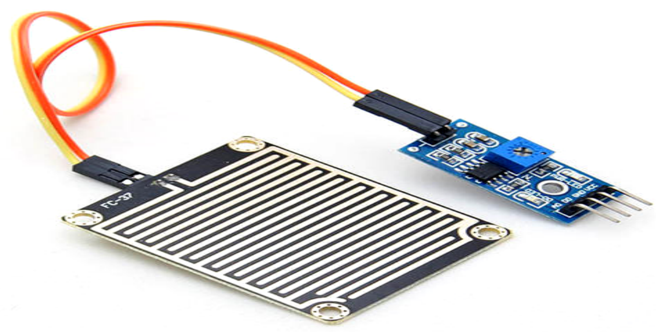

Fig 3.13 : Rain Drop Sensor Module

3.6.3.1 Rain Detection Sensor Pinout

The raindrop sensor module features four pins: VCC, GND, Aout, and Dout. These pins provide the necessary information from the sensor. The pinout for the raindrop detection sensor is as follows:

- Analog Output pin: Provides an analog signal ranging from supply voltage 0V to 5V.
- Digital Output pin: From the internal comparator circuit, provides a digital output. It can be directly linked to a 5V relay or other similar device or to a digital pin on an Arduino.

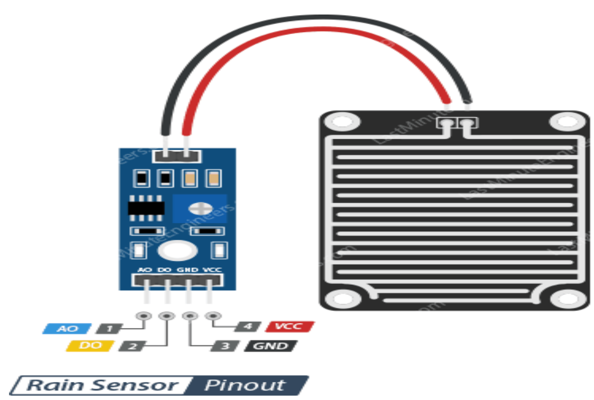

Fig 3.14 : Rain Detection Sensor Pinout

- GND: Ground connection.
- VCC: The sensor's power supply pin. It is advised to use a voltage of between 3.3V and 5V to power the sensor. Please be aware that depending on the voltage applied to the sensor, the analogue output will change.

3.6.3.2 The Sensing Pad

The detecting pad of the raindrop sensor has several exposed copper traces. This pad is placed in an open area, exposed to potential rainfall.

Fig 3.15: The Sensing Pad

3.6.3.3 The Module

This sensor includes an electronic module device which connects the sensing pad to an Arduino or similar microcontroller.

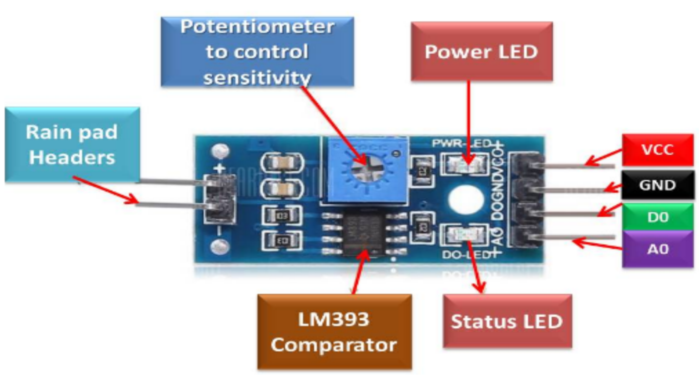

Fig 3.16. Rain Module

This module generates an output voltage corresponding to what is the resistance/resistivity of the sensing pad. The voltage is accessible at an Analog Output (AO) pin. Simultaneously, the signal is provided to an LM393 High Precision Comparator to digitize it, and the digital output is available at a digital Output pin.

Fig 3.17: Rain sensor sensitivity adjustment

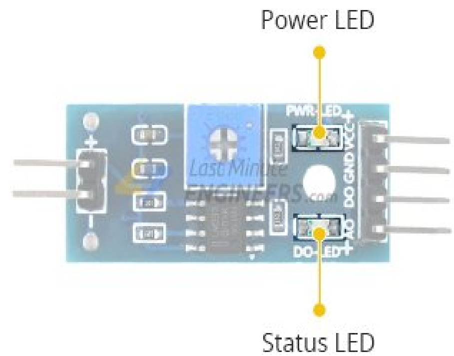

Fig 3.18. LED of Rain Module

The rain module features an internal potentiometer that allows for sensitivity adjustment of the digital output. By setting a threshold using the potentiometer, the module can produce a LOW output when the water amount surpasses the threshold, and a HIGH output otherwise.

3.6.4 MQ135 Air Quality Gas Control Sensor

3.6.4.1 Introduction

The MQ135 Air Quality Gas Sensor is a widely used sensor for monitoring the quality of air and detecting the presence of various harmful gases. It is capable of detecting gases such as ammonia (NH3), nitrogen oxides (NOx), benzene (C6H6), carbon monoxide (CO), and other volatile organic compounds (VOCs) in the atmosphere. This sensor is highly popular due to its affordability, ease of use, and reliable performance.

It operates on the principle of chemical resistance change, where the presence of different gases leads to variations in the sensor's resistance. By measuring these resistance changes, the MQ135 sensor provides valuable insights into the air quality and helps in identifying potential health risks and environmental pollution.

In this project, we explore the functionality and applications of the MQ135 sensor, highlighting its importance in promoting healthier and safer environments.

3.6.4.2 Working Principle of MQ135 Air Quality Sensor

The MQ-135 sensor operates based on a chemical reaction between gas molecules and its sensitive layer. It consists of a ceramic heating element and a sensing element made of tin dioxide (SnO2) coated with a metal oxide sensitive layer. When the target gas enters the sensor, it interacts with the metal oxide layer, leading to a change in the sensor's resistance. This resistance change is then converted into a signal, which is read by a microcontroller.

Fig 3.19. MQ135 Air Quality Gas Control Sensor

3.6.4.2.1 Specifications of MQ135 Air Quality Sensor

The MQ-135 sensor operates at a voltage of DC 5V and has a current power consumption of 150mA. It provides a TTL level digital signal (0.1V and 5V) for digital output (DO). For analogue output (AO), the voltage ranges from 0.1V to 0.3V relative to pollution, with a maximum concentration voltage of about 4V. These specifications enable the MQ-135 sensor to effectively detect and measure air quality levels, making it suitable for various applications related to pollution monitoring and control.

3.6.4.2.3 Advantages and Applications of MQ135 Air Quality Sensor

The MQ135 air quality sensor offers several advantages and applications. Its seamless integration with popular microcontrollers such as Arduino and Raspberry Pi makes it a preferred choice for DIY air quality monitoring projects. The sensor is cost-effective and readily available, making it accessible to hobbyists and enthusiasts. It can detect a wide range of harmful gases, including ammonia, benzene, smoke, and various volatile organic compounds (VOCs). This makes it suitable for applications such as indoor air quality monitoring, detecting gas leaks, and ensuring safety in enclosed spaces. However, it's important to note that the MQ135 sensor may have lower accuracy and sensitivity compared to specialized and more expensive sensors. Factors like temperature and humidity can also affect its readings. Periodic calibration and the use of complementary sensors are recommended for obtaining accurate and reliable data in practical applications.

3.6.5 LCD Display

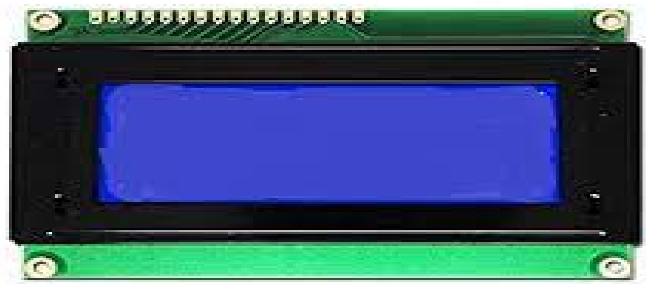

Fig 3.20. LCD Display

The 16x4 LCD Display with I2C, as shown in Fig. 3.20, is a compact and versatile display module that utilizes liquid crystal technology for clear and readable information presentation. It features a 16-character by 4-line display format, making it suitable for various applications. The module communicates through the I2C interface, providing convenient integration with different devices and microcontrollers. The I2C address is set to 0x27 by default, but it can be adjusted to meet specific requirements. The display operates on a 5V power supply and offers an optional blue or white backlight for improved visibility in different lighting conditions. Contrast adjustment can be easily made using the onboard potentiometer. With its standard ASCII character set and operating temperature range of 0°C to 50°C, the 16x4 LCD Display with I2C is a reliable and informative display solution for diverse applications.

Specifications for the 16x4 LCD Display with I2C:

- Display Type: Liquid Crystal Display (LCD)
- Display Size: 16 characters x 4 lines
- Communication Interface: I2C (Inter-Integrated Circuit)
- I2C Address: 0x27 (default, adjustable)
- Supply Voltage: 5V
- Backlight: Blue or White (optional)
- Contrast Adjustment: Potentiometer on the module
- Character Set: ASCII
- Operating Temperature: 0°C to 50°C

3.6.6 HC-05 SERIAL BLUETOOTH MODULE

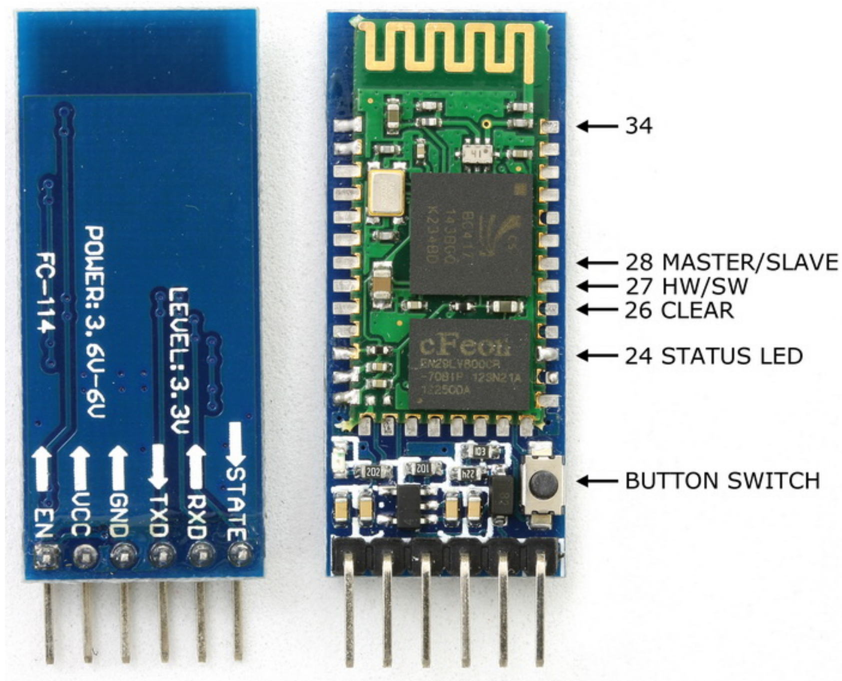

Fig 3.21. HC-05 Bluetooth Module

A class-2 Bluetooth module with Serial Port Profile support is the HC05, shown in figure 3.21. It offers a simple and wireless serial port connection and may be set up as either a master or slave device. The HC-05 module offers transparent operation and simple integration as a drop-in replacement for wired serial connections.

The Bluetooth HC-05 module operates in the 2.4GHz ISM band and is Bluetooth Specification v2.0+EDR compliant. For dependable wireless communication, Gaussian Frequency Shift Keying (GFSK) modulation is used. The module can reach a range of roughly 10 metres with a maximum emission power of 4dBm (Class 2). With a reception level of -84dBm at 0.1% Bit Error Rate (BER), it delivers high sensitivity. The HC-05 can transfer data at synchronous and asynchronous rates of up to 2.1Mbps and 1Mbps/1Mbps, respectively. For improved security, it offers authentication and encryption. The module operates on a +3.3V DC power source with a current consumption of 50mA and is compatible with Bluetooth serial port profiles. From -20 to +75 degrees Celsius, it can resist a wide variety of temperatures.

3.6.6.1 Bluetooth Serial Interface Module

The Bluetooth serial interface module is designed to convert a serial port into a Bluetooth connection. These modules offer 2 modes- master & slave. The mode, either master or slave, is factory-defined and cannot be changed for modules with even-numbered names. However, modules with odd-numbered names can have their work mode set by using AT commands.

The conventional serial port line will be replaced by a Bluetooth serial module with a wireless connection. It enables communication between two microcontroller units (MCUs) by connecting one to the Bluetooth master device and the other to the slave device. Once paired, the devices can establish a connection.

Additionally, An MCU can communicate with Bluetooth adapters on PCs and smartphones if it contains a Bluetooth slave module, creating a virtual serial port connection between the MCU and the computer or smartphone. Many Bluetooth devices on the market, such as Bluetooth printers and Bluetooth GPS devices, are primarily slave devices. To communicate with them, a master module is used to establish a pair and facilitate communication.

By leveraging the HC-05 Bluetooth module, users can achieve wireless serial communication and enable seamless integration between various devices and systems.

3.3.7 ARDUINO UNO

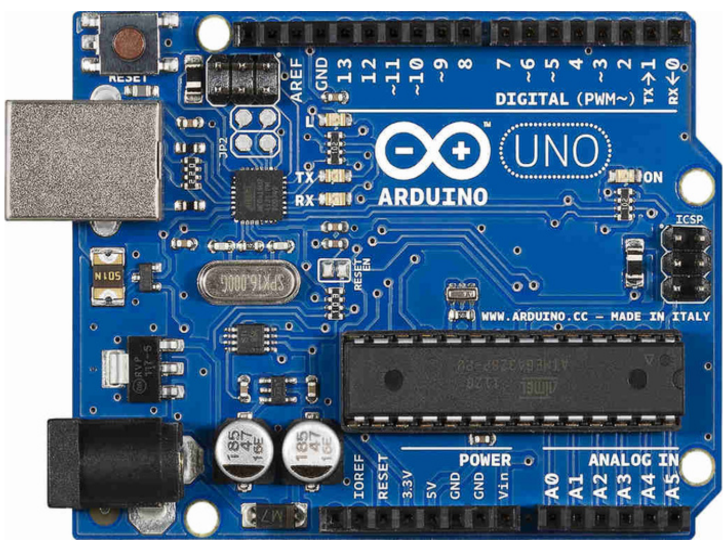

Fig 3.22. Arduino Uno Board

3.3.7.1 Arduino - board Description

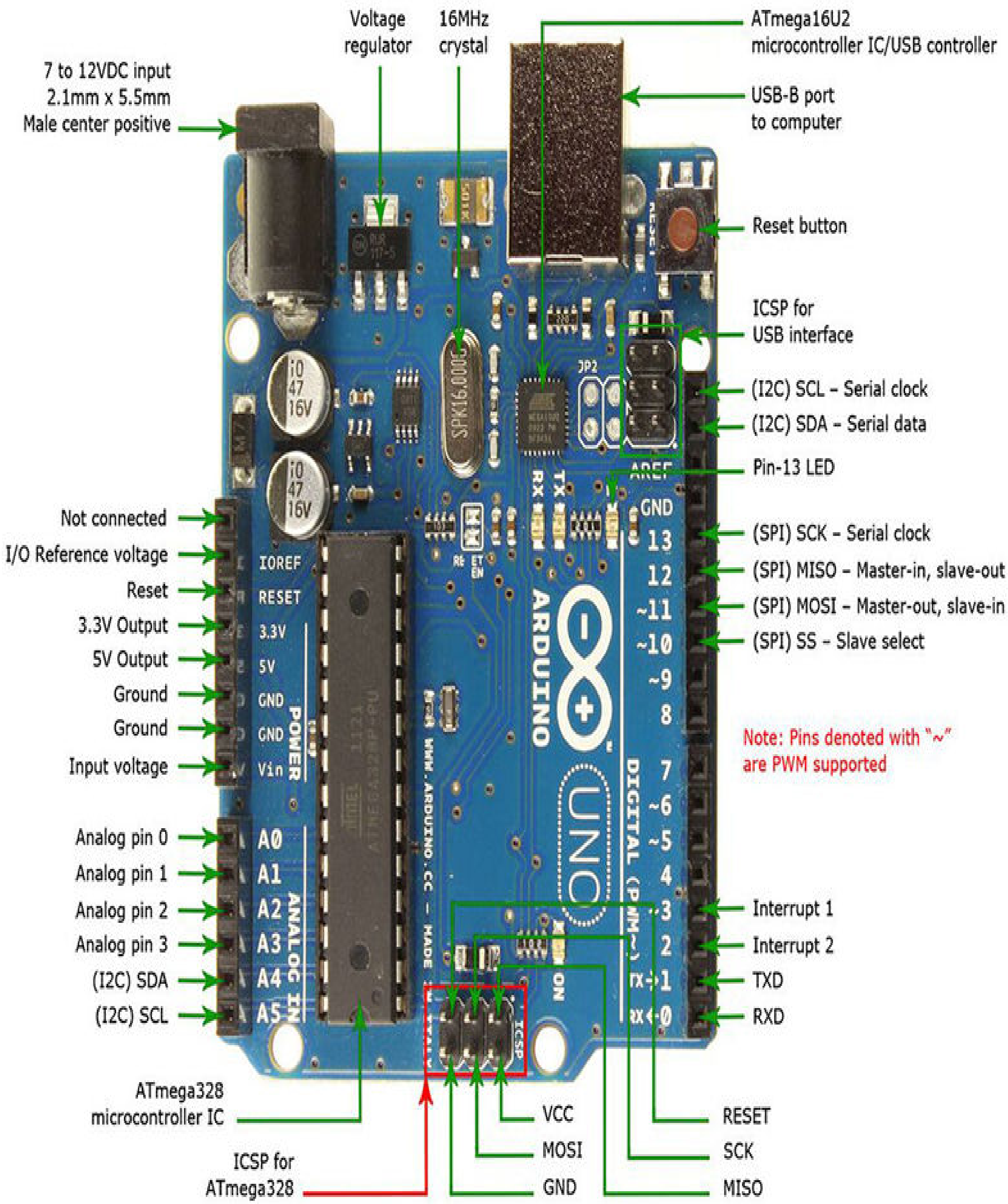

Fig 3.23. Arduino Uno Pin Details

Power:
Either an external power source or the USB connection can be used to power the Arduino Uno. Automatic source selection is made.

You can use a battery or an AC-to-DC adaptor (wall-wart) for external power. Simply insert a 2.1mm center-positive connector into the board's power jack to connect an adapter.The board could become unstable if the supply voltage is less than 7V, as the 5V pin might not give five volts. Utilizing a voltage greater than 12V could result in the voltage regulator overheating and possible board damage. The suggested voltage range is between 7 and 12 volts.

Memory:
The Arduino Uno's ATmega328 microprocessor has 32 KB of flash memory, of which 0.5 KB is needed for the bootloader. Additionally, it features 1 KB of EEPROM that can be read from and written to using the EEPROM library.

Input and Output:
The Uno has a total of 14 pins which are of digital type, each of can be used as an input or output. The board also features 6 analog input pins, labeled A0 through A5, with 10 bits of resolution, allowing for 1024 different values. By default, these pins measure voltages from ground to 5 volts, but it is possible to change the upper end of their range using the AREF pin and the analogReference() function.

Main Microcontroller:
Each Arduino board is having its own microcontroller, which can be considered as the main part of the board. The specific microcontroller used on the Uno may vary.

Generally, the microcontrollers are manufactured by ATMEL. The type of microcontroller can be identified by referring to the top of the IC, and this information is important when loading programs onto the Arduino.

ICSP Pin:
The ICSP (In-Circuit Serial Programming) pin on the Arduino Uno is a tiny programming header consisting of pins for MISO, RESET ,MOSI, VCC, SCK and GND. It enables SPI (Serial Peripheral Interface) communication and facilitates programming and communication between the microcontroller and external devices.

3.6.8 Battery

Fig 3.24. 12 V Lead Acid Battery

Voltage	12 V
Charging Time	4 A/W
Battery Type	Lead Acid
Item Weight	2.5 Kg
Capacity	7Ah

Table 3.2. Lead Acid characteristics

The Amaron Quanta 12V/7Ah Lead Acid Battery, as shown in figure 3.24, is a reliable and high-quality battery designed for various applications. With its compact dimensions of 4.00 x 6.00 x 25.00 cm, it is easy to install and fits well in different setups. The battery operates at a voltage of 12V, providing sufficient power for your devices or systems. It has a charging time of 4 A/W, ensuring quick and efficient charging. The battery cell composition is lead acid, which is known for its durability and long-lasting performance. Weighing 2.5 kg, it is lightweight and portable. The Amaron Quanta battery is manufactured using quality materials and advanced techniques, meeting the standards of the industry. Whether it's for backup power, UPS systems, or other applications, this battery offers reliable performance and durability. Table 3.2 contains the characteristics of Lead Acid battery.

3.6.9 DC-DC Boost Converter

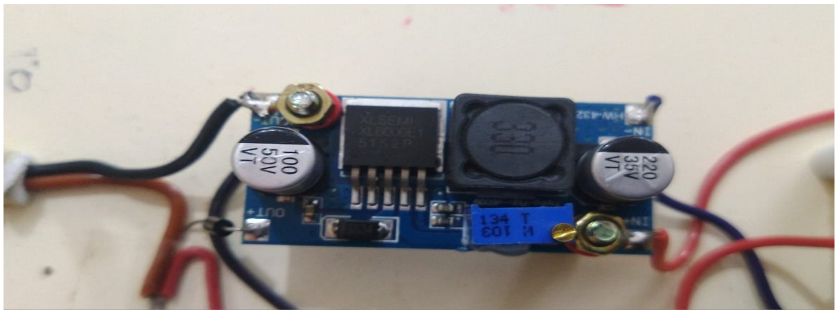

Fig 3.25. DC-DC MOSFET Boost Converter

Converter Specifications-

Output Range- 5V -35V

Input current(max)- 4A

Conversion efficiency <94%

Switching Frequency 400 KHz

Figure 3.25 depicts a DC-DC MOSFET Boost Converter, which is a vital component in various electronic applications. This converter is designed to boost the output voltage range from 5V to 35V. It has a maximum input current of 4A, allowing for efficient power transfer. With a conversion efficiency of less than 94%, it ensures minimal energy loss during the voltage boosting process. The converter operates at a switching frequency of 400 KHz, enabling rapid and precise voltage regulation.

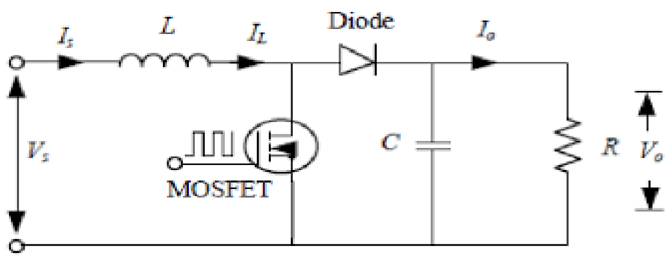

Fig. 3.26 General circuit Diagram of Boost Converter

The DC to DC boost converter plays a crucial role in solar panel systems by increasing the voltage output to charge the battery effectively. In this particular converter, an XL6009 chip is utilized. This chip functions as a boost converter, ensuring that the output voltage exceeds the input voltage. The XL6009 chip generates PWM switching pulses that control the MOSFET within the converter. This control mechanism allows for efficient voltage boosting and reliable power delivery to connected devices or battery charging systems.

3.6.10 Solar Panel

Fig 3.27. Solar Panel

Figure 3.26 shows a 9V 3W solar panel, which offers numerous advantages in terms of portability, ease of installation, and low maintenance requirements. This lightweight solar panel is designed to harness the power of the sun.. It is equipped with a built-in blocking diode that prevents reverse discharge, ensuring the longevity of both the panel and the connected battery. By effectively preventing drain dead, the solar panel helps maintain the battery's lifespan and extends its overall usage.

The solar panel kit operates by converting sunlight into electrical energy, allowing for the continuous and green power supply to our devices. With this solar panel, there is no need to worry about running out of power as it harnesses the renewable energy from the sun. The 9V 3W solar panel utilizes polycrystalline silicon solar cells, enabling efficient energy conversion. It is specifically designed to charge 3V-5V batteries, offering an optimum operating voltage of 9V and an optimum operating current of 600mA as shown in the table 3.3.

Model	9V 3W
Solar Cell	Polycrystalline silicon
Optimum operating voltage	9V
Optimum operating current	600mA

Table 3.3. Solar Panel characteristics

3.7 Working Principle of Weather Monitoring System

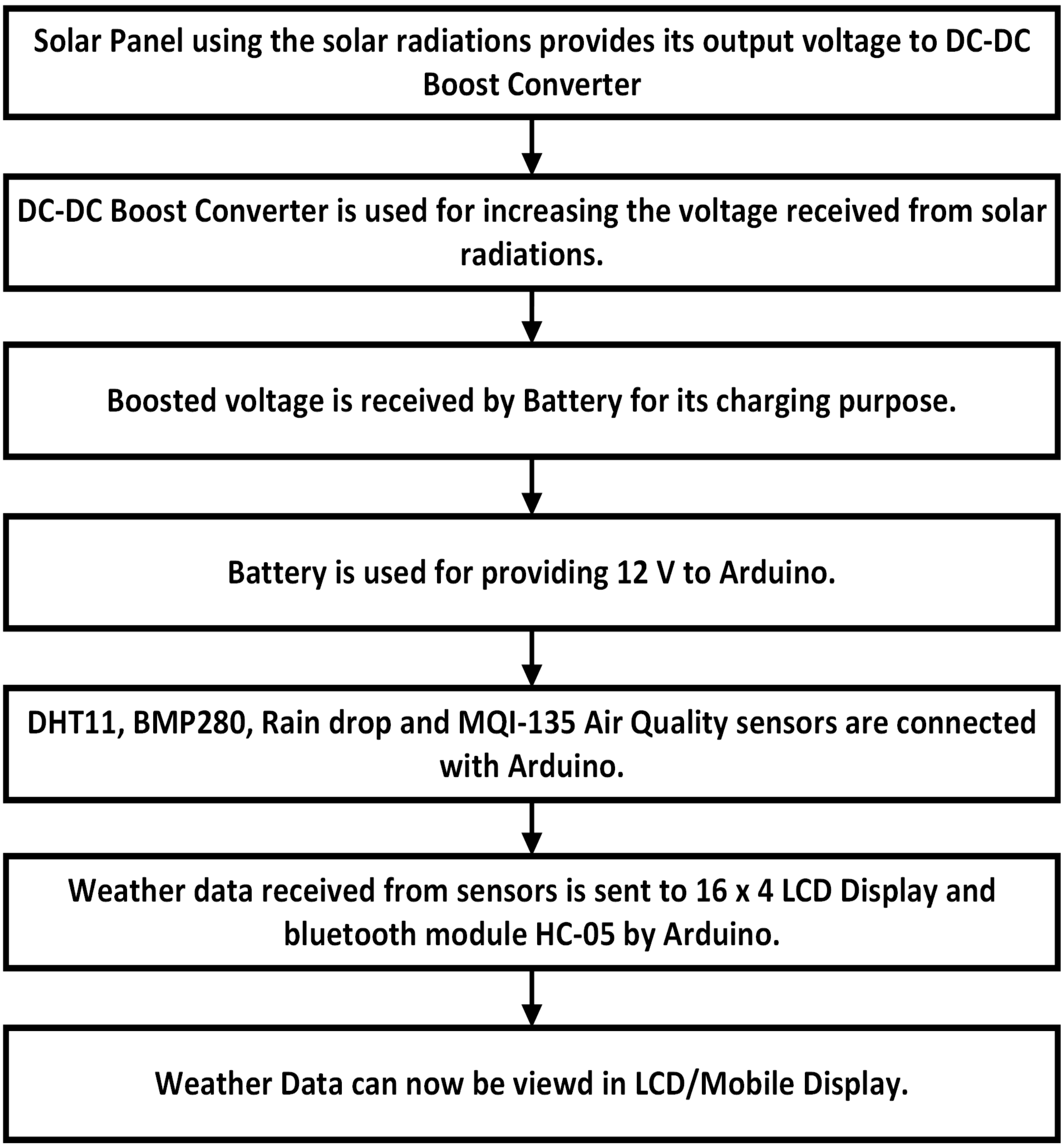

Fig 3.28 Working Principle of Weather Monitoring System

3.8 Circuit Diagram

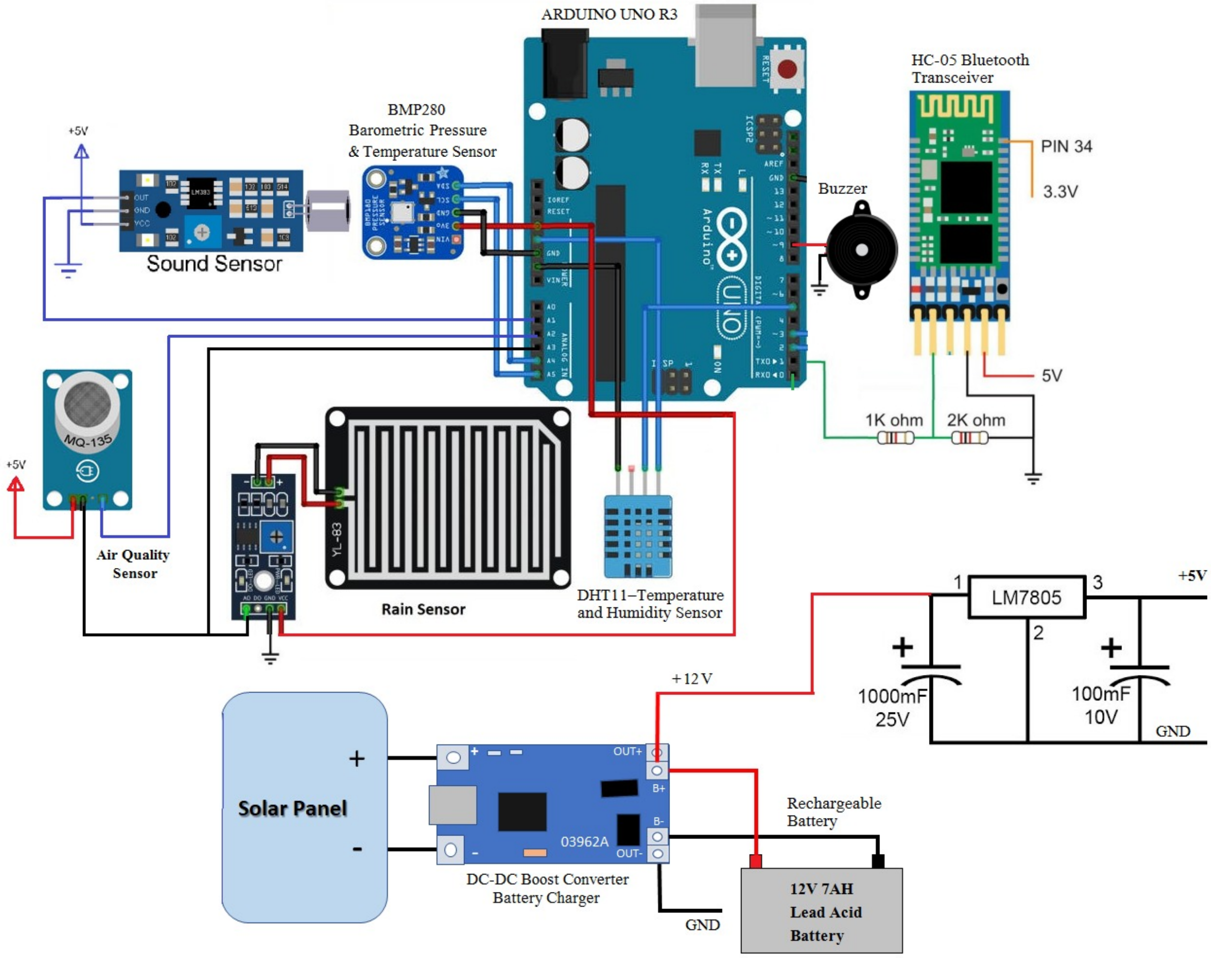

Fig 3.29. Circuit Diagram of Weather Monitoring System

The battery bank in this system is charged using a solar panel, harnessing the power of renewable energy. To gather weather information, the system employs multiple sensors including a temperature sensor, humidity sensor, air quality sensor, barometric pressure sensor, and rain drop sensor. These sensors provide valuable data for monitoring weather conditions. Additionally, the system utilizes a Bluetooth module for wirelessly transmitting the collected data to a remote monitoring station. This enables convenient and efficient monitoring and analysis of the weather information.

CHAPTER 4

CODING AND HARDWARE RESULTS

4.1 Introduction to Arduino IDE

The Arduino IDE is an open source software designed for writing and compiling code for Arduino modules. It provides an easy-to-use platform for beginners and is compatible with various operating systems such as MAC, Windows, and Linux. With inbuilt functions and commands, the IDE facilitates code editing, debugging, and compiling. Different Arduino modules, including Uno, Mega, Leonardo, and Micro, come with microcontrollers that are programmed using the IDE. The IDE environment consists of an editor for code writing and a compiler for code compilation and uploading to the Arduino module. It supports both C and C++ languages. To upload a sketch, the appropriate board and port need to be selected in the IDE's Tools menu. This allows seamless communication between the IDE and the Arduino module.

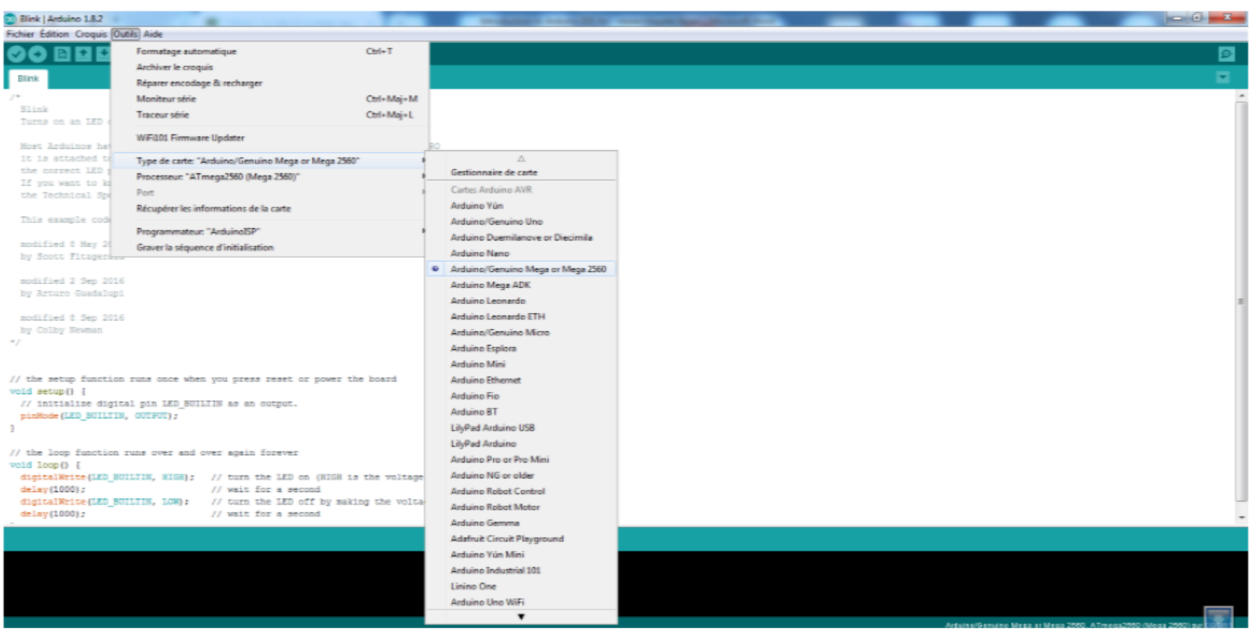

Fig 4.1. Arduino IDE

4.2 Software Program (C Language)

We have written the arduino code using C language. This code helps to receive the weather data from DHT11 Sensor, BMP280 Sensor, MQ135 Air Quality Sensor and Rain-drop sensor.

```
#include <Adafruit_BMP280.h>

#include "DHT.h"

Adafruit_BMP280 bmp; // I2C Interface

#define DHTPIN 2      // DHT11 pin

#define DHTTYPE DHT11   // DHT 11 sensor type

DHT dht(DHTPIN, DHTTYPE);

const int RainSensor = A1;  // Analog input pin for Rain sensor

const int Buzzer = 13;

const int LED = 12;

float RainVoltage = 0.0;  // variable to store water level sensor

float rainlevel = 0.0;

int a=0;

const int sampleWindow = 50;

const int soundSensorPin = A3;

const float refVoltage = 5.0;

const float sensitivity = 0.5;

int MQ135Pin = A2; // define the analog input pin for the MQ135 sensor

float R0 = 76.63; // define the resistance of the sensor at 100 ppm CO2

float VCC = 5.0; // define the supply voltage to the sensor
```

```
void setup(void)
{
 pinMode(MQ135Pin,INPUT);
  pinMode(soundSensorPin,INPUT);
  pinMode(Buzzer, OUTPUT); // initialize pin 8 as an output.
  pinMode(LED, OUTPUT);
  Serial.begin(9600);
  delay(10);
  digitalWrite(LED, HIGH);
  Serial.println("DHT11 intializing..");
  dht.begin();
  delay(2000);
  Serial.println("BMP280 intializing..");
  if (!bmp.begin(0x76))
  {
   Serial.println("Failed to Read BMP280 Sensor!");
  }
  bmp.setSampling(Adafruit_BMP280::MODE_NORMAL,     /* Operating Mode. */
                  Adafruit_BMP280::SAMPLING_X2,
                  Adafruit_BMP280::SAMPLING_X16,
                  Adafruit_BMP280::FILTER_X16,      /* Filtering. */
                  Adafruit_BMP280::STANDBY_MS_500); /* Standby time. */
```

```
 delay(1000);
 digitalWrite(LED, LOW);
 delay(1000);
}
void loop()
{
      readBMP280();
      delay(10);
      readDHT11();
      delay(10);
      readRainSensor();
      delay(10);
      readAirQuality();
      delay(10);
      readNoiseSensor();
      delay(10);
}
    void readBMP280()
    {
    Serial.print("Temp:");
    Serial.print(bmp.readTemperature());
    Serial.print(" ℃");
    Serial.println();
    Serial.print("Press:");
```

```
 Serial.print(bmp.readPressure()/100);

 Serial.print(" hPa");

 Serial.println();

 Serial.print("Alt:");

 Serial.print(bmp.readAltitude(1011.00));

 Serial.print(" m");

 Serial.println();

 }

 void readDHT11()

 {

 float h = dht.readHumidity();

 Serial.print("Hum:");

 Serial.print(h);

 Serial.print(" %");

 Serial.println();

 }

 void readRainSensor()

{

 int val1 = analogRead(RainSensor); //Read value from Water Level Sensor

 delay(10);

 RainVoltage = (val1 * 5.0) / 1024.0;

 rainlevel = ((5-RainVoltage) * 10);

 if (rainlevel < 1)

 {
```

```
  rainlevel = 0;
 }
  Serial.print("Rain Level:");
  Serial.print(rainlevel);
  Serial.print(" mm ");
  if (rainlevel < 1.0) //No Rain
  {
  Serial.println("NO RAIN");
  digitalWrite(Buzzer, LOW);
  digitalWrite(LED, LOW);
  }
  if (rainlevel >= 5 && rainlevel < 15) //MEDIUM
  {
  Serial.println("LOW");
  digitalWrite(Buzzer, LOW);
  digitalWrite(LED, LOW);
  }
  if (rainlevel > 15 && rainlevel < 25) //MEDIUM
  {
  Serial.println("MEDIUM");
  digitalWrite(Buzzer, LOW);
  digitalWrite(LED, LOW);
  }
  if (rainlevel > 25) //HIGH
```

```
    {
    Serial.println("HIGH");
    digitalWrite(Buzzer, HIGH);
    digitalWrite(LED, HIGH);
    delay(2000);
    }
}
  void readAirQuality()
  {int sensorValue = analogRead(MQ135Pin);
  float CO2_ppm = (sensorValue/1024.0) * 5000;
  float AQI = map(CO2_ppm, 0, 2000, 0, 500);
  Serial.print("CO2 concentration: ");
  Serial.print(CO2_ppm);
  Serial.print(" ppm");
  Serial.print("   AQI: ");
  Serial.print(AQI);
  Serial.println(" ppm");
  Serial.println();
  delay(1000);
}
```

4.3 Hardware Model

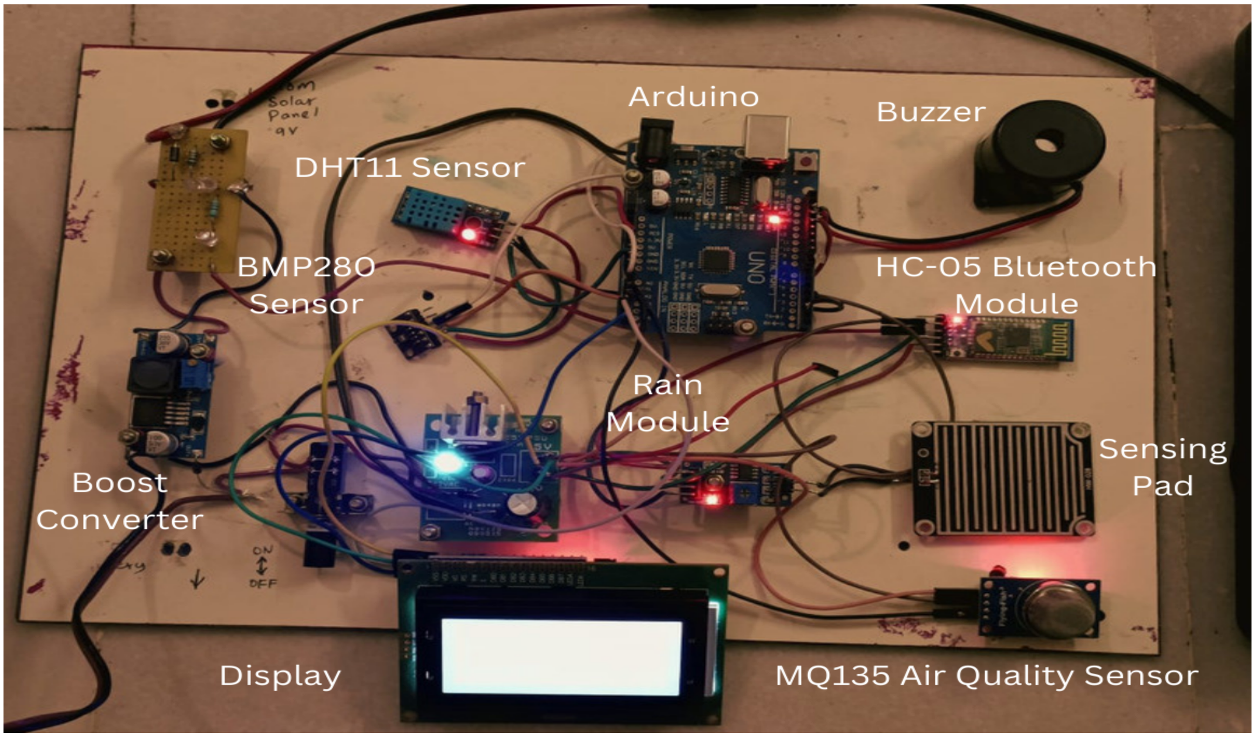

Fig 4.2. Top View of Hardware Model

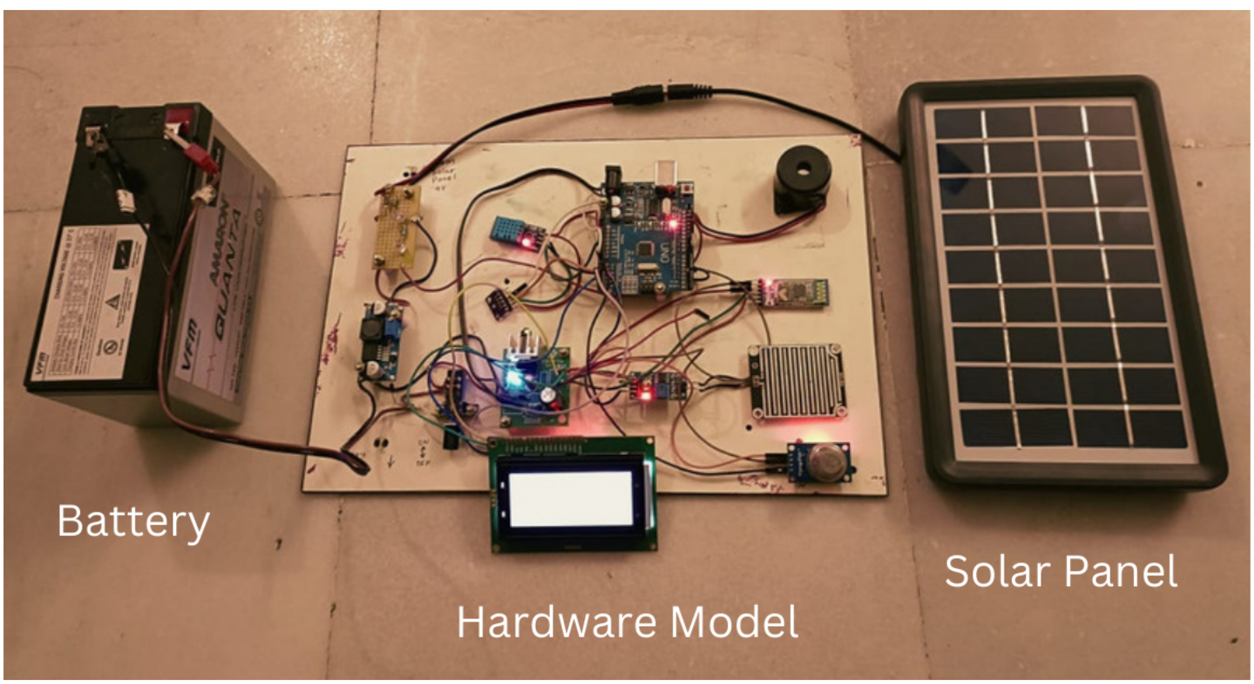

Fig 4.3. Front View of Hardware Model

4.4 Observation Table & Results

4.4.1 Variation of Temperature in a Day

Table 4.2 presents a comparison between the actual temperature readings and the expected temperature values for a particular location over a 12-hour period from March 22, 2023, 13:00 to March 23, 2023, 00:00. The expected values represent the target temperatures that were predicted for each hour, while the actual values are the temperature readings recorded during those hours.

Date & Time	Actual Values	Expected Values	Error
22-03-2023 13:00	27.59℃	28℃	0.41℃
22-03-2023 14:00	28.31℃	29℃	0.69℃
22-03-2023 15:00	29.52℃	29℃	0.52℃
22-03-2023 16:00	28.57℃	28℃	0.57℃
22-03-2023 17:00	27.13℃	26℃	1.13℃
22-03-2023 18:00	24.46℃	24℃	0.46℃
22-03-2023 19:00	23.92℃	23℃	0.92℃
22-03-2023 20:00	23.37℃	23℃	0.37℃
22-03-2023 21:00	22.09℃	22℃	0.09℃
22-03-2023 22:00	21.76℃	22℃	0.24℃
22-03-2023 23:00	20.92℃	21℃	0.08℃
23-03-2023 00:00	19.67℃	20℃	0.03℃

Table 4.1. Variation of Temperature in a Day

To evaluate the accuracy of the system, we calculated the errors by taking the absolute difference between the expected and actual values. The average error over the 12-hour period was approximately 0.56℃, with errors ranging from 0.08℃ to 1.13℃. This indicates that the system is relatively accurate, with an average error rate of around 2% (0.56℃/28℃ x 100%).

While some hourly measurements were further from the expected values than others, the overall error rate suggests that the system provides reasonably accurate temperature readings. These results can be used to further improve the accuracy of the system by analyzing the discrepancies between the predicted and actual temperatures and making necessary adjustments.

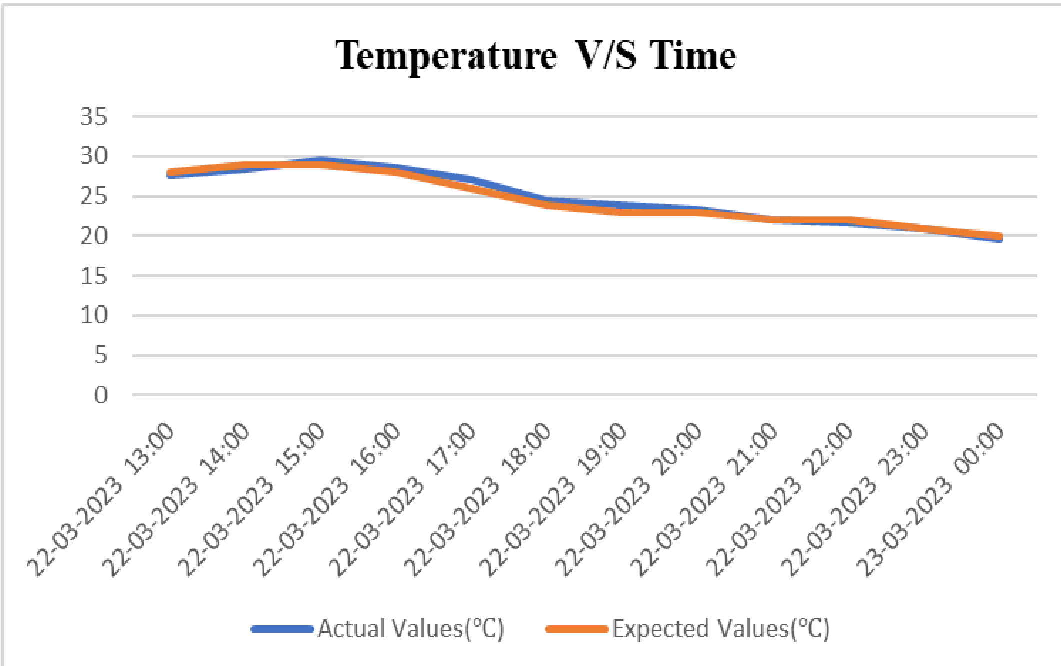

Fig 4.4. Temperature V/S Time

It is evident from the figure 4.4 that the actual temperature readings were generally close to the expected values, with some minor fluctuations throughout the 12-hour period. The deviations between the actual and expected values were relatively small and can be attributed to natural variations in the temperature, measurement errors, or other environmental factors.

Overall, the graph provides a visual representation of the comparison between the expected and actual temperature values and helps to further evaluate the accuracy of the system. The minor deviations between the expected and actual values suggest that the system is relatively accurate in measuring and predicting temperature values. These findings can be used to further improve the system's accuracy by analyzing the discrepancies and making necessary adjustments.

4.4.2 Variation of Humidity in a Day

Time	Actual Values	Expected Values	Error
22-03-2023 13:00	39%	43%	4%
22-03-2023 14:00	36%	40%	4%
22-03-2023 15:00	38%	41%	3%
22-03-2023 16:00	41%	45%	4%
22-03-2023 17:00	46%	48%	2%
22-03-2023 18:00	50%	51%	1%
22-03-2023 19:00	52%	54%	2%
22-03-2023 20:00	56%	59%	3%
22-03-2023 21:00	58%	61%	3%
22-03-2023 22:00	60%	64%	4%
22-03-2023 23:00	63%	65%	2%
23-03-2023 00:00	66%	67%	1%

Table 4.2. Variation of Humidity in a Day

The table 4.2 represents the actual and expected humidity values for a specific location over a 12-hour period from March 22, 2023, 13:00 to March 23, 2023, 00:00. The expected humidity values represent the target levels predicted for each hour, while the actual values are the humidity levels recorded during those hours.

To evaluate the accuracy of the system, we calculated the absolute differences between the expected and actual values. The average error rate over the 12-hour period was approximately 3.27%, with errors ranging from 0.42% to 6.67%. This indicates that the system is relatively accurate in measuring humidity levels, with an average error rate of around 3.27%.

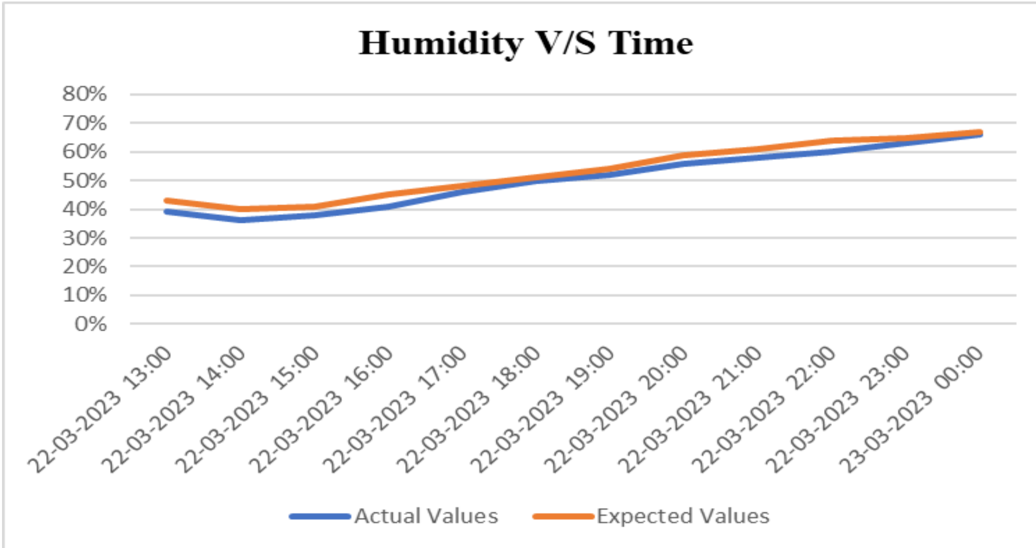

Fig 4.5. Humidity V/S Time

The humidity variation graph plotted, figure 4.5 using this data clearly shows the comparison between the expected and actual humidity levels. The expected values are represented by a solid line, while the actual values are represented by markers on the graph. It is evident from the graph that the actual humidity readings were generally close to the expected values, with some minor variations throughout the 12-hour period.

4.4.3 Variation of Altitude and Pressure

Altitude	Pressure
246.69	981.79
247.90	981.64
233.82	983.29
227.96	983.98
222.29	984.64
220.04	984.91
218.72	985.06
206.91	986.45
203.75	986.88

Table 4.3 Variation of Altitude and Pressure

The table 4.3 represents the relationship between altitude and atmospheric pressure. As the altitude increases, the pressure decreases, as observed in the given data. This inverse relationship can be attributed to the fact that as we move higher up in the atmosphere, the air molecules become less dense, resulting in a decrease in atmospheric pressure.It is a well-known natural phenomenon that the atmospheric pressure decreases with an increase in altitude. This is due to the fact that the Earth's atmosphere is composed of different layers of gases, and the weight of these layers causes the pressure at sea level to be higher than at higher altitudes. The decrease in atmospheric pressure with altitude is also the reason why it is harder to breathe at high altitudes, as the air becomes less dense.

The data in the table shows a consistent decrease in atmospheric pressure as altitude increases, with some small variations. These variations may be due to changes in weather conditions or other factors. However, the general trend is clear, with the pressure decreasing as altitude increases

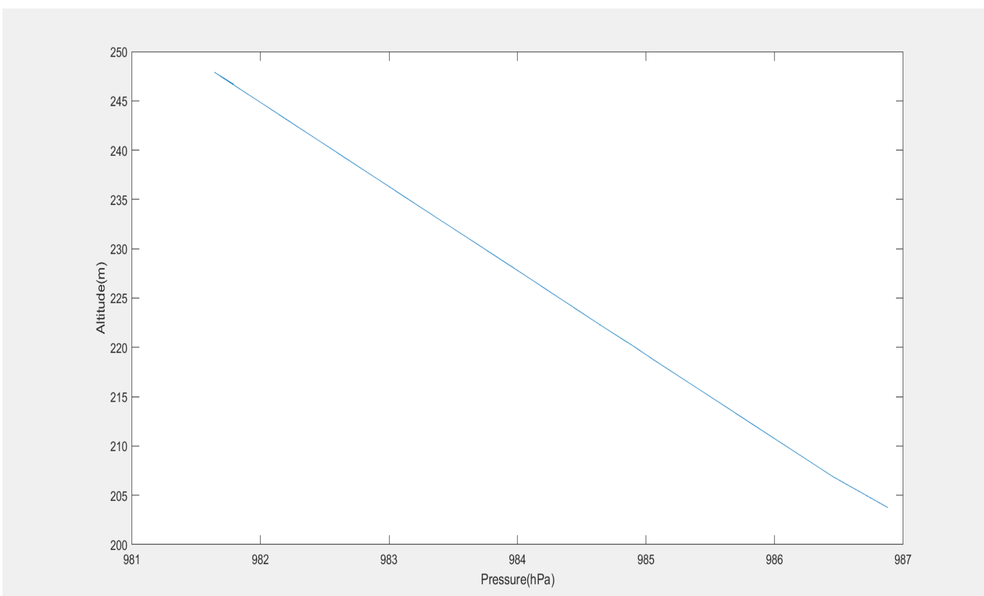

Fig 4.6. Altitude V/S Pressure

The figure 4.6 above represents the relationship between altitude and atmospheric pressure. As altitude increases, atmospheric pressure decreases, as observed by the downward trend of the graph. The data shows a consistent decrease in pressure as altitude increases, with some small variations.

4.5 Output of Serial Bluetooth App

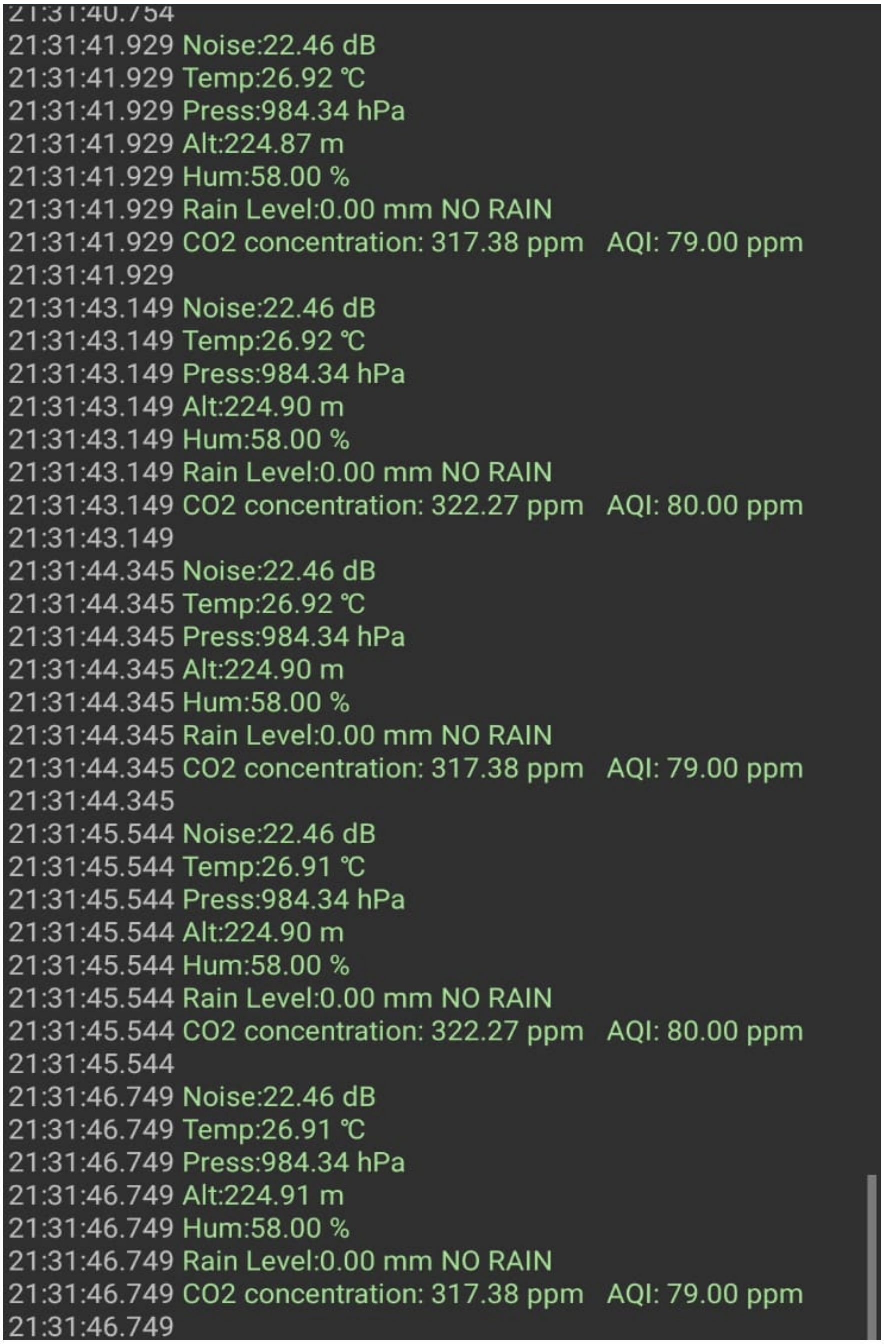

Fig 4.7. Output of Serial Bluetooth Application

The figure 4.7 denotes the display of Serial Bluetooth application, it contains the weather parameters recorded at different times.

4.6 Variation of Weather Parameters in a Day

Time	Temperature(°C)	Pressure(hPa)	Humidity(in %)
10:00	17.13	990.86	48
11:00	17.62	990.76	53
12:00	18.12	989.52	48
13:00	18.25	988.18	49
14:00	18.32	987.59	47
15:00	19.82	986.67	46
16:00	19.46	986.27	47
17:00	18.98	986.25	45
18:00	18.35	986.23	51
19:00	17.52	986.68	50
20:00	17.21	986.75	51
21:00	16.77	986.83	53
22:00	16.68	986.62	53

Table 4.4 Variation of Weather Parameters in a Day

4.7 Limitations of Weather Monitoring System

While the Weather Monitoring System has numerous advantages, it also has certain limitations. One limitation is that it primarily allows users to view weather data, including temperature, humidity, and air pressure. It does not provide advanced analysis or forecasting features. Additionally, there are accuracy limits for each sensor, which should be taken into consideration. Users must have access to a mobile application or computer to interact with the system. Furthermore, the system's effectiveness is valid within a certain range, and data collection may be limited beyond that range.

4.8 Applications

The Weather Monitoring System has a wide range of applications. It is particularly suitable for industrial purposes, offering high-quality and industrial-grade sensors for monitoring, alarming, and reporting. In the field of agriculture, the system can be utilized for monitoring crop conditions, soil moisture levels, and weather patterns, aiding in optimal agricultural management. Additionally, it can be employed for roadside monitoring, providing real-time weather data for traffic management and road safety purposes.

Furthermore, the integration of wireless technology enables seamless communication and data transmission between the weather sensors and the remote monitoring unit. This wireless connectivity eliminates the need for extensive wiring installations, making the system highly flexible and easy to deploy. The use of wireless technology also allows for real-time data monitoring and analysis, providing immediate insights into changing weather conditions.

The system's implementation of IoT principles adds another layer of functionality and convenience. With IoT, the weather monitoring system can be connected to a larger network of devices and systems, enabling centralized monitoring, data aggregation, and advanced analytics. This connectivity opens up possibilities for integrating weather data with other applications and services, such as smart agriculture, urban planning, and disaster management.

CONCLUSION

In conclusion, the proposed weather monitoring system offers a portable and cost-effective solution for monitoring various weather parameters. With sensors detecting temperature, humidity, barometric pressure, air quality, heat index and rain level, the system can be used in various applications such as weather monitoring in a specific location, packaging industry, and environmental sensing in rooms or industries. The embedded computing system ensures unique identification of parameters, and the low energy Bluetooth wireless platform enables communication with a remote monitoring unit via an Android mobile app. The collected weather data can be accessed and logged through the mobile app, providing real-time information about the surrounding environment.

The system's accuracy has been evaluated by comparing the collected data with actual weather conditions and calculating the percentage of error. Overall, this weather monitoring system offers an efficient and reliable solution for monitoring and analyzing weather conditions in different contexts. Average error found for temperature was around 2 % , while for humidity it was calculated as approximately 3.27 %. Moreover, the relationship between the atmospheric pressure and height was observed to be as expected i.e. atmospheric pressure decreases, as the altitude increases. We were successful in obtaining the results for the rain drop sensor, air quality (CO_2 gas concentration) was also obtained for different places/time.

In addition to its practical applications, the proposed weather monitoring system also incorporates renewable energy, wireless technology, and IoT, making it an environmentally friendly and efficient solution. By harnessing renewable energy sources such as solar power, the system reduces its carbon footprint and promotes sustainability. This feature is particularly beneficial in remote or off-grid locations where access to traditional power sources may be limited.

In conclusion, the proposed weather monitoring system offers a comprehensive and versatile solution for monitoring weather conditions. Its use of renewable energy, wireless technology, and IoT integration enhances its efficiency, accessibility, and potential for integration into various sectors. By providing accurate and real-time weather data, this system can facilitate informed decision-making, improve safety measures, and contribute to the overall understanding of weather patterns.

FUTURE SCOPE

- There are certain range limits for each kind of sensor like in BMP280 accuracy is high only when temperature is above 0 degree celsius. To analyze our system at critical conditions. So that a solution in abnormal conditions can be obtained.
- By utilizing the Thingspeak cloud platform and the ESP8266 Module, data can be easily visualized from our sensors in real-time. It basically uses wifi transmission over bluetooth. Aim is to try this out, so that a comparison of which way of transmission will be better can be obtained. This allows instant access to visual representations of the collected data.
- Furthermore, the aim is to leverage the power of MATLAB for online analysis and data processing. With the help of MATLAB, automated data processing generates dynamic visualizations from the live data. This integration of MATLAB adds a layer of sophistication to the system, enabling it to gain valuable insights and make informed decisions based on the processed data.
- Our project is limited to some ranges. Future work is looking forward to increasing the range limits of the Weather Monitoring system.
- Another future scope is to convert the Weather monitoring system into a weather forecasting system by analyzing the previous data.

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