Envision D02

IoT-Based Weather Monitoring System Using Arduino

National Institute of Technology Karnataka, Surathkal, Mangaluru

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1. Introduction

Weather Monitoring is an essential problem in today's world. The absence of adequate weather monitoring infrastructure leads to significant calamities impacting people severely. There are lots of IoT devices that can monitor the weather in a region over the Internet. The meteorological department also take advantage of these smart devices to keep an eye on the weather. An IoT-based weather monitoring system is a sophisticated network of sensors, devices, and software that collects, processes, and analyses weather-related data in real-time. This system makes use of the Internet of Things (IoT) technology to provide accurate and timely information about various weather parameters such as temperature, humidity, air quality and wind speed.

2. Motivation

Transform weather monitoring with an IoT-based system that revolutionizes how we understand and respond to weather conditions. Empower communities and industries with real-time weather data and actionable insights. Integrate IoT sensors across regions to capture key parameters like temperature, humidity, wind speed, and air quality, enabling accurate forecasting and early warning systems for severe weather events.

Make use of advanced analytics to detect the trends and improving predictions. Enable seamless data sharing and collaboration between meteorological agencies and emergency responders enhancing overall preparedness and resilience. Implement smart IoT devices in urban areas for microclimate monitoring, supporting sustainable urban planning and infrastructure management.

Facilitate remote access to weather information, beneficial for agriculture, transportation and disaster management sectors.

This comprehensive IoT weather monitoring system fosters a safer, more resilient society, prepared to address the challenges of a changing climate.

3. Objectives

The project aims to design, develop, and evaluate a functional prototype of an IoT-based Weather Monitoring System. This system aims to provide real-time weather data monitoring

and analysis capabilities, catering to the needs of meteorological agencies, disaster management teams, and environmental researchers.

a) Ease of real-time monitoring

   Enable users to easily monitor local weather condition in real time from anywhere in the world. This includes parameters such as temperature, humidity, windspeed and air quality. Offering a user-friendly interface accessible via web enabling quick access to critical weather information.

b) Data Storage and Analysis

   The system stores weather and environmental data in a web server and facilitates the extraction of statistical insights regarding weather fluctuations observed over preceding days.

c) Deployment for Weather Forecasting

   The setup allows for easy deployment of IoT sensors in various locations to monitor local atmospheric conditions and microclimates. This data is essential for weather forecasting and prediction, helping meteorologists and environmentalists make informed decisions and issue timely warnings for severe weather events.

By achieving these objectives, the IoT based weather monitoring system aims to revolutionize how weather data is monitored, analysed, and utilized for decision making and research.

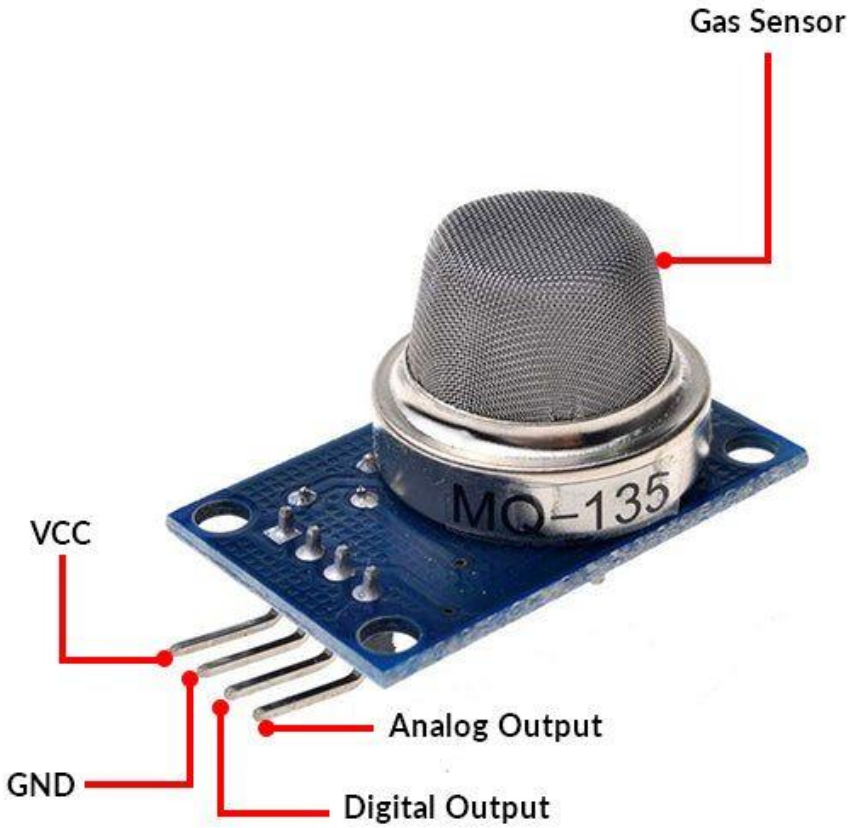
4. Literature Review

Our project aims to monitor the weather conditions in an area for a long time too and the people residing in the area will be able to track the changing weather conditions through the web.

Our project includes monitoring of multiple weather conditions including temperature, humidity, air quality and wind speed.

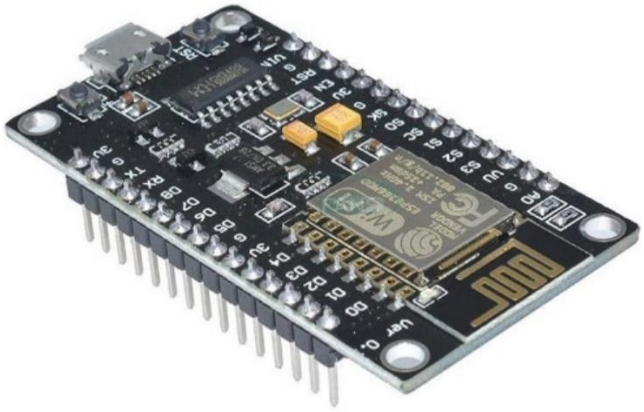
5. Component Specification

A. MQ-135 – Air quality sensor

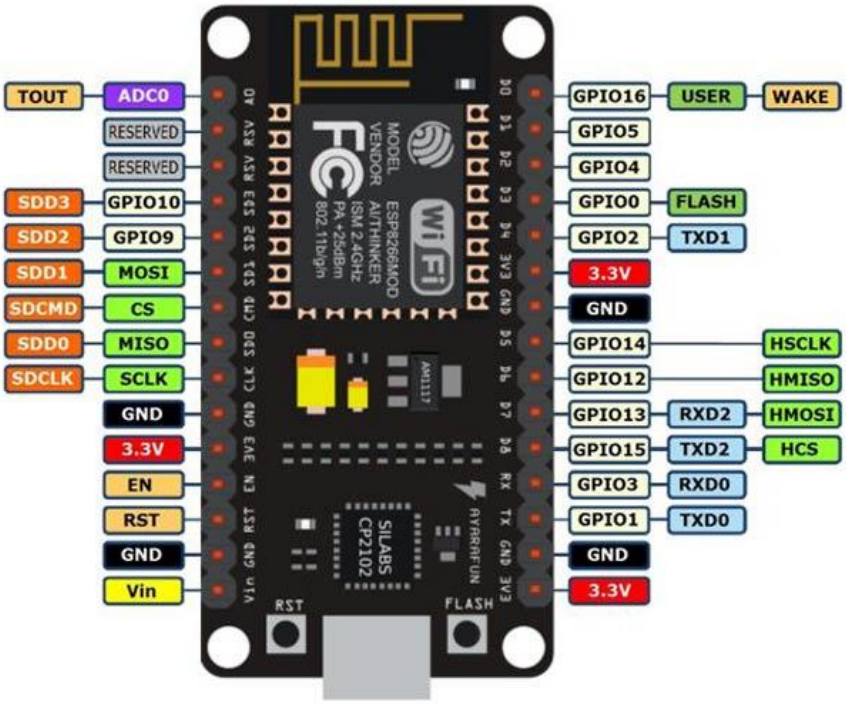


The MQ-135 is a semiconductor based analog air quality sensor that takes air samples from the surroundings and gives out an analog voltage at its output terminal. It works on the principle of gas sensing through the change in electrical conductivity when exposed to different gases. The sensor's detection range and sensitivity can be adjusted by varying the circuit's load resistance.

B. ESP8266

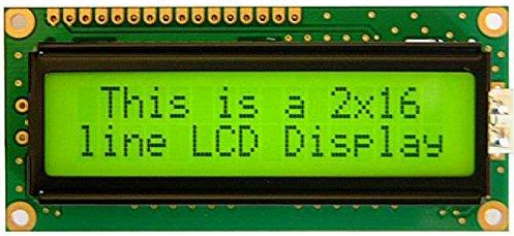


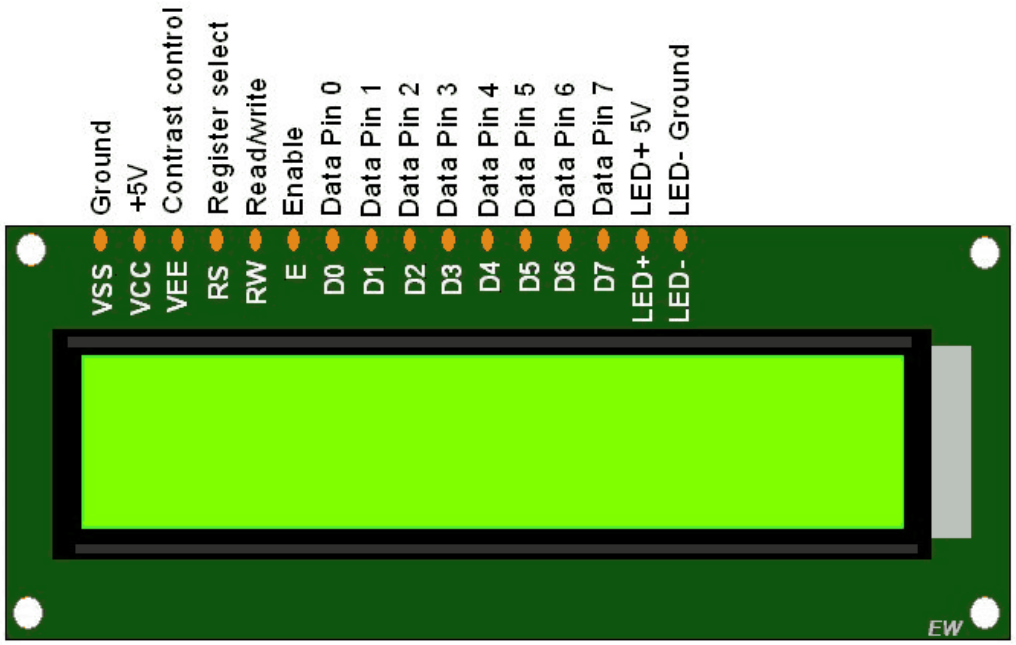
Pin Diagram



The ESP8266 is a very user-friendly and low-cost device to provide internet connectivity to our projects. The module can work both as an Access point (can create hotspot) and as a station (can connect to Wi-Fi), hence it can easily fetch data and upload it to the cloud server making the Internet of Things as easy as possible. It can also fetch data from the internet using API's hence the project could access any information that is available on the internet, thus making it smarter. Another exciting feature of this module is that it can be programmed using the Arduino IDE which makes it a lot more user-friendly.

C. Liquid Crystal Display (LCD)

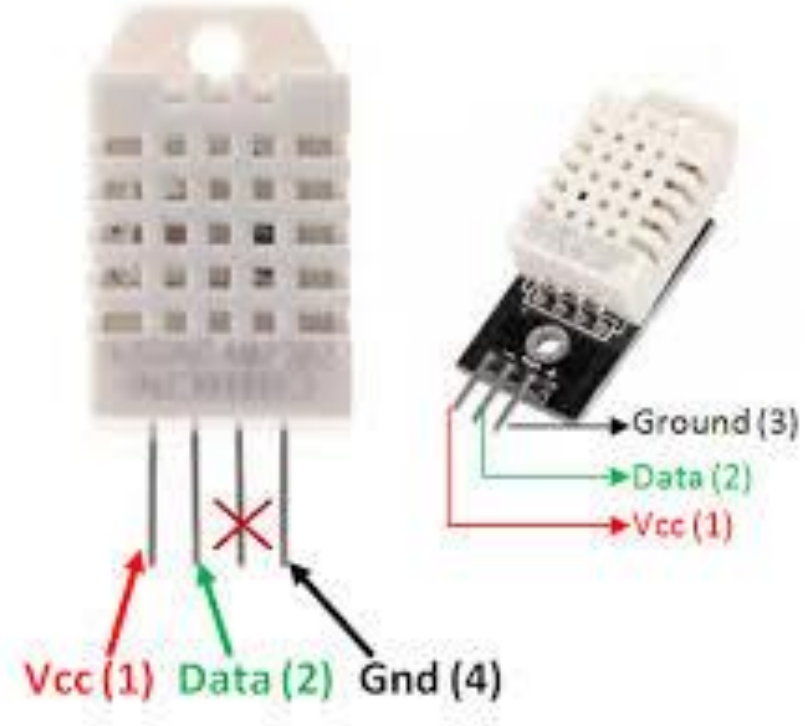




A 16×2 LCD display is a liquid crystal display that can show 16 characters in each of its two rows, providing a total of 32 characters of information. It's commonly used to display alphanumeric information in various electronic devices. A 16×2 LCD display works by controlling the liquid crystals to either block or allow light to pass through, creating characters and symbols on the screen. It is controlled by sending data and commands to its controller, which, in turn, manages the display of information.

The data sent by ESP8266 to the cloud server will also be showcased on the 16x2 LCD Display so that we can observe the real time data locally.

D. DHT22 Humidity and Temperature Sensor



Digital-output relative humidity and temperature sensor or DHT22 (aka AM2302) is a device which is used to measure the humidity and temperature of the surroundings. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements connects with an 8-bit single-chip computer.

Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of programme in OTP memory, when the sensor is detecting, it will cite coefficient from memory.

Small size, low consumption, and long transmission distance(20m) enables DHT22 to be suited in all kinds of harsh application occasions.

Single-row packaged with four pins, making the connection very convenient.

The DHT22 sensor operates based on the capacitive humidity sensing principle and uses a thermistor for temperature measurement.

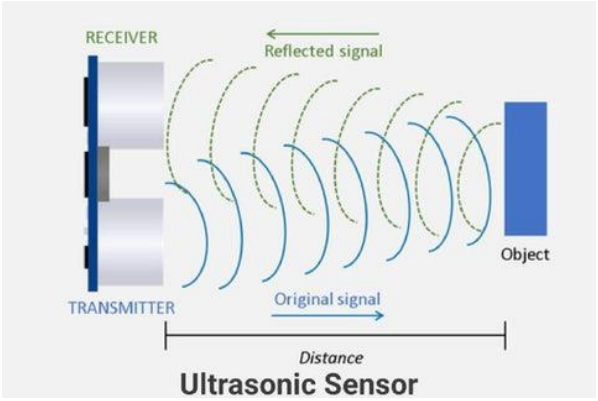
E. Ultrasonic Sensor

The Ultrasonic Sensor is an electronic device that calculates distance by emitting sound waves and collecting their echoes.

It can measure objects from up to 4.5 meters away, which makes it a versatile instrument for correctly measuring both short and long distances without making contact with the target object, which is critical in many applications such as obstacle avoidance systems in robotics or autonomous cars.

The sensor features adjustable pulse widths, allowing for higher resolution measurements when set at lower levels though this comes at the cost of range accuracy diminishing as a result, however, due to its affordability compared to other forms of distance sensing technologies makes it incredibly suitable where budget constraints are paramount factor within projects evaluating solutions using ultrasonic technology.

Working Principle: An ultrasonic sensor is a type of electronic sensor that uses ultrasonic waves to determine the distance between two objects and converts the reflected sound into electrical signals.



The distance is calculated by measuring the ultrasonic sound's travel time and speed.

$$\text{Distance} = \frac{Time\ x\ Speed\ of\ sound}{2}$$

Ultrasonic sensors can measure rainfall by calculating the height of water in a rain gauge. The sensor emits a sound wave at a frequency above human hearing, and a transducer acts as a microphone to receive the reflected sound. The sensor then measures the time it takes for the sound to travel to the water and back, which determines the distance to the water.

F. Arduino UNO

Arduino is an open-source physical computing platform based on a simple input/output (1/0) board and a development environment that implements the Processing language. Arduino can be used to develop standalone interactive objects or can be connected to software on a computer. Arduino hardware is an open-source circuit board with a microprocessor and input/output (1/0) pins for communication and controlling physical objects (LED, servos, buttons, etc.). The board is powered via USB or an external power supply which, in turn, allows it to power other hardware and sensors.

G. Buzzer

A piezo buzzer is an electronic component that generates sound by using the piezoelectric effect.

The core component of a piezo buzzer is a piezoelectric ceramic disc or element. This material has the property of generating a voltage when mechanical stress is applied to it, such as when it is bent or compressed.

When voltage is applied to the piezoelectric material, it causes the material to vibrate at the same frequency as the applied voltage. This vibration produces sound waves in the surrounding air.

When the gas sensor value goes above 200, the piezoelectric buzzer buzzes, making us aware that the air quality is not good.

H. Anemometer

A digital anemometer is a type of wind speed sensor that measures wind speed using digital technology and displays the readings digitally.

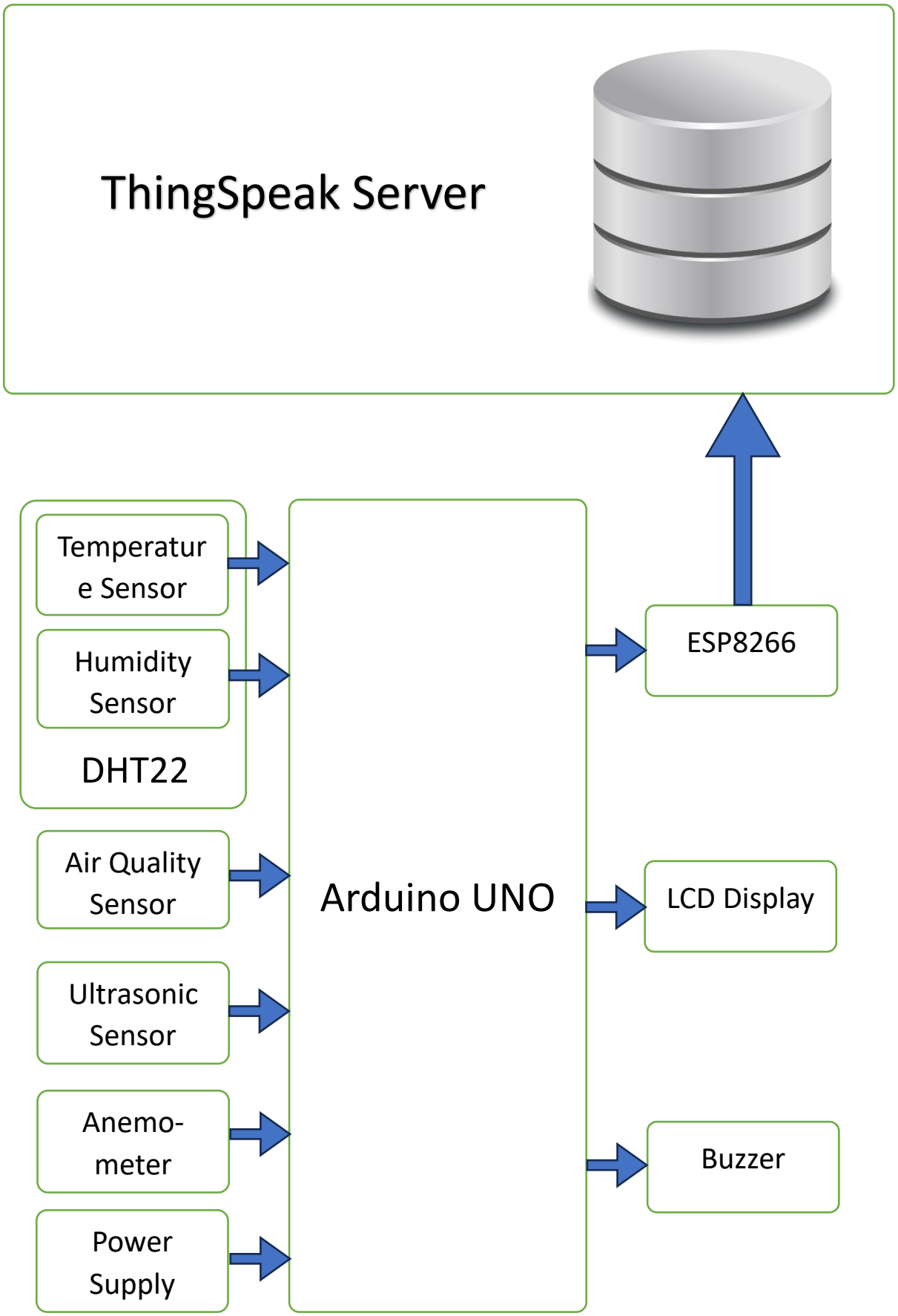
The working of a digital anemometer involves several key steps:

Wind Sensing: The anemometer uses a wind sensor, which could be a cup anemometer, vane anemometer, hot wire anemometer, ultrasonic anemometer, or another type depending on the model. The sensor detects wind speed based on its specific working principle (e.g., rotation of cups, alignment of vane, change in electrical resistance, ultrasonic sound wave analysis).

Analog-to-Digital Conversion: The analog signals from the wind sensor are converted into digital data using an analog-to-digital converter (ADC) in the Arduino.

Data Processing: The obtained value is then processed and displayed on the LCD.

6. Block Diagram



The DHT22 (Digital-output Humidity and Temperature) Sensor, Air quality sensor, ultrasonic sensor, power supply, LCD Display, piezoelectric buzzer and ESP8266 are connected to the Arduino UNO.

- ⇒ The temperature sensor measures the temperature of the surroundings.
- ⇒ The humidity sensor measures the humidity in the surroundings.
- ⇒ The air quality sensor measures the quality of air in the surroundings.
- ⇒ The piezoelectric buzzer buzzes when the air quality (gas sensor reading) goes above 200 making us aware of the air quality.
- ⇒ Ultrasonic sensor is used to calculate the rainfall in mm.
- ⇒ Anemometer is used to calculate Wind Speed.
- ⇒ A power supply is also connected to power up the IoT system.

The Arduino processes the code and displays the data of the weather conditions to the LCD Display. The Wi-Fi module ESP8266 provides internet connectivity through which the data will be monitored on the IoT server. Thus, the people can access the weather data and monitor the changes remotely.

7. Hardware Design

A remote weather monitoring system using IoT is proposed, where the people can access the real-time statistics of the weather conditions in an area.

The DHT22 sensor utilizes exclusive digital-signal-collecting-technique and humidity sensing technology which makes it more precise and reliable.

The ESP8266 is a very user-friendly and low-cost device to provide internet connectivity to our projects. It can also fetch data from the internet using API's hence the project could access any information that is available on the internet, thus making it smarter.

Arduino hardware is an open-source circuit board with a microprocessor and input/output (I/O) pins for communication and controlling physical objects (LED, servos, buttons, etc.). The board is powered via USB or an external power supply which in turn allows it to power other hardware and sensors.

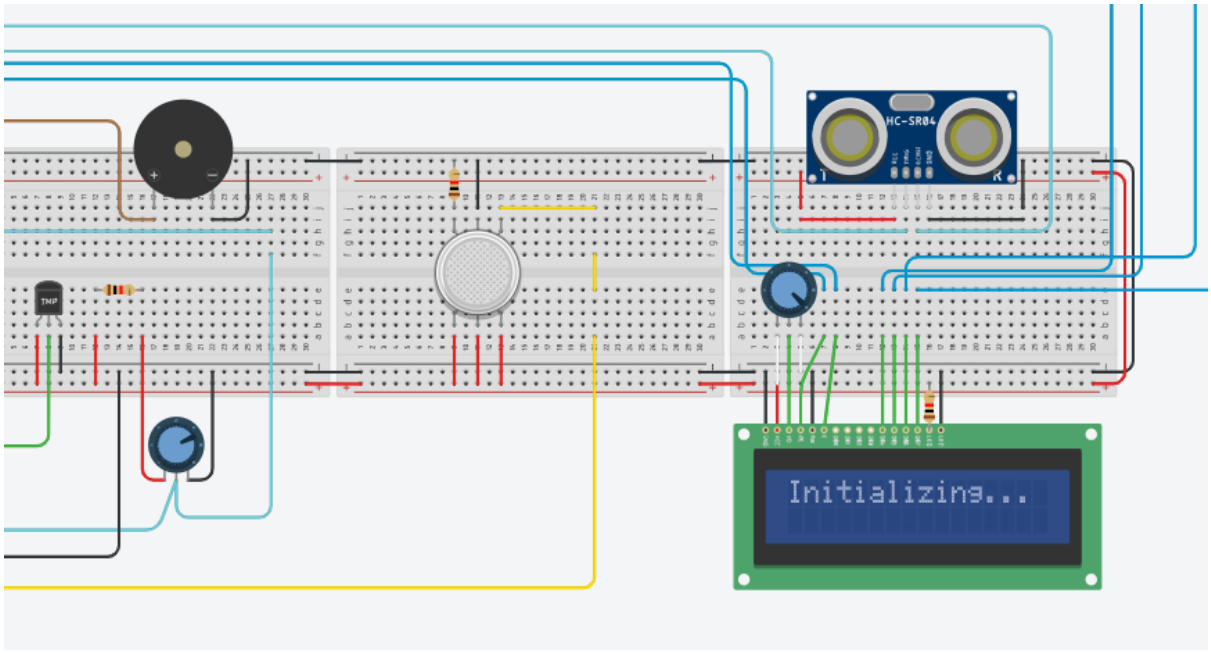
The temperature and humidity sensor (DHT22), Anemometer, Air quality sensor, Ultrasonic sensor, a power supply and an ESP8266 are connected to the Arduino UNO. The sensor measures the weather conditions of the surroundings. The Arduino processes the code and displays the data of the patient to the LCD Display. The Wi-Fi module provides internet connectivity through which the data will be monitored on the IoT Server.

8. Methodology

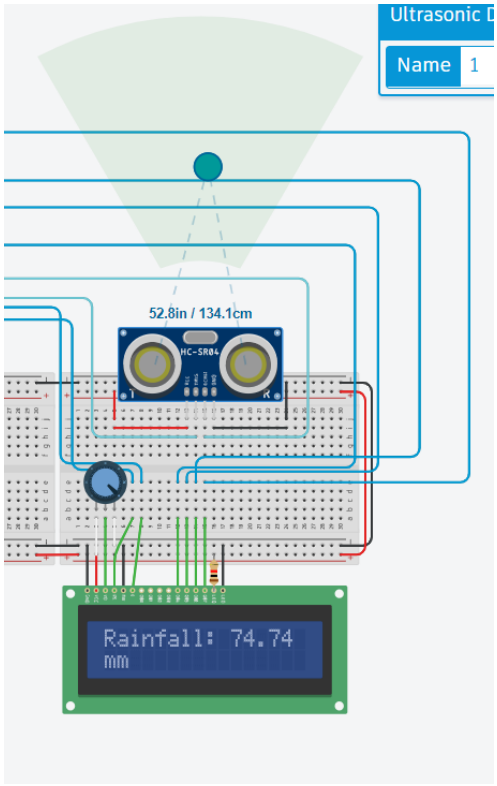
- ⇒ The temperature sensor measures the Temperature.

⇒ The humidity sensor measures the Humidity.
⇒ The Ultrasonic sensor measures the Rainfall.
⇒ The Anemometer measures the wind speed
⇒ The gas sensor (Air quality sensor) measures the air quality.
⇒ The Arduino will process the code and display the parameters of the weather to an LCD Display.
⇒ The Wi-Fi module ESP8266 provides internet connectivity through which the data will be monitored on the IoT server.
⇒ Thus, the meteorological department and the people in the locality can monitor the changes in the weather remotely.

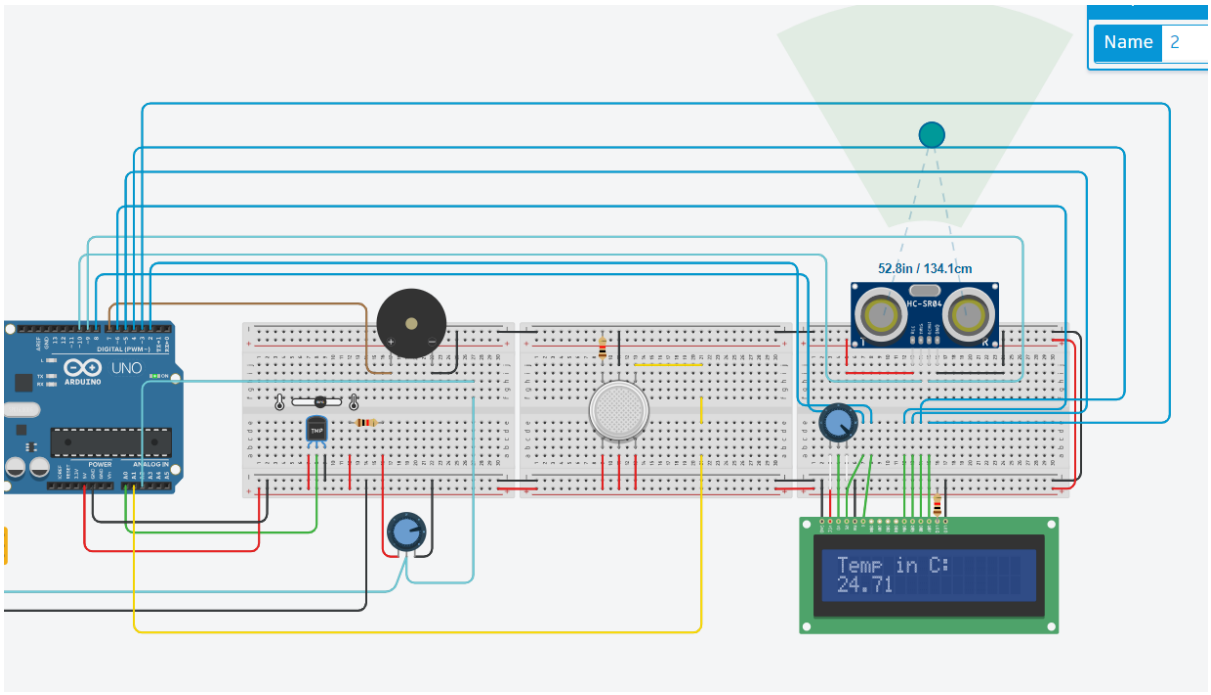
1. Initializing



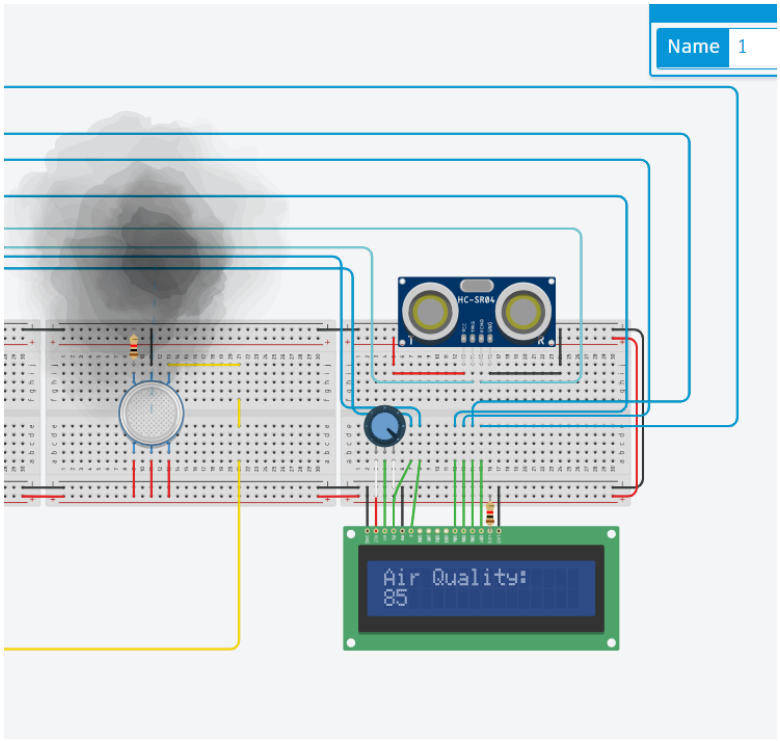
2. Rainfall



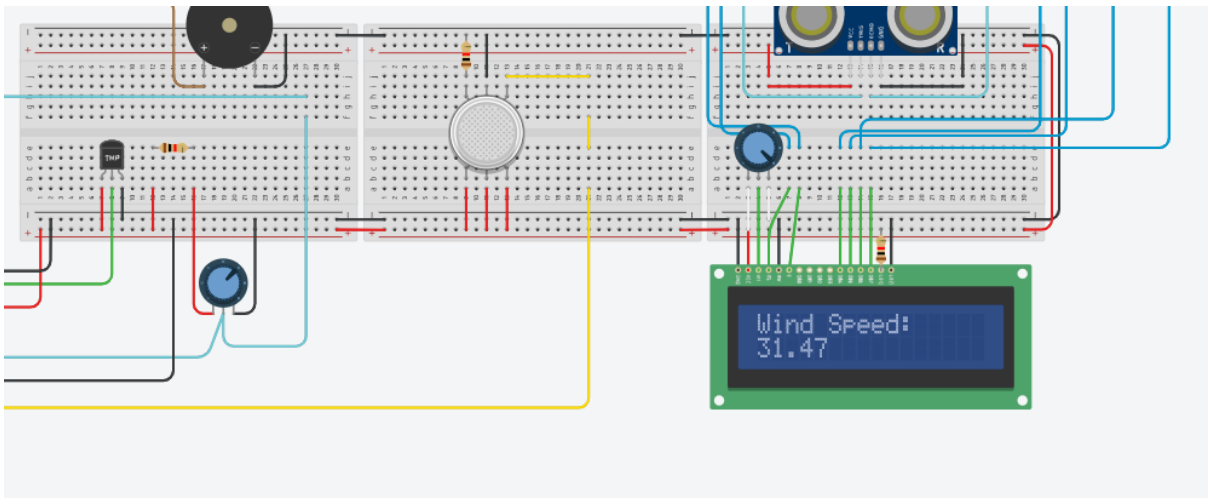
3. Temperature



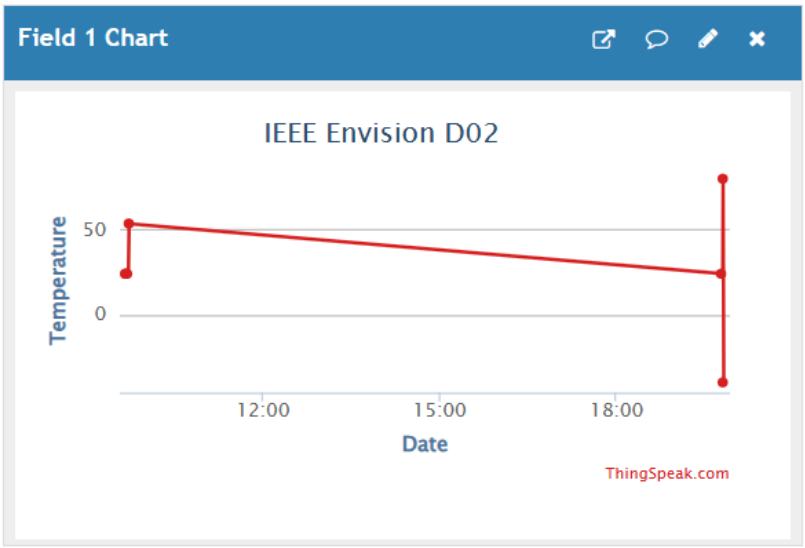
4. Air Quality

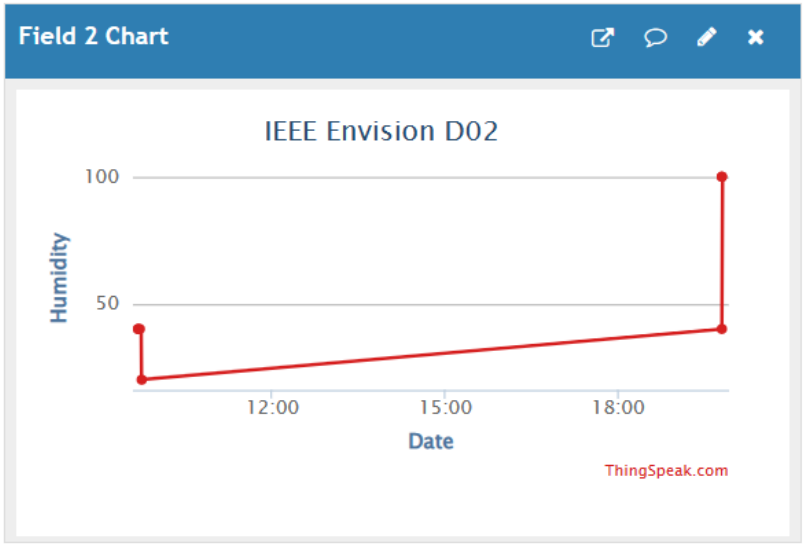


5. Wind Speed



6. ThingSpeak





9. Conclusion

The implementation of IoT based weather monitoring system incorporating temperature, humidity, anemometer, air quality and ultrasonic sensors make a significant stride towards revolutionizing weather monitoring. By harnessing the power of Internet of Things technology, this robust framework has been developed capable of continuously monitoring weather parameters of an area with unprecedented accuracy and efficiency.

The seamless integration of the above-mentioned sensors into the IoT ecosystem empowers individuals to know the real-time weather conditions by facilitating remote monitoring and timely detection of changes.

In essence, this IoT-based weather monitoring system represents a paradigm shift in meteorological data collection and analysis, bridging the gap between conventional weather monitoring methods and advanced technology. By leveraging the interconnectedness of the digital world, the aim is to provide real-time weather data, improve forecasting accuracy, and enhance disaster preparedness and response efforts. This approach seeks to empower individuals and organizations with actionable weather insights, ultimately contributing to safer communities and better decision-making in various sectors worldwide.

10. References

1. Arduino Course for Beginners - https://youtu.be/zJ-LqeX_fLU?si=XUi4szg7wfiEm1iz
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5. IoT - https://youtu.be/6mBO2vqLv38?si=dvq4sT2BsUChGaFa
6. Setting up ThingSpeak Server - https://www.youtube.com/watch?v=8fcQuMRSNBw&t=281s&pp=ygUadGhpbmdzcGVhayBjcmVhdGUgY2hhbm5lbCA%3D