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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

A Project Report on

"IoT Based Air Pollution Monitoring System"

Under the guidance of

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VISVESVARAYA TECHNOLOGICAL UNIVERSITY - BELAGAVI

2022-23

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CERTIFICATE

Certified Project work entitled on "IoT Based Air Pollution Monitoring System" is a bonafide work carried out by Naveen K (3BR18EC159), J Hanumantha Reddy (3BR19EC052), Khaja Moinuddin Khadri (3BR19EC067), Noor Mohammed G (3BR19EC101), in partial fulfillment for the award of Degree in Bachelor of Engineering in ELECTRONICS & COMMUNICATION, as prescribed by VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI during the academic year 2022-2023. It is certified that all corrections and suggestions indicated for internal assessment have been incorporated in the report submitted to the department library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering Degree.

Project guide **HOD, Dept. of ECE** **Principal**

External Exam **Signature with date**
Name of the Examiner

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

DECLARATION

We undersigned students of final semester B.E in Electronics and Communication Engineering, Ballari Institute of Technology and management, Ballari, hereby declare that the dissertation entitled "IoT based Air Pollution Monitoring System", embodies the report of my project work carried out independently by us under the guidance of Dr. Mallikarjuna A, Associate Professor, E & CE Department, Ballari Institute of Technology and management, Ballari in partial fulfillment for the award of Bachelor of Engineering in Electronics and Communication Engineering from Visvesvaraya Technological University, Belgaum during the academic year 2022-2023.We also declare that to the best of our knowledge and belief, this project has not been submitted for the award of any other degree on earlier occasion by any student.

Place: Ballari

Date:

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ABSTRACT

According to population reference bureau, at present, a total number of the vehicles is 1.2 Billion according to survey and it will be 2 Billion up to 2035. Then pollution level has increased due to various factors like the increase in population, increased vehicle use, industrialisation and urbanisation which results in harmful effects on human wellbeing by directly affecting health of population exposed to it. In order to monitor, in this project we have successfully implemented an IoT based air pollution monitoring system in which we will monitor the air quality over a web server using internet and will trigger a alarm when the air quality goes down beyond a certain level, means when there are sufficient amount of harmful gases are present in the air like CO_2, smoke, alcohol, benzene and NH_3. In this IoT project, we will monitor the pollution level from anywhere using our computer or mobile.

CHAPTER - 1

1.1 INTRODUCTION

With the excellence of industrial establishment and rapid increase of population, air pollution is increasing day by day. The increase in industrial activities triggers increases the use of vehicles. Combustion of fuels in the different production process in the industry and vehicles produce a lot of hazardous gases in the environment.

Air pollution is the reasons of many known and the acute problem of the current world which includes greenhouse effects, global warming, depleting the ozone layer, climate change and the reason of extinction of different animals and many more are endangered[1].

Due to air pollution, air is contaminating day by day which means the standard quality of air is decreasing which have negative effects on our health causing different severe diseases like lung diseases and asthma, allergic reactions and cardiac diseases[2]. Air pollution can also cause premature deaths [3]. So, air pollution must be controlled to ensure a better, green and pollution free world.

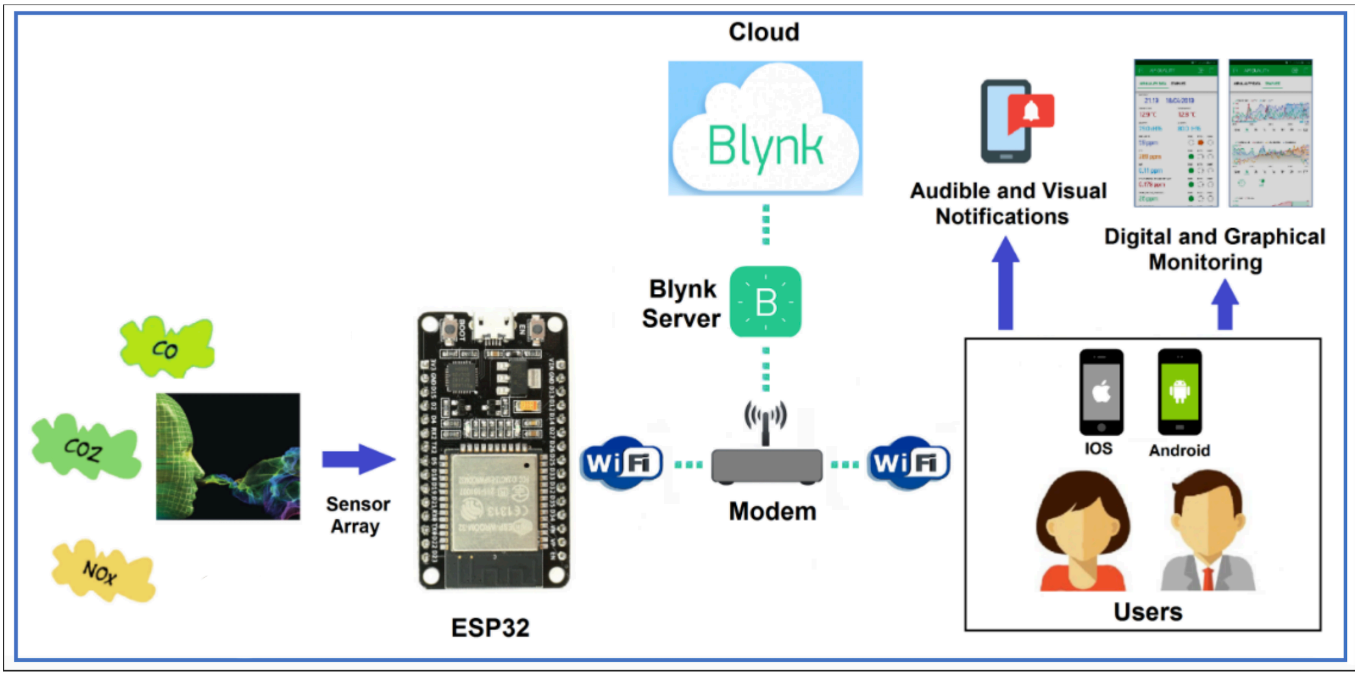

Fig - 1.1 (a) : IoT Based Air Pollution Monitoring using Blynk Server

Air pollution presents a serious threat to human health, especially in densely populated urban areas where the pollution levels continue to increase above the safe limits. Statistics also show that about 30% of air pollution on an average is attributed to pollutants from automobiles. Such kind of pollution can lead to various health implications like heart and lung disorder [10].

A portion of the air toxins produce through human activities are carbon dioxide gas (CO_2), carbon monoxide (CO), sulphur oxides (SO_2), nitrogen oxides (NO_2), volatile organic compounds (VOC), ammonia (NH_3) and methane gas (CH_4). At the point when a portion of these compound toxins is uncovered into the air and the environment, it will increase the occurrence of ailments for example, pneumonia, lung malignant growth, ceaseless bronchitis, asthma, constant respiratory infections and coronary artery disease [12].

The Internet of Things is the inter-networking of physical devices, buildings, vehicles and other items embedded with electronics, sensors, software, actuators and network connectivity as shown in Fig 1.1(a) that enable each object to collect and exchange Data.

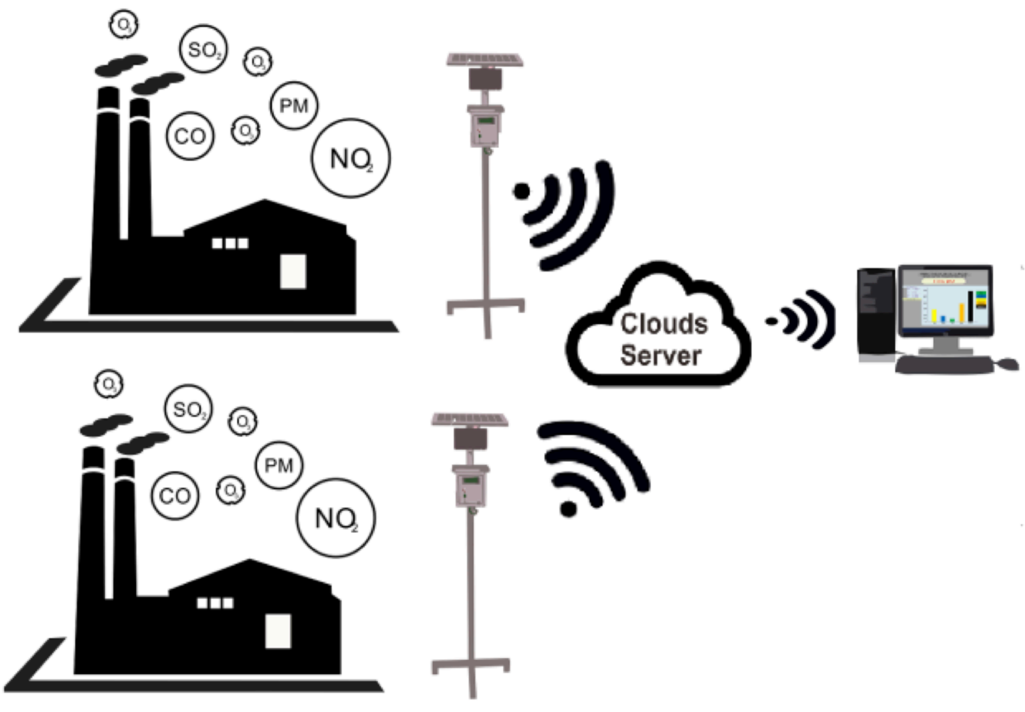

Fig - 1.1 (b) : Industries using IoT based Air Pollution Monitoring System

Our system uses an MQ-2, MQ-4, MQ-7 and MQ-135 sensors to detect sulphur dioxide, Methane, carbon monoxide and Ammonia (NH_3), sulfur (S), Benzene (C_6H_6), CO_2, and other harmful gases and smoke. Our system uses Esp32 microcontroller to compares the level of Pollutants with the stipulated level allowed by the Government[4] as shown in Fig 1.1(b).

Monitoring gives measurements of air pollutant concentrations, which can then be analysed interpreted and presented. This information can then be applicable in many ways. Analysis of monitoring data allows us to assess how bad air pollution is from day to day[5].

Therefore, to overcome the issues of toxic gas poisoning in the surroundings, the development of an air quality monitoring system capable of providing notification updates on the air quality levels is very important. Internet of things (IoT) based air quality monitoring with low-cost energy by using Esp32 Microcontroller on the integration of Blynk App is presented in this paper.

IoT systems with embedded air quality sensors, microcontroller units (MCUs) and electronic software frameworks to provide data exchange and the corresponding information. Furthermore, the data outcomes can be utilised by enhancing communication technology systems to provide instant updates besides monitoring the impact of air quality levels in particular areas [11].

1.2 OBJECTIVES

- Design a circuit using the ESP32 microcontroller and multiple gas sensors (MQ2, MQ4, MQ7, and MQ135) to measure the concentration of different pollutants in the air.
- Develop a Blynk mobile application that can communicate with the ESP32 module and display real-time air quality data.
- Integrate the Blynk application with the ESP32 module and gas sensors to enable remote control of the system and real-time monitoring of air quality data.
- Test the system in different environments to evaluate its accuracy and reliability in detecting various air pollutants.
- Provide an alarm or notification system to alert users when air pollution levels exceed safe limits.

CHAPTER - 2

2.1 LITERATURE SURVEY

- Authors have proposed [5] using IoT technology, enhances the process of air quality monitoring. They have used MQ135 gas sensor for sensing different type of dangerous gases. The have also used Automatic Air & Sound management system that overcomes the problem of the highly-polluted areas & supports the healthy life concept & using this system.

- Authors have proposed [6] work on air pollution monitoring and prediction system, which enables us to monitor air quality with the help IoT devices. The system utilises air sensors to detect and transmit the data to microcontroller. Then the microcontroller stores the data into the web server. For predicting the LSTM is implemented. It has a quick convergence and reduces the training cycles with a good.

- Authors have proposed [7] a prototype, monitoring of potholes and real-time location-based air pollution monitoring along-with on-time alert of existing pot- holes. The proposed prototype is also an economical solution, as it requires a few components to build up, and the compact form factor allow them to be embedded in a helmet very conveniently. The data of the pothole and pollution provided by the system could also be utilised by various satellite navigation routing applications to ensure a safer and relatively less polluted route.

- Authors have proposed [8] a successfully designed and implemented a low-cost air pollution detection and monitoring device which can continuously monitor air pollution data.The system has features such as extensibility, mobility, and robustness which gives it more credibility over existing systems that are being used as prototype in various applications.

- Authors have proposed [9] an indoor air quality detector (IAQD) and implemented by using the advanced IoT techniques. This IAQD comprises five sensors that could detect temperature, humidity, PM2.5, CO_2 and formaldehyde in real time. This IAQD can be applied in wired communication scenario, short-range wireless network communication scenario, long-distance to cloud platform scenario, or mixed applications.

- Authors have proposed [7] and the trial was carried out in the campus environment to monitor air quality conditions on the campus. From the results of the trial monitored data of compounds in the air that were measured were data on levels of Ozone, SO2, CO and PM10 particles. Data received by ThingSpeak can be monitored on the channel pages provided. From the results obtained, further development can be done by making a mobile-based client application.

- Authors have proposed [4] a system which will monitor air pollution and Noise created by vehicles. Our proposed system is a low cost, simple to operate and portable. The developed system provides better efficiency and accuracy with low cost than the existing proposed system. It will gradually reduce Global Warming if implemented on a global scale.

- Authors have proposed [9] an IoT-based 3D air quality sensing system, which is designed to be fine-grained, real-time, and power efficient. The architecture of this system includes the sensing layer to collect data, the transmission layer to enable bidirectional communications, the processing layer to analyse and process the data, and the presentation layer to provide graphic interface for users. To further optimise the quality of the collected data, deployment strategies for ground sensing and aerial sensing are executed to adjust the sensing locations.

- Authors have proposed [10] a system for air quality monitoring which uses various sensors to measure the concentration of different gases in the air in real-time. The collected data is then processed by an algorithm which predicts the overall air quality of the area. One unique feature of the system is that it can transmit the calculated information for traffic control purposes if the air quality is found to be detrimental. Additionally, the system includes a mobile application that can be used by the general public to understand and be aware of the pollution status of localities, which could contribute to reducing pollution levels. The proposed system was designed and tested successfully.

- Authors have presented [11] the development of the Blynk IoT platform for air quality monitoring systems using Arduino Uno. The system was tested to demonstrate air quality monitoring. Several valuable achievements were made, including development of IoT-based systems, reliability of sensors, and NodeMCU as a key component. In the future, IoT can be integrated with artificial intelligence for automated air quality monitoring. Additionally, an automated ventilation system can be connected to the device for improved performance.

- Authors have designed [12] an IoT based air pollution monitoring system using Q-2 gas sensor, ESP8266 Wi-Fi module, and DHT22 temperature and humidity sensors. The system measured air pollution using MQ-2 gas sensor and DHT22 temperature sensor, and results indicated AQI less than 100 for good air quality and more than 200 AQI for hazardous air quality. The system used green LED to indicate good air quality and red LED to indicate hazardous gas. All data were monitored in real-time through ThingSpeak for every 15 seconds. The system also provided notification of hazardous gas to users in a mobile phone app.

2.2 PROBLEM STATEMENT

- Air pollution is a major global issue that affects the health and wellbeing of people.
- Traditional air quality monitoring systems are often expensive, stationary, and not easily accessible to the public.
- There is a need for a low-cost, portable, and real-time air quality monitoring system that can provide accurate and timely information to individuals and authorities.
- The use of IoT technology in air quality monitoring has the potential to provide a solution to this problem by allowing for remote monitoring and data collection from various locations.
- However, there is a need for a comprehensive system that can measure multiple pollutants and provide a user-friendly interface for data visualisation and analysis.
- The goal of this project is to design and develop an IoT-based air pollution monitoring system using ESP32 and gas sensors (MQ2, MQ4, MQ7, and MQ135) that can measure multiple pollutants in real-time and provide users with a user-friendly mobile app interface.

CHAPTER - 3

3.1 METHODOLOGY

The methodology used in implementing IoT based Air Pollution Monitoring System is discussed in detail as shown below

1. Develop an IoT-based air pollution monitoring system using ESP32 and gas sensors such as MQ2, MQ4, MQ7, and MQ135.
2. Create a hardware module to collect real-time data on air quality in a particular area.
3. Implement the Blynk platform for data visualisation and monitoring on a mobile application.
4. Analyse and measure the concentrations of various harmful gases like carbon monoxide, ammonia, and other particulate matter in the air.
5. Provide warnings or messages on the mobile application based on the gas concentrations and temperature readings.
6. Increase awareness about air pollution levels in the community and encourage individuals to take steps towards reducing pollution levels

3.1.1 BLOCK DIAGRAM

Before sketching our block diagram we have gone through the pin out of ESP32 as shown in Fig - 3.1.1(a) & listed the components that can be used in the implementation, that consists of both hardware & software designs

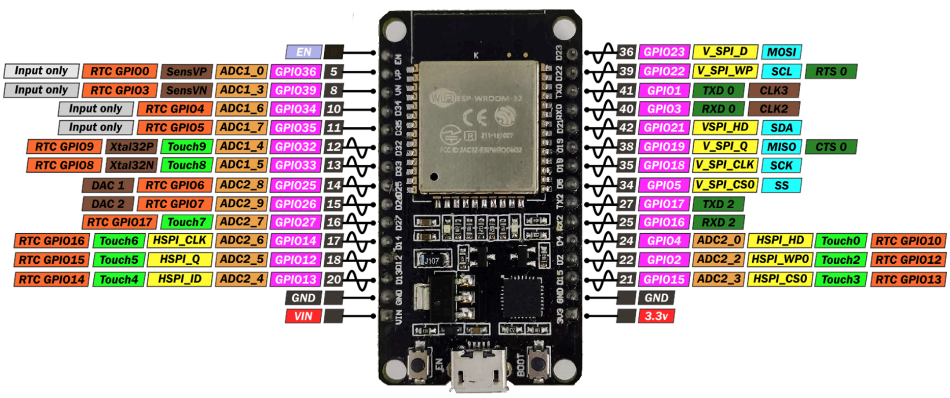

Fig - 3.1.1(a) : Pinout diagram of ESP32 Microcontroller.

The implementation of our project is as shown in the Fig 3.1.1(b)

- From the Block Diagram as shown in Fig 3.1.1(b), Our system uses an MQ-2, MQ-4, MQ-7 and MQ-135 sensors to detect sulphur dioxide, Methane, carbon monoxide and Ammonia (NH_3), sulfur (S), Benzene (C_6H_6), CO_2, and other harmful gases and smoke.
- Our system uses ESP32 microcontroller to compares the level of Pollutants with the stipulated level allowed by the Government.
- Our system collects the data from the sensors MQ-2, MQ-4, MQ-7 and MQ-135 then for processing it is sent to ESP32 microcontroller that provides a interface by sending data to Blynk Cloud [IoT Broker], then it is sent to monitor the data using Web / Mobile Application.
- Monitoring gives measurements of air pollutant and sound pollution concentrations, which can then be analysed and recorded.

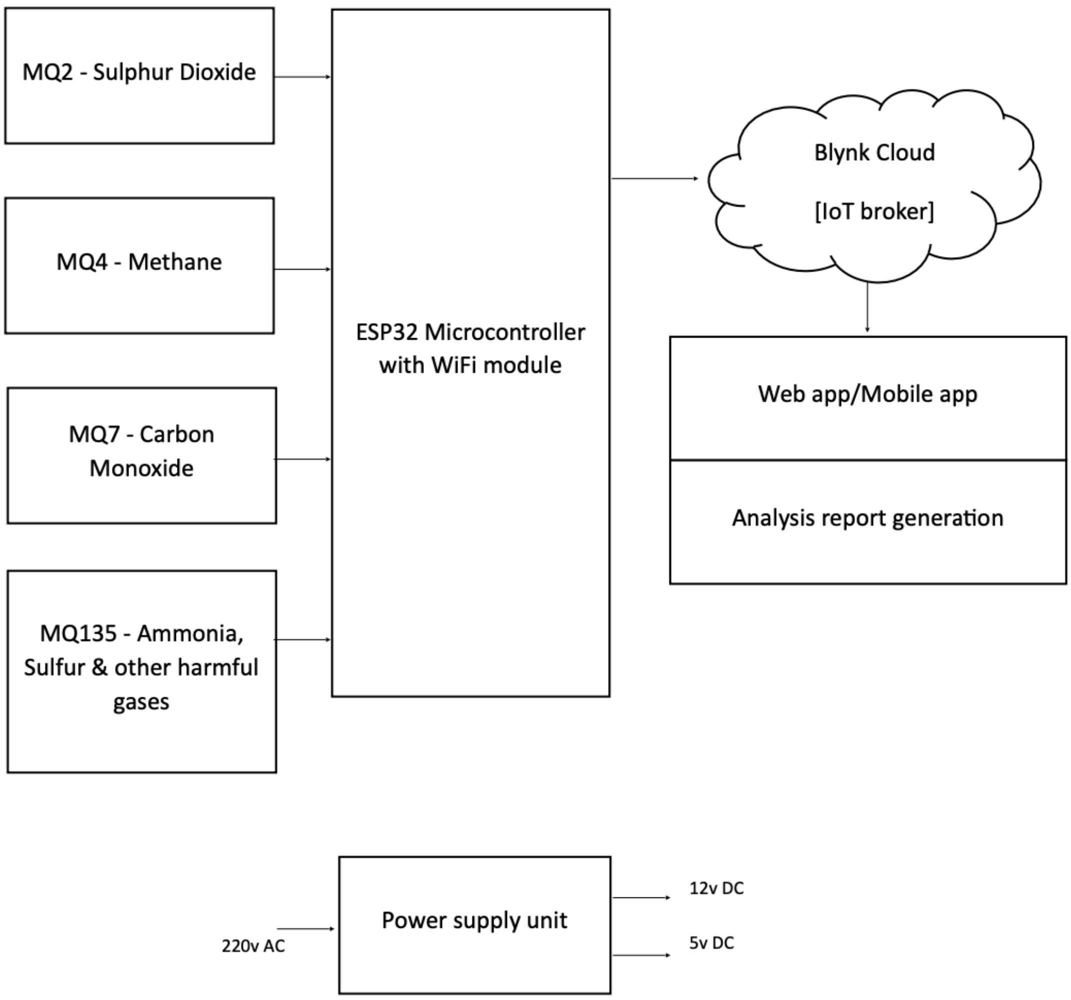

Fig - 3.1.1(b): Block Fig Diagram of IoT based air pollution monitoring system

3.1.2 DESIGN

Hardware design:

- ESP32 development board will be used as the main controller for the system.
- Four gas sensors (MQ2, MQ4, MQ7, and MQ135) will be used to detect the concentration of different gases in the air.

Software design:

- The Blynk IoT platform will be used for data visualisation and user interaction.
- The Arduino IDE will be used to write the code for the ESP32 board.
- The code will include the setup and loop functions to initialise the sensors and read the data from them.
- The Blynk library will be used to connect the ESP32 board to the Blynk app and send data to it.

System architecture:

- The ESP32 board will be the main controller and will collect data from the gas sensors.
- The data will be processed and sent to the Blynk app for visualisation and user interaction.
- The Blynk app will display the current values of each sensor and will provide alerts if the air quality reaches a hazardous level.
- The system will be powered by a USB cable connected to the ESP32 board.

3.1.3 FLOWCHART

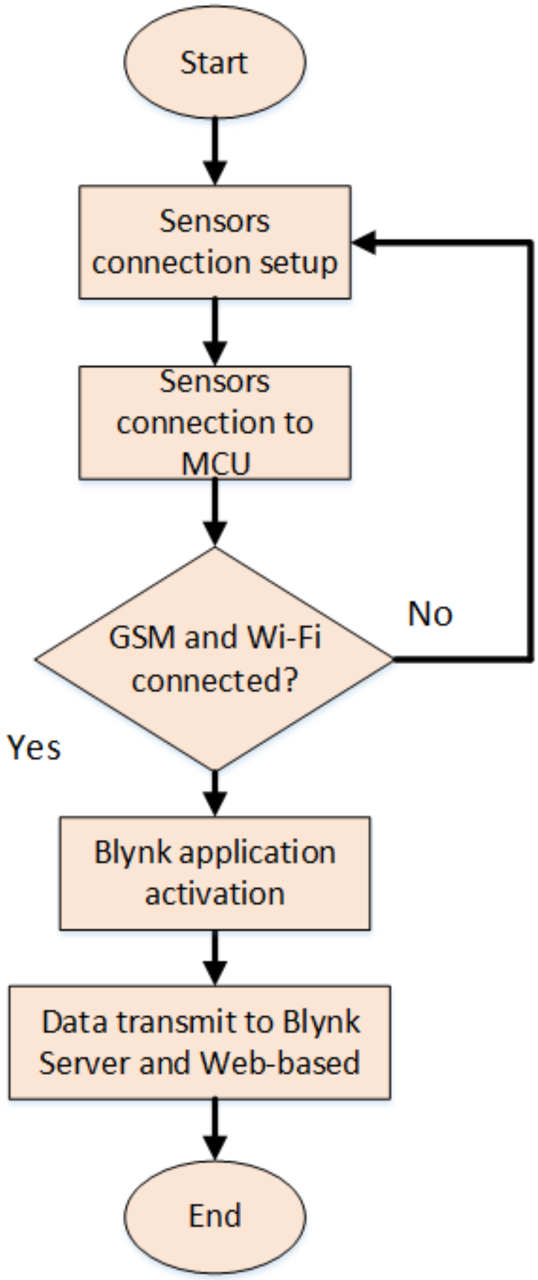

Fig - 3.1.3 : Flowchart of IoT Based Air Pollution Monitoring System

- The flowchart as shown in Fig 3.1.3 provides a visual representation of the steps involved in the system's operation, from the start to the end of the process.

- The sensors connection setup step involves connecting the MQ2, MQ4, MQ7, and MQ135 gas sensors to the ESP32 microcontroller unit (MCU) in the system.

- The next step is to connect the sensors to the MCU, followed by checking if the GSM and Wi-Fi connections are established.
- In case the GSM and Wi-Fi connections are not established, the system will return to the sensors connection setup step to ensure the connections are established correctly.
- Once the connections are established, the Blynk application is activated, allowing the user to access the data collected by the sensors in real-time.
- The collected data is then transmitted to the Blynk server and web-based platforms for monitoring purposes.
- The end of the flowchart represents the conclusion of the system's operation.

3.1.4 COMPONENTS DETAIL

The Components are MQ2, MQ4, MQ7, and MQ135 these sensors all use a similar method to detect gas. The sensors have a sensing material that changes its electrical resistance when it comes into contact with a gas. The change in resistance is proportional to the concentration of the gas.

The MQ2 sensor is a metal oxide semiconductor (MOS) sensor that is sensitive to a wide range of gases, including LPG, methane, alcohol, and smoke. The MQ4 sensor is also a MOS sensor, but it is specifically designed to detect methane. The MQ7 sensor is a carbon monoxide sensor that uses a sensing material made of carbon monoxide. The MQ135 sensor is an air quality sensor that is sensitive to a variety of gases, including ammonia, nitrogen dioxide, and sulfur dioxide.

The sensors are typically used in conjunction with an Arduino or other microcontroller to measure the change in resistance and convert it to a concentration value. The concentration value can then be used to control a variety of devices, such as alarms, valves, and motors.

3.1.4.1 MQ2 Gas Sensor :

The MQ2 sensor is shown in Fig 3.1.4.1, One of the most widely used in the MQ sensor series. It is a MOS (Metal Oxide Semiconductor) sensor. Metal oxide sensors are also known as Chemiresistors because sensing is based on the change in resistance of the sensing material when exposed to gasses

Fig - 3.1.4.1: MQ2 - Sulphur Dioxide

The MQ2 gas sensor operates on 5V DC and consumes approximately 800mW. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations ranging from 200 to 10000 ppm.

The MQ2 sensor uses a sensing material made of tin dioxide (SnO2). When the sensor is exposed to a gas, the SnO2 changes its electrical resistance. The change in resistance is proportional to the concentration of the gas.

- **Internal Structure of MQ2 Gas Sensor :**

The MQ2 is a heater-driven sensor. It is therefore covered with two layers of fine stainless steel mesh known as an “anti-explosion network” as shown in Fig - 3.1.4.1(a), It ensures that the heater element inside the sensor does not cause an explosion because we are sensing flammable gasses.

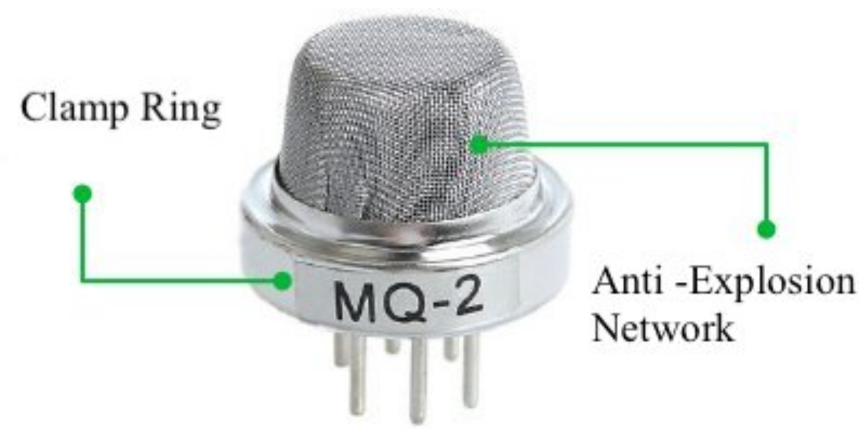

Fig - 3.1.4.1 (a) : MQ2 - Outer surface

It also protects the sensor and filters out suspended particles, allowing only gaseous elements to pass through the chamber. A copper-plated clamping ring secures the mesh to the rest of the body.

When the outer mesh is removed, the sensor looks like this. The sensing element and six connecting legs that extend beyond the Bakelite base form the star-shaped structure. Two (H) of the six leads are in charge of heating the sensing element and are linked together by a Nickel-Chromium coil (a well-known conductive alloy) as shown in Fig - 3.1.4.1(b).

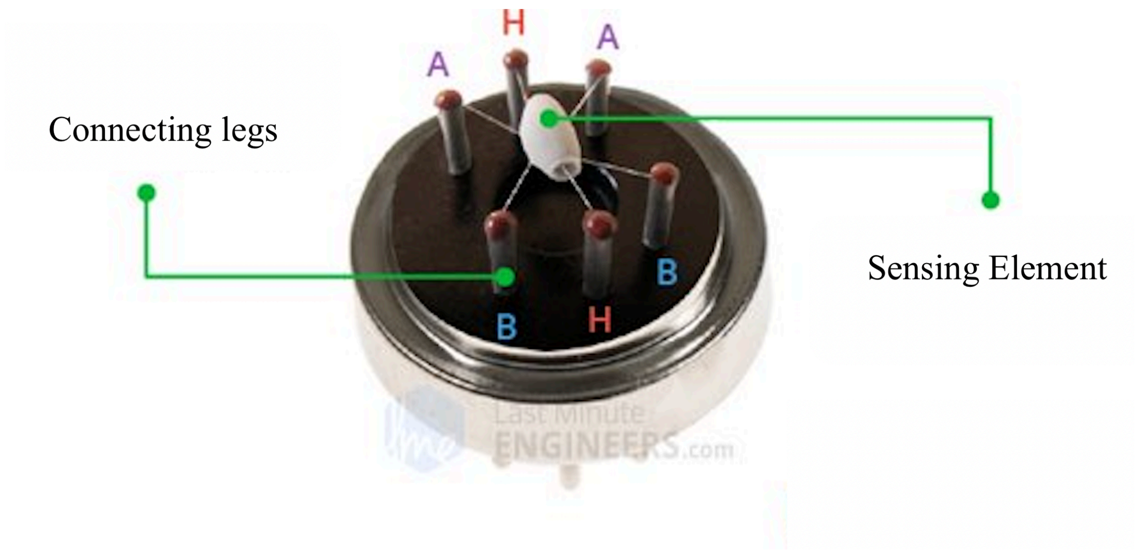

Fig - 3.1.4.1 (b) : MQ2 - Inside structure

The remaining four signal-carrying leads (A and B) are connected with platinum wires. These wires are connected to the body of the sensing element and convey slight variations in the current flowing through the sensing element.

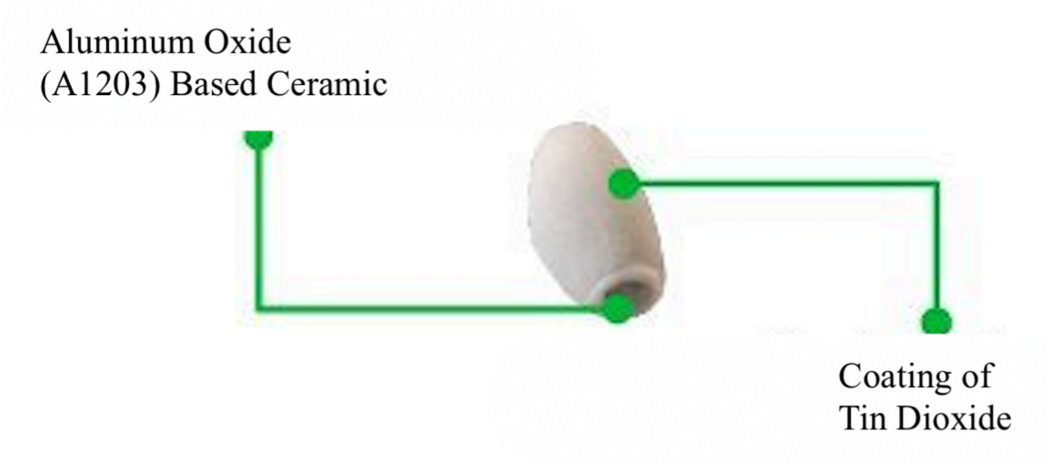

Fig - 3.1.4.1 (c) : MQ2 - Sensing element

The tubular sensing element is made of Aluminium Oxide (AL2O3) based ceramic with a Tin Dioxide coating (SnO2). Tin Dioxide is the most important material because it is sensitive to combustible gasses as shown in Fig - 3.1.4.1 (c).

The ceramic substrate, on the other hand, improves heating efficiency and ensures that the sensor area is continuously heated to the working temperature.

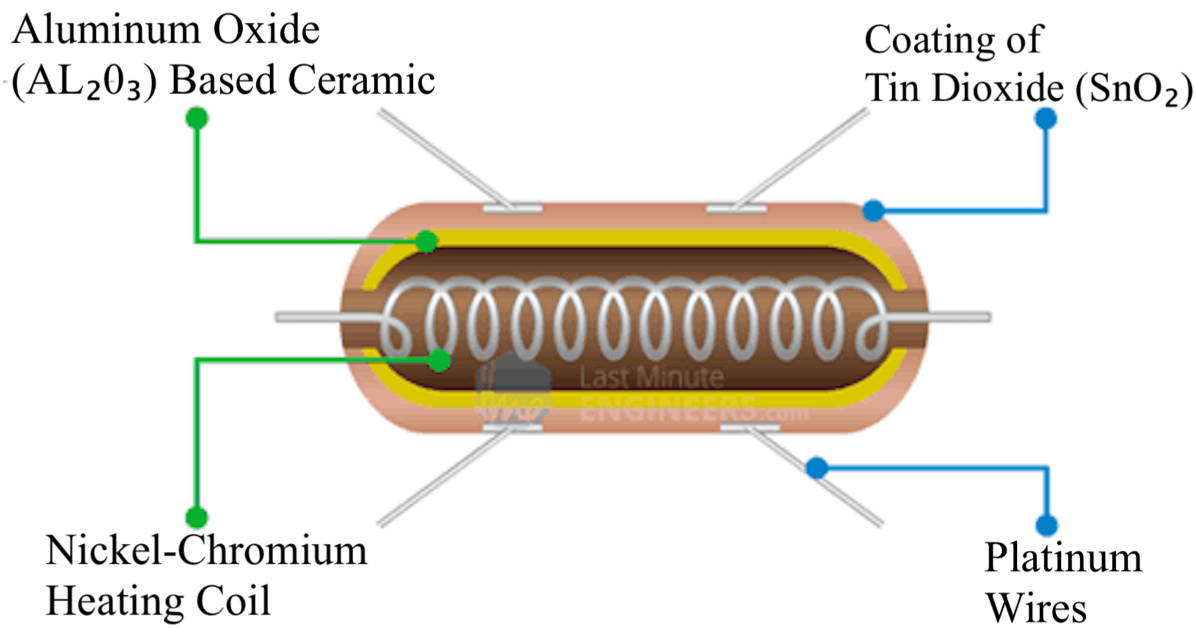

Fig - 3.1.4.1 (d) : MQ2 - Ceramic Substrate

To summarise, the Heating System is composed of a Nickel-Chromium coil and an Aluminium Oxide-based ceramic, while the Sensing System is composed of Platinum wires and a Tin Dioxide coating as shown in Fig - 3.1.4.1 (d).

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3.1.4.2 MQ4 Gas Sensor :

MQ4 methane gas sensor is shown in Fig Fig - 3.1.4.2, A MOS (metal oxide semiconductor) type sensor, used to detect the methane gas concentration within the air at either home or industries & generates output like analog voltage by reading it. Here, the range of concentration for sensing ranges from 300 pm – 10,000 ppm which is appropriate for the detection of a leak.

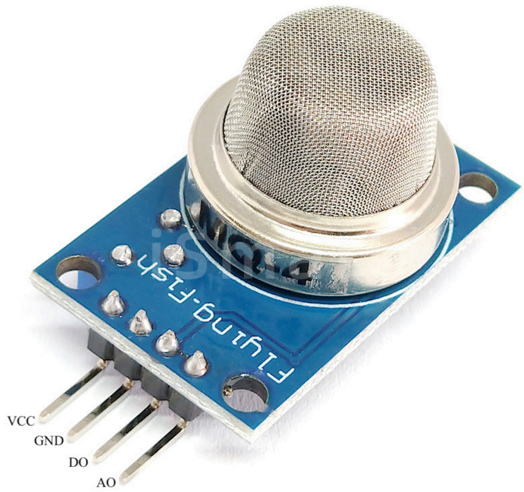

Fig - 3.1.4.2 : MQ4 - Methane

The MQ4 sensor also uses a sensing material made of SnO2. However, the MQ4 sensor is specifically designed to detect methane. The MQ4 sensor is more sensitive to methane than the MQ2 sensor.

3.1.4.3 MQ7 Gas Sensor :

This Carbon Monoxide (CO) / MQ7 gas sensor is shown in Fig Fig - 3.1.4.3, which detects the concentrations of CO in the air and outputs its reading as an analog voltage. The sensor can measure concentrations of 10 to 10,000 ppm.The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V.

Fig - 3.1.4.3 : MQ7 - Carbon Monoxide

The MQ7 sensor uses a sensing material made of carbon monoxide. When the sensor is exposed to carbon monoxide, the carbon monoxide reacts with the sensing material and changes its electrical resistance. The change in resistance is proportional to the concentration of the carbon monoxide.

3.1.4.4 MQ135 Gas Sensor :

The MQ-135 Gas sensor is shown in Fig Fig - 3.1.4.4, which can detect gases like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gases and smoke. Similar to other MQ series gas sensor, this sensor also has a digital and analog output pin. The MQ135 air quality sensor module operates at 5V and consumes around 150mA. It requires some pre-heating before it could actually give accurate result.

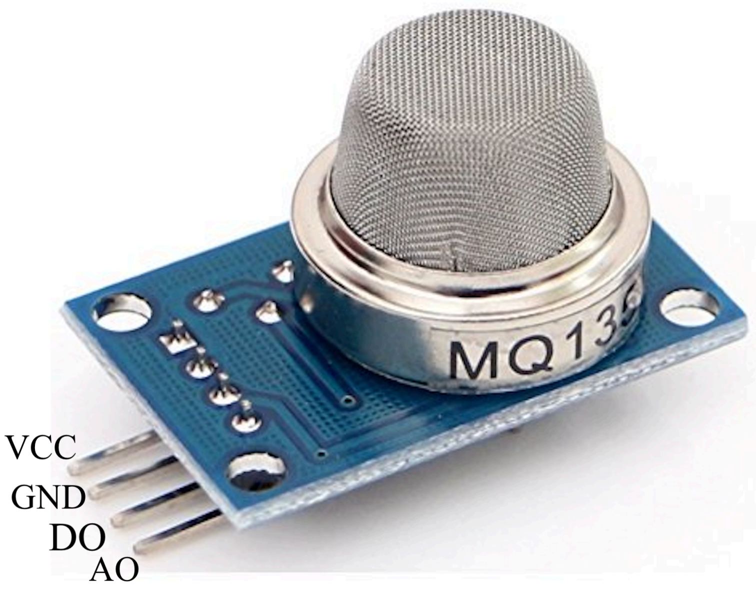

Fig - 3.1.4.4 : MQ135 - Gas sensor

The MQ135 sensor uses a sensing material made of titanium dioxide (TiO2). When the sensor is exposed to a gas, the TiO2 changes its electrical resistance. The change in resistance is proportional to the concentration of the gas.

3.1.4.5 ESP32 MICROCONTROLLER :

The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities as shown in the Fig - 3.1.4.5, It can be programmed using the Arduino IDE and is widely used for Internet of Things (IoT) applications. The ESP32 module operates at 3.3V and has several digital and analog input/output pins for interfacing with various sensors and devices.

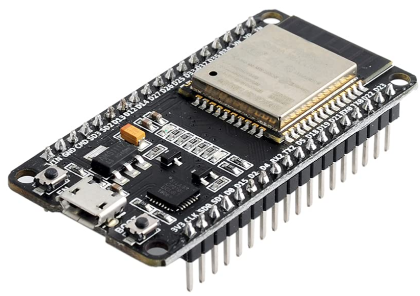

Fig - 3.1.4.5 : ESP32 - Microcontroller

It also has a built-in ADC (Analog to Digital Converter) and DAC (Digital to Analog Converter) for analog signal processing.The ESP32 can be powered by a USB cable or an external power source and has low power consumption features.

- **Main Components OF ESP32 :**
  Here are some details about the main components of the ESP32 development board as show in Fig - 3.1.4.5(a) :

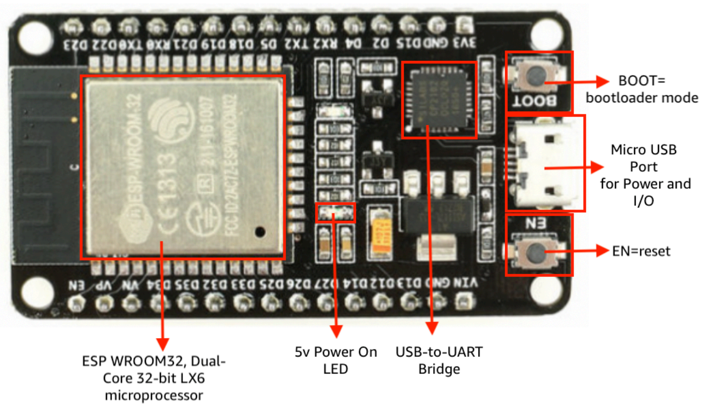

Fig - 3.1.4.5 (a) : ESP32 - Microcontroller Details

- ESP32 Microcontroller: The ESP32 is a powerful microcontroller developed by Espressif Systems. It features a dual-core Xtensa LX6 processor, Wi-Fi and Bluetooth connectivity, and a rich set of peripherals.

- CPU: The ESP32 microcontroller uses a dual-core Xtensa LX6 processor, which operates at a clock frequency of up to 240 MHz. The dual-core architecture allows for efficient multitasking and handling of multiple tasks simultaneously.

- Wi-Fi and Bluetooth: The ESP32 supports both Wi-Fi (802.11b/g/n) and Bluetooth (v4.2 and BLE) connectivity. It enables seamless wireless communication with other devices and can be used in various IoT applications.

- GPIO Pins: The ESP32 board provides a number of General Purpose Input/Output (GPIO) pins. These pins can be used to interface with external components such as sensors, actuators, and displays. The exact number of GPIO pins may vary depending on the specific ESP32 development board you are using.

- Analog Inputs: The ESP32 has a built-in Analog-to-Digital Converter (ADC), allowing it to read analog input signals. This is useful for interfacing with analog sensors that provide continuous voltage outputs.

- USB Interface: The ESP32 board typically includes a micro USB port for power supply and programming. It allows you to upload code and communicate with the microcontroller using a USB connection.

- Serial Communication: The ESP32 has multiple UART (Universal Asynchronous Receiver/Transmitter) interfaces that support serial communication. This enables communication with other devices using protocols such as UART, SPI, and I2C.

- Integrated Development Environment (IDE): To program the ESP32, you can use the Arduino IDE or other compatible development environments. The ESP32 board is supported by the Arduino core for ESP32, which provides libraries and examples to simplify the development process.

- Additional Features: Depending on the specific ESP32 development board, you may find additional features such as integrated LED indicators, reset buttons, voltage regulators, power management circuits, and external memory options (e.g., SPI Flash).

3.2 IMPLEMENTATION

Firstly, the hardware components such as the ESP32 board, gas sensors, and supporting components like resistors, capacitors, and wires need to be assembled according to the circuit diagram. This requires a basic understanding of electronics and soldering skills.

Next, the firmware for the ESP32 board needs to be developed using programming languages like Arduino IDE or MicroPython. This firmware should be able to read the sensor data, convert it into meaningful values, and transmit it to the cloud server or a mobile application using the Wi-Fi connectivity feature of ESP32.

After developing the firmware, it needs to be uploaded to the ESP32 board. This can be done using a USB cable and a computer. Once the hardware and firmware are ready, the system needs to be calibrated to ensure accurate readings from the gas sensors as shown in the Fig - 3.2.

This involves exposing the sensors to known concentrations of gases and adjusting the calibration settings in the firmware.Finally, the system needs to be tested and evaluated in real-world conditions.

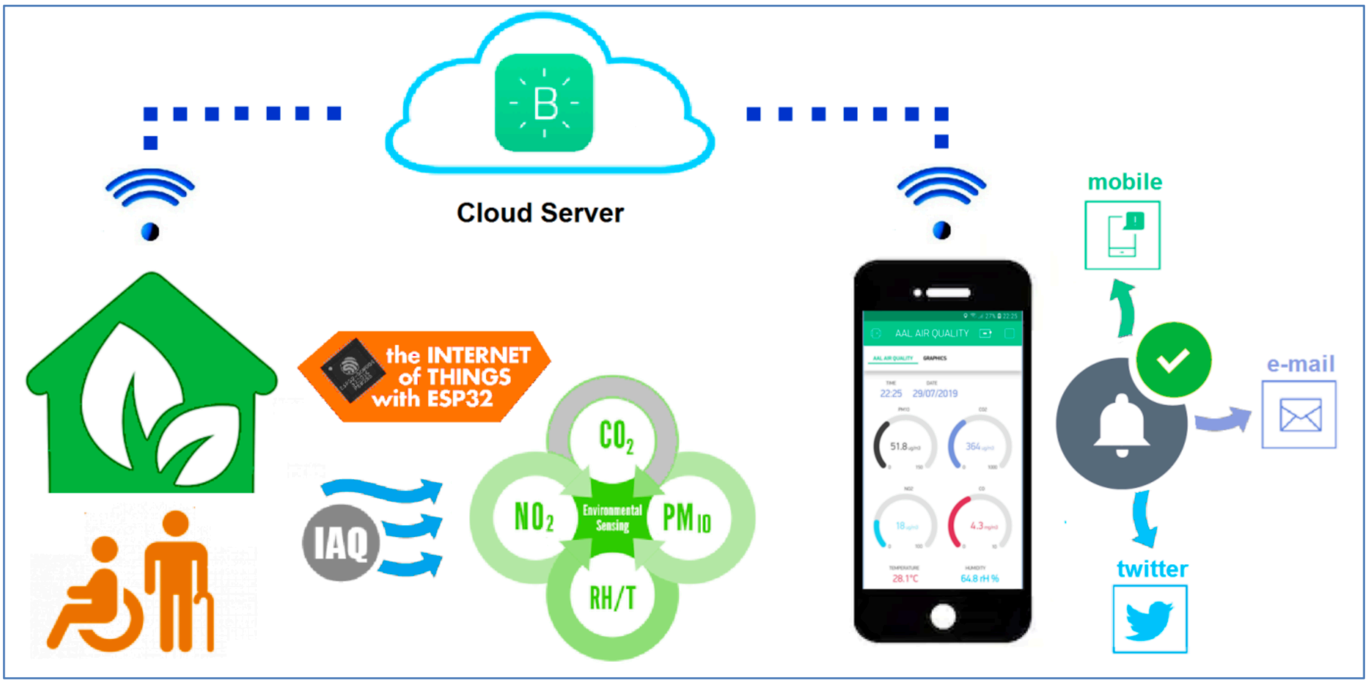

Fig - 3.2 : Implementation Model

This involves installing the system in the desired location, monitoring the data readings, and ensuring that the system is functioning as intended.

In summary, the implementation process for an IoT-based air pollution monitoring system using ESP32 and gas sensors involves assembling the hardware, developing and uploading the firmware, calibrating the system, and testing it in real-world conditions

3.2.1 WORKING MODEL

The working model of the IoT based air pollution monitoring system involves the following steps:

- Sensors Connection Setup: Firstly, all the sensors (MQ2, MQ4, MQ7, and MQ135) are connected to the microcontroller (ESP32) with the help of jumper wires. The connections are made in a way that the analog output pins of the sensors are connected to the analog input pins of the microcontroller as shown in the Fig - 3.2.1, and the digital output pins of the sensors are connected to the digital input pins of the microcontroller.

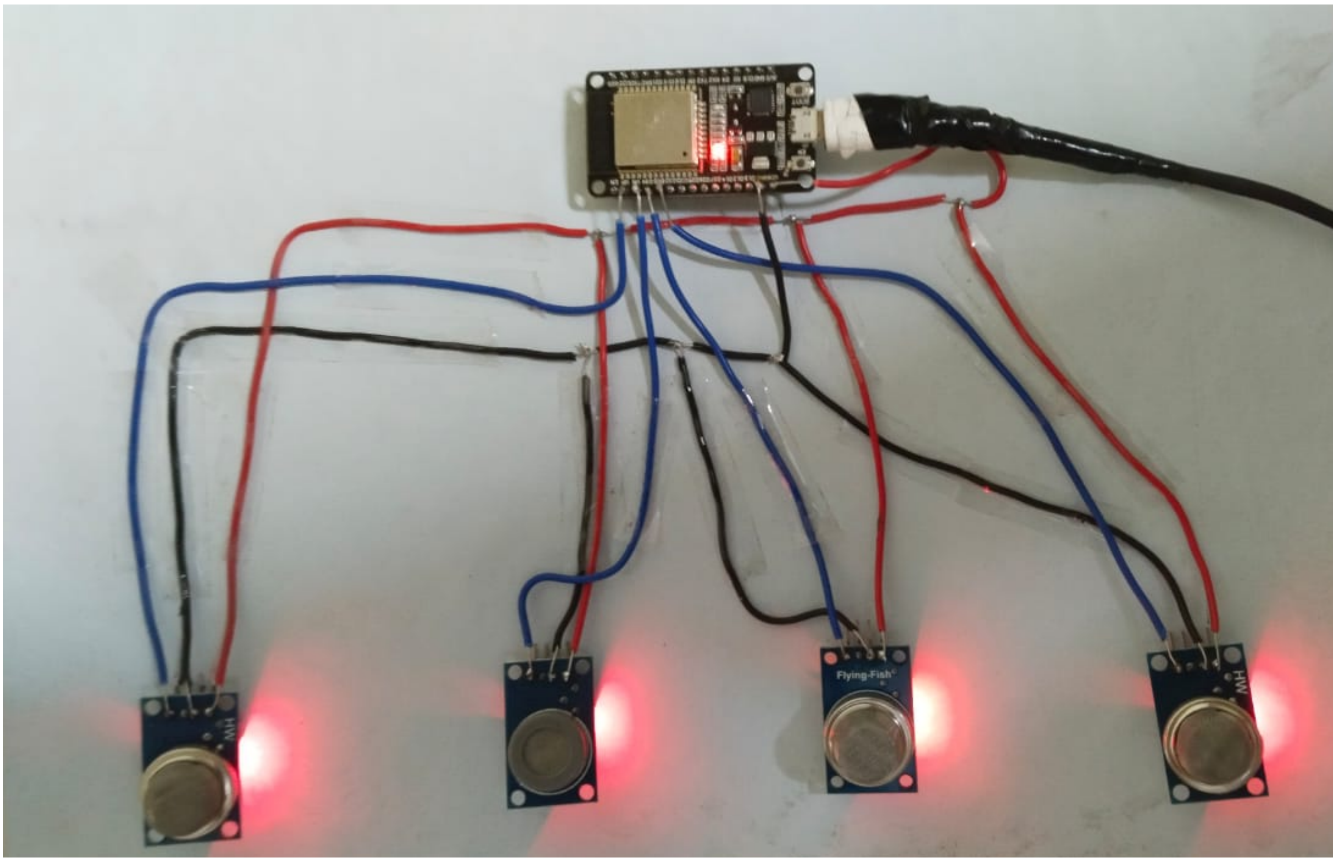

Fig - 3.2.1 : Working Model

- Sensors Connection to MCU: After connecting the sensors to the microcontroller, the necessary libraries for the sensors are included in the code, and the sensors are initialised. The readings from the sensors are then taken using the analog and digital input pins of the microcontroller.

- GSM and Wi-Fi Connected: The ESP32 microcontroller is connected to both GSM and Wi-Fi modules. The Wi-Fi connection is used to transmit the data to the Blynk server, while the GSM connection is used to send SMS notifications to the user in case of hazardous air quality. If both the Wi-Fi and GSM connections are established, the system continues to transmit data to the Blynk server. However, if there is an issue with either connection, the system returns to the sensors connection setup step to fix the problem.

- Blynk Application Activation: A mobile application is developed using the Blynk platform, which displays the real-time data from the sensors on the user's smartphone. The user can also set threshold values for each pollutant and receive SMS notifications in case the threshold is crossed.

- Data Transmit to Blynk Server and Web-based Application: The data obtained from the sensors is transmitted to the Blynk server through the Wi-Fi connection. The data is displayed on the Blynk application in real-time, allowing the user to monitor the air quality from anywhere with an internet connection. Additionally, the data is also sent to a web-based dashboard for easy monitoring.

- End: The system continuously monitors the air quality and transmits the data to the Blynk server. The user can monitor the air quality in real-time through the mobile application and receive SMS notifications in case of hazardous air quality.

CHAPTER - 4

4.1 RESULTS

The developed IoT-based air pollution monitoring system using Blynk and ESP32 microcontroller has shown promising results as shown in Table below, in detecting and monitoring air quality as shown in Fig 4.2. The system was able to measure parameters like concentration levels of harmful gases such as CO, CO2, NH3, and benzene using sensors like MQ2, MQ4, MQ7, and MQ135.

The system was tested in a controlled environment, where the concentration levels of various gases were altered to check the accuracy and sensitivity of the sensors used in the system.

The system was able to detect the presence of hazardous gases such as CO, CO2, NH3, and benzene that provided real-time data on the mobile / web application developed using Blynk.

The data collected from the system was transmitted to the Blynk server, and the user was able to monitor the data from anywhere in the world using an internet connection.

The application was able to display the concentration levels of various gases in a graphical format, which made it easier for the user to understand the air quality.

The system was also tested in real-time scenarios by deploying it in a busy street, near factories, and inside the home to monitor the air quality. The system was able to detect the presence of harmful gases and notify the user through the mobile / web application developed using Blynk.

The system's reliability and durability were tested by running it continuously, and it was found that the system was stable and produced consistent results throughout the testing period.

The sensors used in the system were found to be reliable and accurate, and the data collected from the system was consistent with the actual air quality in the testing environment.

The system's ease of use was also evaluated by testing it on non-technical users, and it was found that the system was easy to install and use. The mobile application developed using Blynk was found to be user-friendly, and the data was easy to interpret.

Promising Results :

Sensors	MQ135	MQ7	MQ2	MQ4
Gases	CO_2, NO_2, NH_3	CO(Carbon Monoxide)	LPG, Propane, Hydrogen	CNG, CH_4(Methane)
Range	10 - 1,000 PPM	20 - 2,000 PPM	300 - 10,000 PPM	200 - 10,000 PPM
Results	177 PPM	300 PPM	664 PPM	300 PPM

In conclusion, the developed IoT-based air pollution monitoring system using Blynk and ESP32 microcontroller has shown promising results in detecting and monitoring air quality.

The system's reliability, accuracy, and ease of use make it a valuable tool in monitoring air quality and taking necessary actions to improve it. And the exposed level is calculated in PPM (Parts per Million).

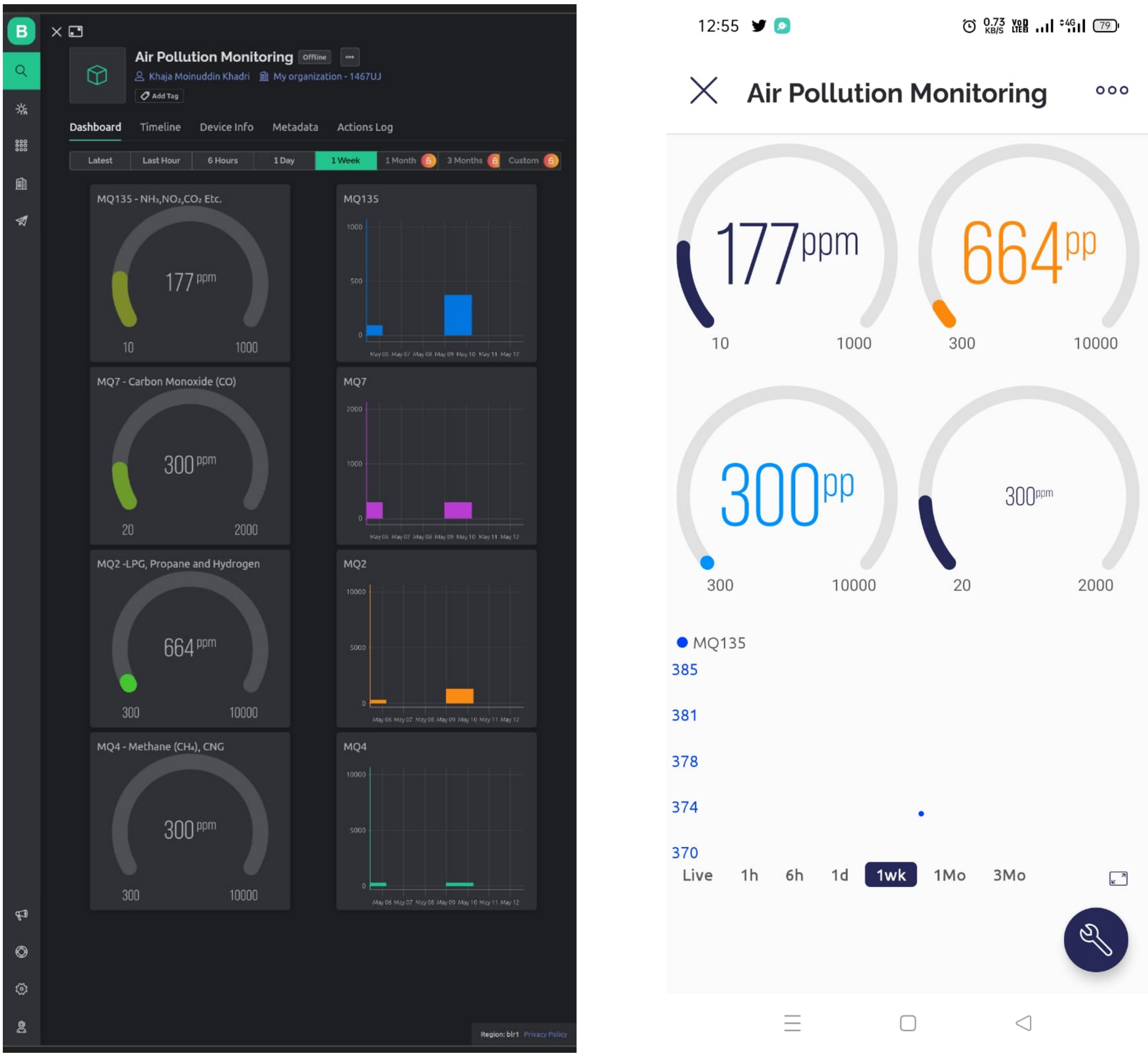

Fig - 4.1 : Results of the working model with Web And Mobile Application using Blynk

4.2 DISCUSSIONS

- Importance of Air Quality Monitoring: Air pollution is a major public health concern globally. Poor air quality can cause various health problems, such as respiratory and cardiovascular diseases. Hence, it is essential to monitor air quality to protect human health and the environment.

- Working Principle of IoT-based Air Pollution Monitoring System: The IoT-based air pollution monitoring system consists of sensors that measure the concentration of various air pollutants, such as CO, CO2, NOx, SO2, O3, and PM2.5. These sensors are connected to an IoT platform that collects and analyses the data. The IoT platform uses machine learning algorithms to provide insights into air quality and generates alerts if air pollution exceeds the threshold limits.

- Components of an IoT-based Air Pollution Monitoring System: An IoT-based air pollution monitoring system consists of various components, such as sensors, microcontrollers, communication modules, and IoT platforms. The selection of these components depends on the specific application requirements, such as the pollutants to be monitored, the measurement accuracy, and the data transfer rate.

- Benefits of IoT-based Air Pollution Monitoring System: An IoT-based air pollution monitoring system provides real-time air quality data, which can be used to make informed decisions to protect human health and the environment. It also helps to identify the sources of air pollution and to evaluate the effectiveness of air pollution control measures.

- Challenges in IoT-based Air Pollution Monitoring System: One of the major challenges in IoT-based air pollution monitoring is the selection of appropriate sensors that can measure the concentration of various air pollutants accurately and reliably. Other challenges include the integration of sensors with communication modules, data processing, and the scalability of the IoT platform.

- Future Directions: In the future, IoT-based air pollution monitoring systems can be integrated with other smart city applications, such as traffic management, waste management, and energy management, to create a more sustainable and liveable environment. The use of advanced sensors, such as hyper-spectral imaging, can also improve the accuracy and reliability of air quality data. Furthermore, the integration of IoT platforms with artificial intelligence and blockchain technologies can enhance the security and privacy of air quality data.

CHAPTER - 5

5.1 CONCLUSION

In conclusion, an IoT-based air pollution monitoring system is an essential tool that can help individuals and communities better understand the air quality in their surroundings. By using sensors and connected devices, such a system can gather real-time data on various pollutants, providing valuable insights into the air quality conditions.

The system we have discussed in this report uses MQ gas sensors to measure the concentration of various pollutants such as CO, CO2, and NO2. The data is then transmitted wirelessly to an IoT platform, where it can be visualised and analysed using a web or mobile application. Additionally, the system sends alerts to users when the pollutant levels exceed the threshold limits, allowing them to take timely measures to protect their health and well-being.

Air Pollution is the major affecting factor to our environment. Not only affecting the environment and also affects the human health. The mobile application is developed to monitoring system it tracking the how much the human has exposed in a day. The gas sensors was used for identifying the Leakage Gas, Carbon Monoxide, Smoke, and Propene. The sensor senses the gases and convert from analog to digital and displays in the application. The exposed level is calculated in PPM (Parts per Million).

Overall, an IoT-based air pollution monitoring system can contribute to improving air quality and public health. It can also provide valuable data to policymakers, enabling them to make informed decisions and implement effective strategies to reduce air pollution levels. With the increasing concerns about air pollution and its impact on human health, such systems can play a crucial role in mitigating the adverse effects of air pollution.

5.2 FUTURE SCOPE

The future scope for an IoT-based air pollution monitoring system is vast, and there are several areas where improvements and advancements can be made. Some of the potential future developments include:

- **Integration with smart city infrastructure**: The integration of an air pollution monitoring system with smart city infrastructure would allow city planners to make better-informed decisions regarding urban development, traffic management, and public health policies.
- **Predictive analytics**: By incorporating machine learning algorithms into the system, it would be possible to predict air pollution levels in specific areas based on past data, weather forecasts, and other factors. This could help city officials take proactive measures to prevent high pollution levels.
- **Low-cost sensors**: One of the biggest challenges in deploying air pollution monitoring systems is the high cost of sensors. In the future, advancements in sensor technology could lead to the development of low-cost sensors that can be easily deployed across large areas.
- **Mobile apps**: The development of mobile apps that allow individuals to track air pollution levels in real-time could help raise awareness about the impact of air pollution on public health. These apps could also be used to provide personalised recommendations on reducing exposure to air pollution.
- **Community involvement**: The involvement of local communities in the monitoring and management of air pollution could be critical in improving air quality. By providing citizens with real-time air quality data and engaging them in the decision-making process, it would be possible to create a more sustainable and healthier environment for everyone.

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