VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

DEPARTMENT OF ELECTRICAL ENGINEERING

BTECH ELECTRONICS ENGINEERING

ENGINEERING SERVICE TO SOCIETY (ESS) PROJECT REPORT

by

Sojwal kuthe (211020059)
Harshay Dharade(211060055)
Sameer Bhondhate(211060065)
Archit Khobragade(211060015)

Supervisor - Prof Rohin Daruwala

Electronics in Service to Society
Certificate of Achievement

This is to certify that

Sojwal Kuthe
Archit Khobragade
Harshay Dharade
Sameer Bondhate

has successfully completed the laboratory session in

Electronics in Service to Society Lab

For the Academic Year

2023-24

Lab Teacher

Date: __________

Lab Teacher

Date: __________

Introduction:

The AQI (Air Quality Index) Monitoring System is a comprehensive project aimed at providing real-time monitoring and analysis of air quality in a given region. Air pollution is a significant environmental and public health concern globally, affecting millions of people. This project seeks to address this issue by developing a system that measures various air pollutants and calculates the AQI, providing valuable information for decision-makers and the general public.

Objective:

1. Data Collection: Set up IoT devices equipped with sensors to collect real-time air quality data, including parameters like PM2.5, PM10, CO, NH3.

2. Data Transmission: Establish a reliable communication network (e.g., Wi-Fi, LoRaWAN, or GSM) to transmit the collected data from IoT devices to a central server or cloud platform.

3. Data Processing: Develop algorithms to process the raw sensor data, including data cleaning, filtering, and aggregation, to ensure accuracy and consistency.

4. AQI Calculation: Implement algorithms to calculate the Air Quality Index (AQI) based on the measured pollutant concentrations using standard formulas recommended by regulatory agencies.

5. Visualization: Create a user-friendly interface (e.g., web-based dashboard or mobile app) to visualize the real-time AQI data, historical trends, and geographical distribution of air quality levels.

Methodology:

1. **Sensor Selection and Installation:**
    - Identified suitable sensors for measuring various air pollutants.
    - Installed sensors at strategic locations within the target area, ensuring adequate coverage.
    - Calibrated sensors to ensure accuracy and reliability of data.
2. **Data Collection and Transmission:**
    - Established data collection mechanisms to gather readings from sensors in real-time.
    - Implemented wireless communication protocols for transmitting data to a centralized server.
    - Developed fail-safe mechanisms to ensure uninterrupted data transmission.
3. **AQI Calculation:**
    - Developed algorithms based on established standards (e.g., IND AQI) to calculate AQI values.
    - Incorporated weighting factors for different pollutants based on their impact on human health.
    - Utilized interpolation techniques to estimate AQI values between sensor locations.
4. **System Integration and Testing:**
    - Integrated all components of the system into a cohesive platform.
    - Conducted extensive testing to ensure the accuracy, reliability, and scalability of the system.
    - Addressed any issues or bugs identified during testing phases.

5. **User Interface Development:**
    - Designed an intuitive user interface accessible via web and mobile platforms.
    - Implemented features for displaying real-time AQI values, historical trends, and alerts.
    - Incorporated geographical mapping to visualize AQI data spatially.
    - The specific calculation of AQI varies depending on the pollutant being measured. Each pollutant has its own AQI scale, and the overall AQI is determined by the highest AQI value among the individual pollutants, known as the "dominant pollutant." The AQI value for each pollutant is calculated based on its concentration in the air and its potential health effects.

Components Used

- Raspberry Pi (4B)
- Nova PM Sensor SDS011
- MQ 7 – CO gas detection sensor
- MCP 3008 - 10-bit Analog-to-Digital Converter (ADC) for MQ 7
- MQ 135 – NH_3 gas detection sensor
- HDMI cable
- Male to Male , Male to female , female to female jumper wires
- Breadboard
- zero PCB

Software Requirements:

- IDE - Thonny, Geany
- Hosting Website - AdaFruit

Component Description:

1. **MQ-135:**

Air quality click is suitable for detecting ammonia (NH_3), and other harmful or poisonous gases that impact air quality. The MQ-135 sensor unit has a sensor layer made of tin dioxide (SnO_2), an inorganic compound which has lower conductivity in clean air than when polluting gases are present. To calibrate Air quality, use the on-board potentiometer to adjust the load resistance on the sensor circuit.

Range:10-1000

Pin Description:

- the **VDD** power supply 5V DC
- **GND** , used to connect the module to system ground
- **DIGITAL OUT**, You can also use this sensor to get digital output from this pin, by setting a threshold value using the potentiometer
- **ANALOG OUT**, This pin outputs 0-5V analog voltage based on the intensity of the gas.

2. **MQ-7:**
The MQ-7 is a gas sensor module designed to detect carbon monoxide (CO) gas in the environment. It operates based on the principle of gas sensing through a semiconductor material that changes its electrical conductivity in the presence of CO gas. The MQ-7 sensor is sensitive to low concentrations of CO gas and provides an analog output voltage proportional to the gas concentration. It is commonly used in various applications such as air quality monitoring systems, industrial safety equipment, and carbon monoxide detection alarms.

Range:20-2000ppm

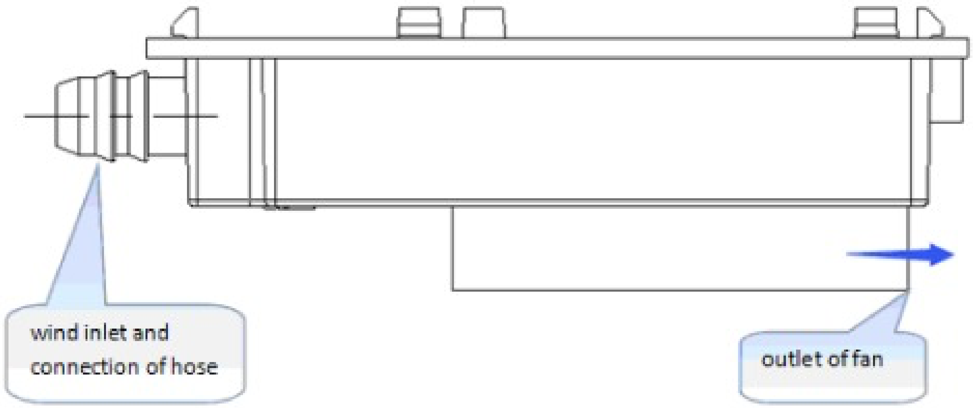
The **MQ-7** gas sensor usually has 4 pins:
VCC: This pin is used to connect the sensor to a power supply. It typically operates at 5V.
GND: This pin is connected to the ground of the circuit to complete the circuit and provide a reference voltage.
AOUT: This pin outputs an analog voltage signal proportional to the concentration of carbon monoxide (CO) gas detected by the sensor.
DOUT: This pin provides a digital output signal that indicates whether the CO gas concentration exceeds a certain threshold. It is often connected to a microcontroller or other digital input device for further processing.

3. SDS011:
The **SDS011** sensor is an advanced laser-based particulate matter (PM) sensor designed for highly accurate measurement of fine particles in the air. Utilizing laser scattering technology, it emits a laser light beam into the air sample and measures the intensity of scattered light to precisely determine the concentration of particles present. Capable of detecting particles with diameters of 2.5 micrometers (**PM2.5**) and 10 micrometers (**PM10**), the **SDS011** sensor offers exceptional accuracy in monitoring air quality. Its compact and lightweight design makes it suitable for integration into both portable and fixed air quality monitoring systems, providing flexibility in deployment across various environments. With a UART serial interface, it facilitates seamless communication with microcontrollers or other devices, enabling easy integration into IoT platforms and environmental monitoring networks. Operating at a low voltage of 5V DC, the **SDS011** sensor consumes minimal power, making it ideal for battery-powered applications. Widely used in indoor and outdoor air quality monitoring, pollution detection, and research projects, the **SDS011** sensor plays a crucial role in understanding and addressing air pollution concerns.

Range:0-999.0ug/m3

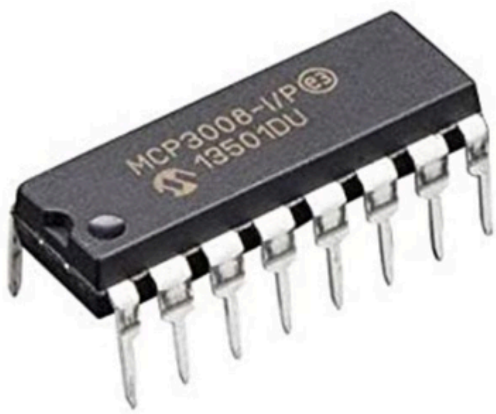
The **SDS011** sensor typically has six pins, which serve different functions:
1. **5V**: This pin is used to supply power to the sensor. It usually requires a 5V DC power source.
2. **Ground (GND)**: This pin is connected to the ground of the power supply or microcontroller to complete the circuit.
3. **RX (Receive):** This pin receives data from the sensor. It is often connected to a microcontroller's TX (transmit) pin for data reception.
4. **TX (Transmit)**: This pin transmits data from the sensor. It is typically connected to a microcontroller's RX (receive) pin for data transmission.
5. **RESET**: This pin is used to reset the sensor. Applying a reset signal to this pin resets the sensor to its default state.
6. **Reserved/Unused**: Some versions of the SDS011 sensor may have additional pins that are reserved for future use or left unused in typical applications.

These pins enable the SDS011 sensor to interface with microcontrollers or other devices for data acquisition and processing, power supply, and system control.

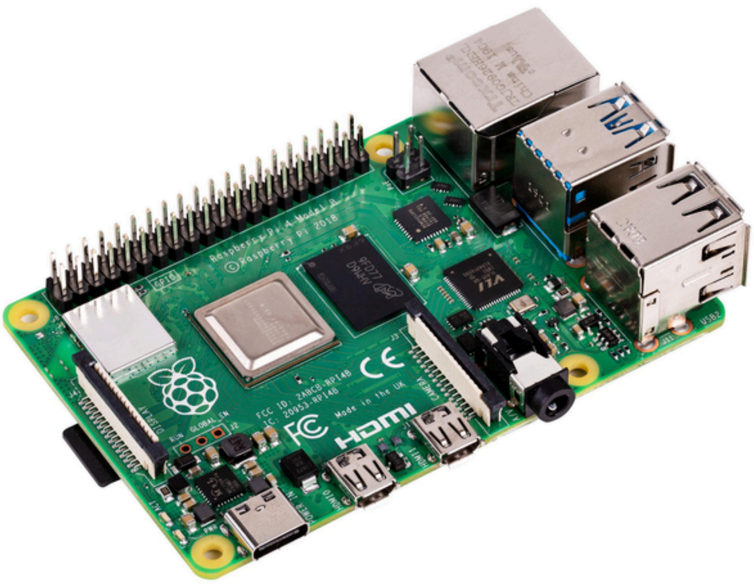


4. IC mcp3008:

The **MCP3008** is an 8-channel, 10-bit Analog-to-Digital Converter (ADC) chip frequently utilized in electronic projects. With its Serial Peripheral Interface (SPI), it enables microcontrollers to efficiently convert analog signals from sensors or other devices into digital data for processing. Its versatility, low power consumption, and ease of integration make it a preferred choice for tasks requiring precise analog-to-digital conversion, such as monitoring environmental sensors, reading analog sensors, and interfacing with various input devices in embedded systems.



Raspberry Pi 4 Model B:
In addition to its hardware enhancements, the **Raspberry Pi 4 Model B** offers support for multiple displays with resolutions up to 4K via dual micro HDMI ports, making it suitable for multimedia applications and digital signage. Its compact form factor and low power consumption make it energy-efficient and portable, allowing for deployment in various environments. Furthermore, the Raspberry Pi community provides extensive resources, including a vast array of software libraries, tutorials, and projects, fostering innovation and creativity among users worldwide. Whether used for learning programming, building IoT devices, or powering small-scale servers, the **Raspberry Pi 4 Model B** continues to be a versatile and cost-effective solution for a wide range of computing needs.



The Raspberry Pi 4 Model B features a 40-pin GPIO (General Purpose Input/Output) header, which provides access to various hardware interfaces and communication buses. Here's a brief description of some of the pins:

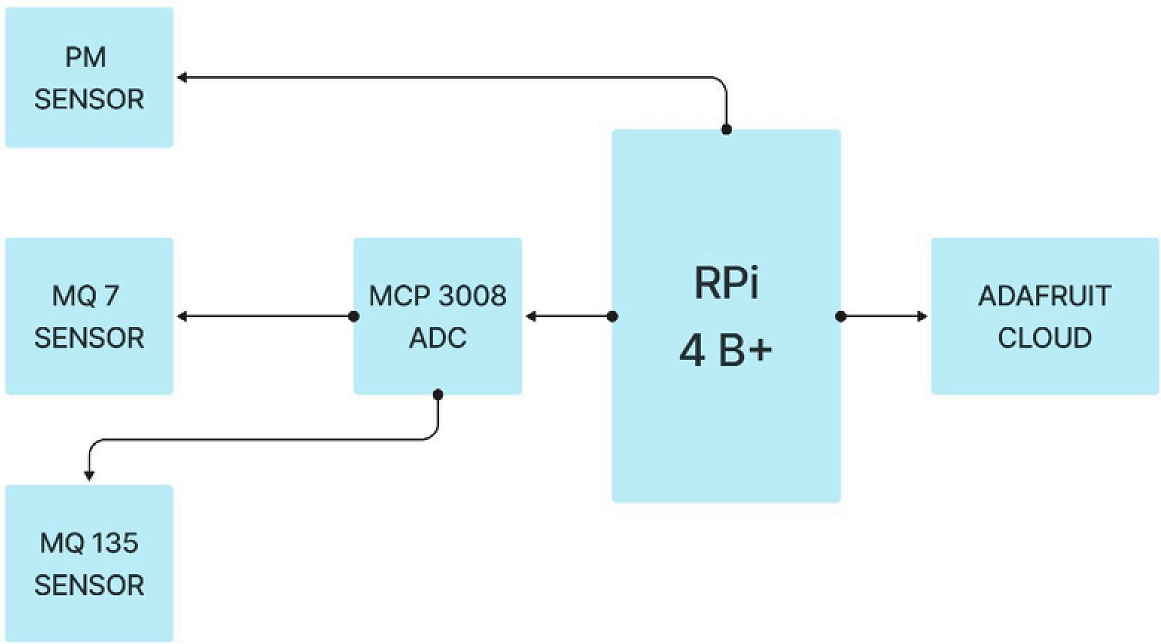
1. **3.3V Power:** Provides 3.3 volts of power output.
2. **5V Power:** Provides 5 volts of power output.
3. **GPIO (General Purpose Input/Output) Pins:** These pins can be configured as digital input or output.
4. **Ground (GND):** Connects to the ground.
5. **I2C (Inter-Integrated Circuit):** Used for connecting to I2C devices like sensors and displays.
6. **SPI (Serial Peripheral Interface):** Used for high-speed communication with SPI devices.
7. **UART (Universal Asynchronous Receiver-Transmitter):** Used for serial communication with other devices.
8. **PWM (Pulse Width Modulation):** Used for generating analog-like signals for controlling things like motors and LEDs.
9. **ID_SD and ID_SC:** Reserved for the HAT (Hardware Attached on Top) EEPROM to provide automatic configuration.

These are just a few examples, and there are more pins with various functions on the GPIO header of the Raspberry Pi 4 Model B.

Cost Estimation Structure

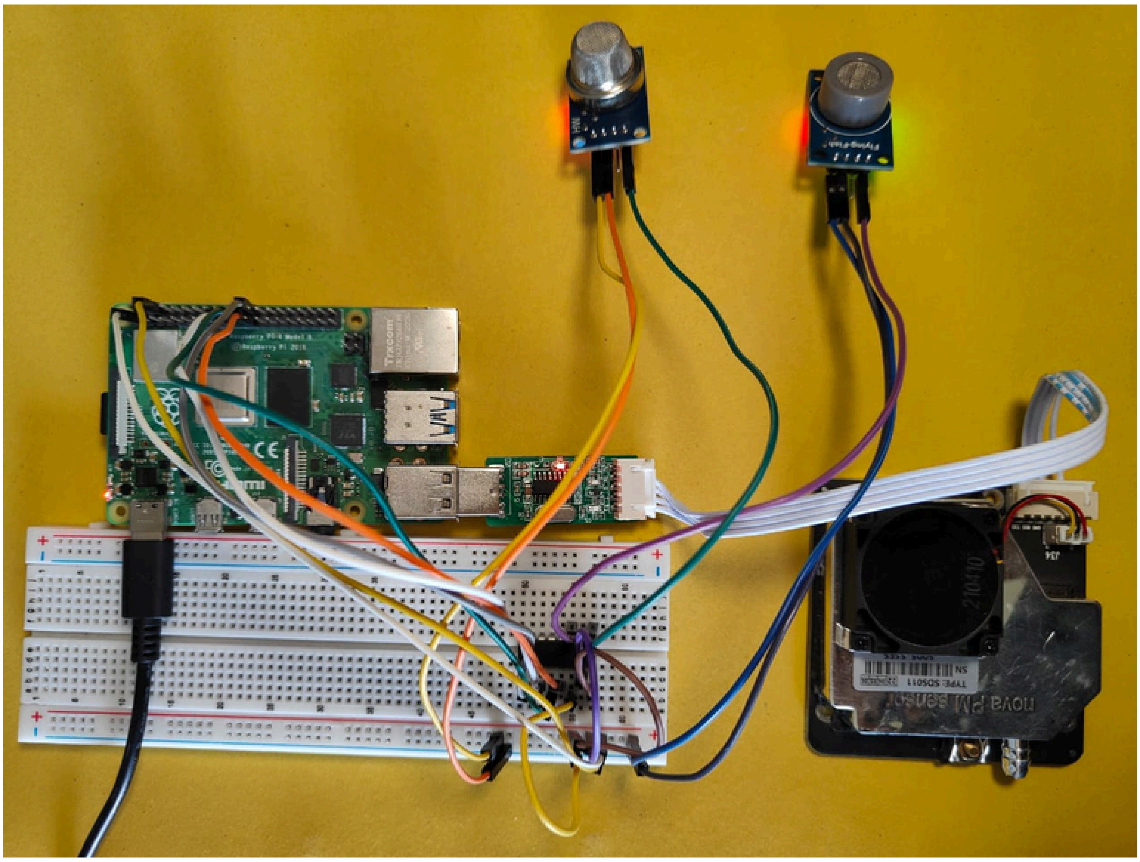
SR. NO.	Component Name	Cost of Component
1.	RaspberryPi 4B	5000/-
2.	SDS011 PM Sensor	2600/-
3.	MQ135	135/-
4.	MQ7	150/-
5.	IC mcp3008	250/-
7.	Breadboard	100/-
8.	Connecting Wires	60/-
9.	Zero PCB	10/-
	Total Cost	8305/-

Block Diagram:

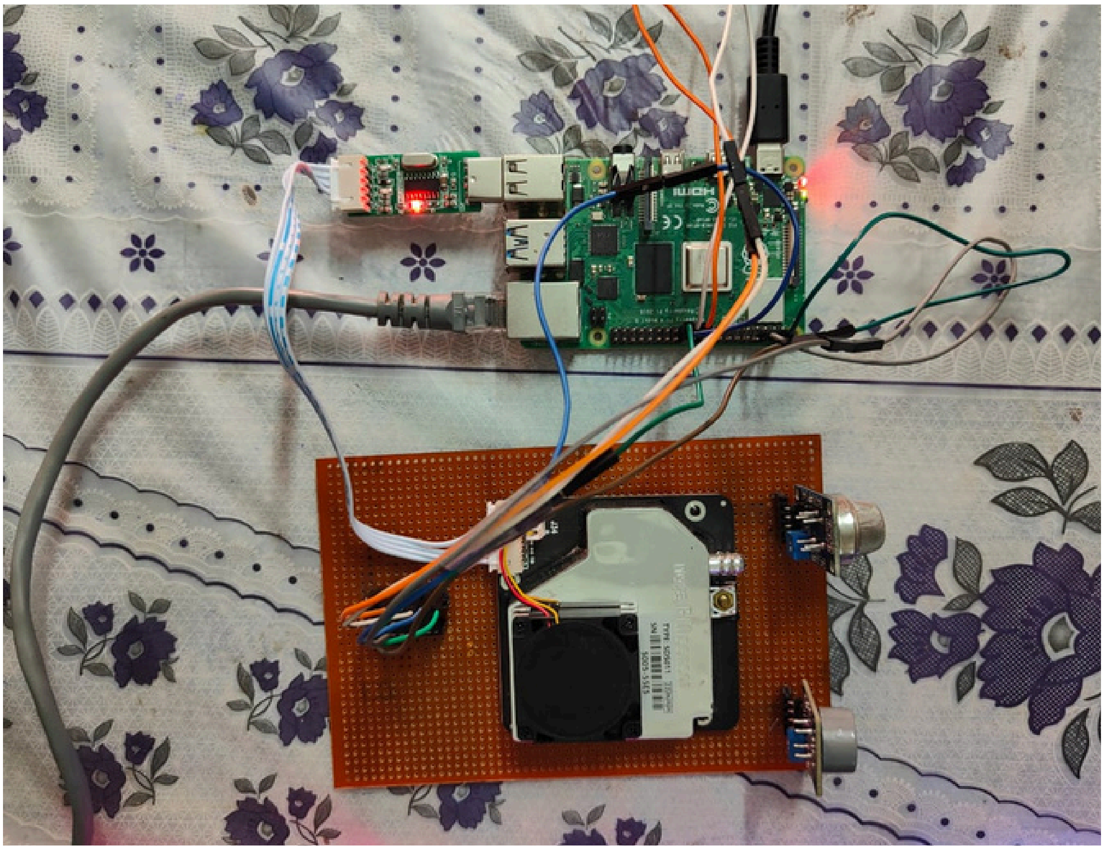


Project:

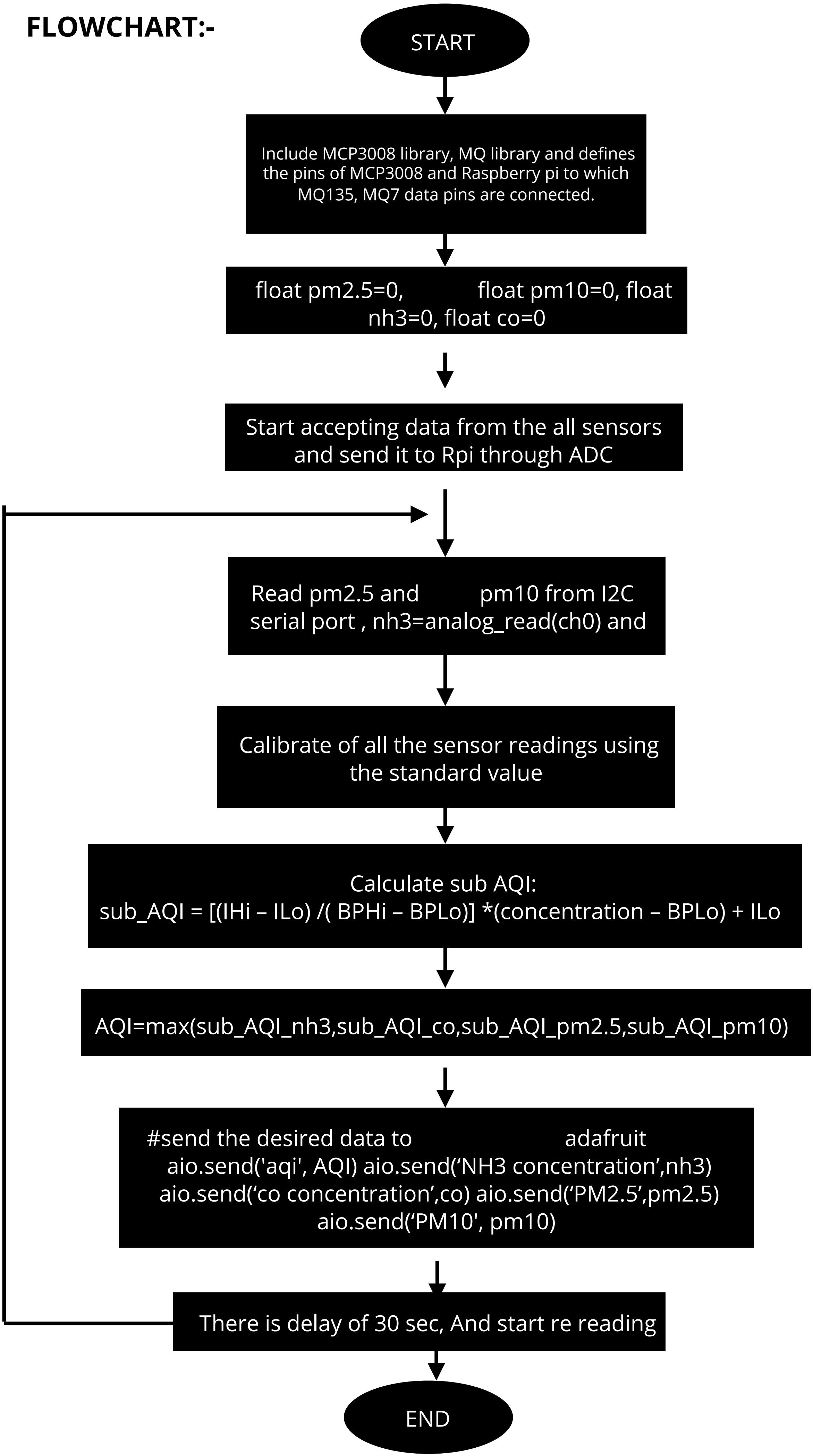
Prototype:



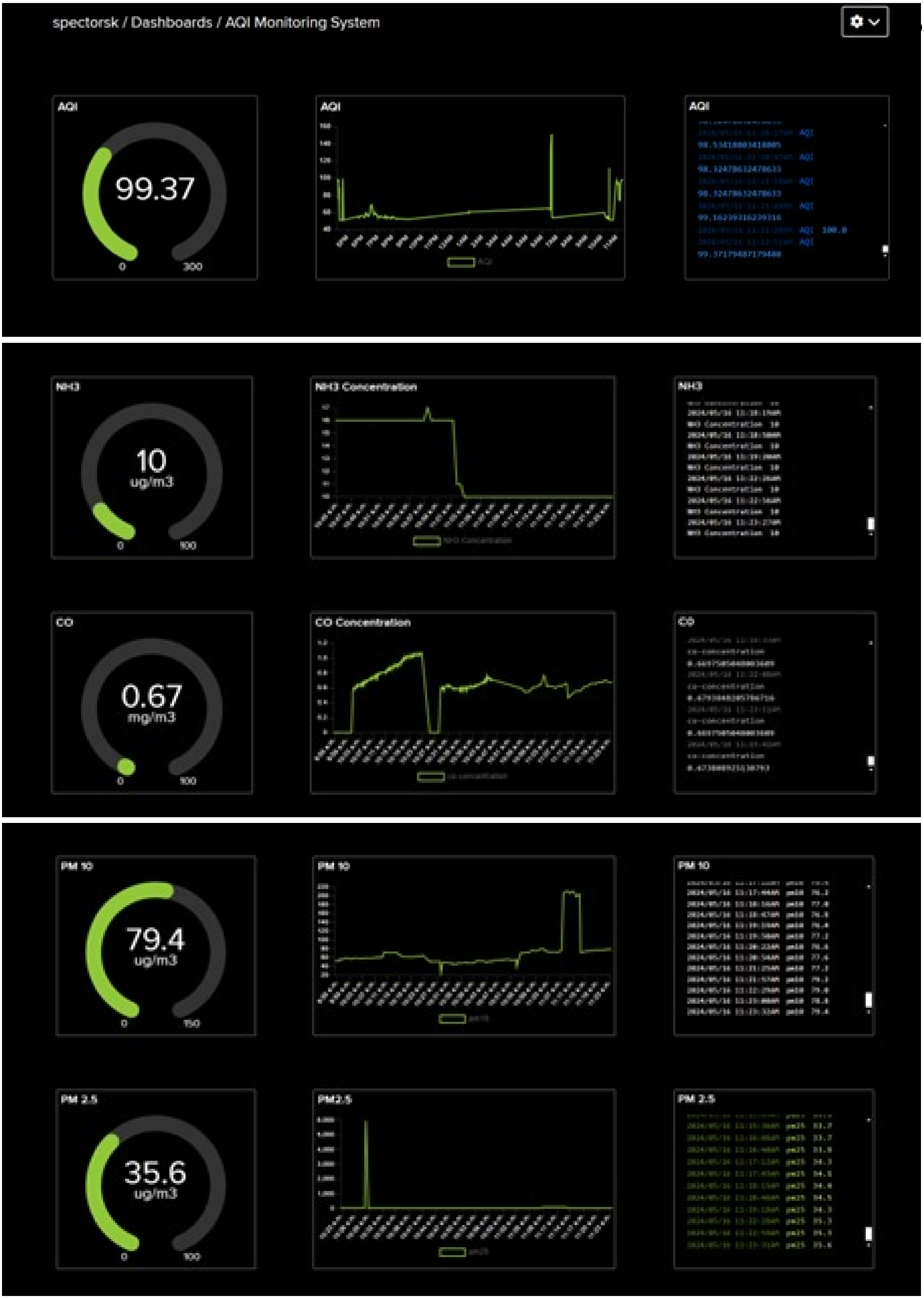
Final Project



FLOWCHART:-


START
Include MCP3008 library, MQ library and defines the pins of MCP3008 and Raspberry pi to which MQ135, MQ7 data pins are connected.
float pm2.5=0, float pm10=0, float nh3=0, float co=0
Start accepting data from the all sensors and send it to Rpi through ADC
Read pm2.5 and pm10 from I2C serial port , nh3=analog_read(ch0) and
Calibrate of all the sensor readings using the standard value
Calculate sub AQI:
sub_AQI = [(IHi – ILo) /(BPHi – BPLo)] *(concentration – BPLo) + ILo
AQI=max(sub_AQI_nh3,sub_AQI_co,sub_AQI_pm2.5,sub_AQI_pm10)
#send the desired data to adafruit
aio.send('aqi', AQI) aio.send('NH3 concentration',nh3)
aio.send('co concentration',co) aio.send('PM2.5',pm2.5)
aio.send('PM10', pm10)
There is delay of 30 sec, And start re reading
END

Dashboard:


spectorsk / Dashboards / AQI Monitoring System
AQI
99.37
0
300
AQI
AQI
NH3
10
ug/m3
0
100
NH3 Concentration
NH3
CO
0.67
mg/m3
0
100
CO Concentration
CO
PM 10
79.4
ug/m3
0
150
PM 10
PM 10
PM 2.5
35.6
ug/m3
0
100
PM2.5
PM 2.5

Applications:

1. Real-time Monitoring: IoT-based AQI systems provide real-time data on air quality parameters such as particulate matter (PM2.5 and PM10), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3). This enables continuous monitoring of air quality levels.

2. Remote Accessibility: Users can access AQI data remotely through web or mobile applications, allowing them to monitor air quality from anywhere with internet connectivity. This accessibility enhances awareness and enables prompt responses to changes in air quality.

3. Data Visualization: IoT platforms often include data visualization tools that present AQI data in intuitive graphs, charts, and maps. Visual representations make it easier for users to interpret and understand air quality trends over time and across different locations.

4. Alerting and Notifications: IoT-based AQI systems can send alerts and notifications to users when air quality levels exceed predefined thresholds. This proactive approach enables individuals and authorities to take timely actions to mitigate exposure to poor air quality.

5. Integration with Smart Devices: AQI monitoring systems can integrate with smart home devices such as air purifiers, HVAC systems, and smart thermostats. Integration allows these devices to automatically adjust settings based on real-time air quality data, thereby optimizing indoor air quality.

6. Environmental Health Management: AQI data collected over time provides valuable insights into long-term air quality trends and pollution hotspots. This information aids environmental health management efforts, supporting initiatives to reduce pollution and improve public health outcomes.

7. Urban Planning and Policy Making: Governments and city planners use IoT-enabled AQI data to inform urban planning decisions and environmental policies. Data-driven insights help in designing sustainable cities, implementing pollution control measures, and allocating resources effectively.

8. Research and Analysis: Researchers leverage IoT-generated AQI data for scientific studies, epidemiological research, and environmental impact assessments. Analyzing large datasets enables deeper insights into the causes and effects of air pollution, supporting evidence-based policymaking and public health interventions.

Problems Faced:

- **Sensor Reliability:** Ensuring accurate sensor readings amidst calibration challenges, malfunctions, and maintenance requirements.
- **Data Transmission Interruptions:** Overcoming issues like signal interference and network outages for continuous data transmission.
- **Algorithm Complexity:** Developing and validating algorithms for AQI calculation considering pollutant weighting, interpolation, and threshold values.

Results:

- Successful deployment of AQI Monitoring System in the target area.
- Real-time monitoring of key air pollutants and calculation of accurate AQI values.
- User-friendly interface accessible to both decision-makers and the general public.
- Improved awareness of air quality conditions, leading to informed decision-making.
- Positive feedback from stakeholders regarding the effectiveness and usability of the system.

Conclusion:

The AQI Monitoring System represents a significant step towards addressing the challenges posed by air pollution. By providing real-time data and insights into air quality conditions, the system empowers individuals, communities, and policymakers to take proactive measures to safeguard public health and the environment. Continued enhancements and collaborations will further strengthen the system's effectiveness in combating air pollution and promoting sustainable development.

References:

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- https://nicovibert.com/2020/03/16/how-to-monitor-air-quality-with-a-raspberry-pi/
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