VEHICLE EMISSION MONITORING AND CONTROL USING IOT

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***Abstract*—Vehicle emissions monitoring and control using the Internet of Things is a promising approach to reduce air pollution and improve public health. IoT-based vehicle emissions monitoring systems can collect real-time data on the levelsof pollutants emitted by vehicles, such as carbon monoxide, Hydrocarbon, and Carbon dioxide. This data can be used to identify vehicles with high emissions, to notify vehicle owners of potential problems, and to enforce emissions standards. IOT-based vehicle emissions control systems can go even further, using the collected data to automatically adjust vehicle settings or even to take vehicles out of service if their emissions exceed certain levels. This can help ensure that all vehicles operate as cleanly as possible. The sensor data is then transmitted to an ESP32 micro-controller development board which analyzes the data and takes appropriate action.**

The sensor data is then transmitted to a microcontroller, which analyzes the data and takes appropriate action. IoT-based vehicle emissions monitoring and control systems have a number of potential benefits. They can result in reducing air pollution and improve public health, increase fuel efficiency and save drivers money, Extend the life of vehicles and reducing greenhouse gas emissions and mitigate climate change.

As the technology continues to develop and become more affordable, IoT-based vehicle emissions monitoring and control systems are expected to become more widely deployed. Here are some specific examples of how IoT-based vehicle emissions monitoring and control systems can be used: In identify vehicles with high emissions: IoT-based systems can be used to identify vehicles that are emittinghigh levels of pollutants. This information can be used to notify vehicle owners of potential problems, such as a faulty catalytic converter, or to enforce emissions standards. Reducing vehicle idling: Idling vehicles are a major source of air pollution. IoT-based systems can be usedto detect idling vehicles and to send alerts to drivers or to take other measures to reduce idling and Promote preventive maintenance: IoT-based systems can be used to monitor vehicle emissions over time. This information can be used to identify vehicles that are due for maintenance or that have developing problems. This can help to prevent vehicles from breaking down and emitting excessive pollutants.

***Index Terms*—vehicles, CO, HC, CO2, ESP32**

I. INTRODUCTION

It is critical that we efficiently monitor and control vehicle emissions to reduce these emissions, which are one of the most significant sources of air pollution and can have major consequences on human health and the environment.

The Internet of Things uses the Internet to create real-time connections between components and the Internet, enabling emissions monitoring and control systems to be developed in a more efficient and effective approach than is currently available.

The ESP32 development microcontroller, with its Wi-Fiand Bluetooth modules, is an extremely flexible and powerful microcontroller that has the potential to be used to design IOT devices. It is equipped with a Wi-Fi and Bluetooth module, enabling it to connect to the internet and other devices.

In India, the Pollution Under Control (PUC) system is a mandated vehicle emission testing initiative aimed at lowering vehicle-related air pollution. Since its initial introduction in Delhi in 1991, the program has been carried out in all of the nation's main cities.

All cars must submit to periodic emissions testing at PUC centers that have been authorized under the PUC system. The vehicle's emissions of different pollutants, including nitrogen oxides, hydrocarbons, and carbon monoxide, are measured during the tests.

India's air pollution has been decreased thanks in large part to the PUC system. But the system's shortcomings and lack of openness have also drawn criticism. The prevalence of phony PUC certificates is one of the main obstacles. By paying PUC center employees, or by having their cars evaluated without being examined, many car owners are able to get PUC certificates. This compromises the system's efficacy and permits the continued use of cars that cause pollution on the highways.

A further difficulty is the absence of national standards. Every state has its own emission standards and PUC testing protocols. Car owners may find it challenging to adhere to the PUC system as a result, particularly if they travel between states frequently.

The PUC system is nevertheless a valuable instrument for lowering air pollution in India in spite of these difficulties. The government has implemented several initiatives to increase the system's efficacy, including the creation of online PUC centers and increased transparency in the testing procedure.

The PUC system has been the subject of several reform suggestions in recent years. Creating a centralized database with all of the PUC test results is one suggestion. This will facilitate the tracking of vehicles that are either phony or have not gotten a PUC certificate. Testing car emissions while they are on the road using remote sensing technologies is another suggestion. This would make it easier to find vehicles that emit pollutants and can avoid PUC testing.

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In general, India's PUC system is a well-meaning initiative with the potential to significantly lower air pollution. The system is not without its difficulties, though. To fully realize the potential of the system, additional actions by the government are required to enhance its efficacy and openness.

The following example shows how to set up an IoT-based automotive emissions monitoring and control system using the ESP32 development micro-controller via sensors from the

Mq2: Capture Hydrocarbon

Mq7: Capture Carbon Monoxide

Mq135: Capture Carbon Dioxide

The ESP32 microcontroller can be connected to the gas sensors that have been installed on the car. The ESP32 microcontroller calculates a car’s emissions using a combination of gas sensors and a microprocessor to calculate the ppm emissions. To send the emission data from the vehicle to a cloud server, the ESP32 microcontroller uses WiFi technology. Real-time vehicle emission levels can be monitored via a web-based program or a mobile app. Suppose the emissions from your vehicle exceed a certain point in time. In that case, the ESP32 microcontroller is capable of triggering a control device, such as a fan or a valve, to reduce the pollutants

II. LITERATURE SURVEY

A thorough review of the literature on "Vehicle Emission Monitoring and Controlling Using IoT" demonstrates the increasing amount of research addressing the pressing need for creative solutions to deal with the problems related to public health and the environment that are becoming more and more pressing.

Analyzing and tracking vehicle emissions is essential for tackling environmental issues and guaranteeing environmentally friendly transportation methods. Vehicle emissions are having a growing impact on air quality and climate change, thus advanced technologies are being used to measure and evaluate the toxins that vehicles release. Certain surveys offer creative methods for tracking and analyzing vehicle emissions. Kumaran et al. (2023) offers an Internet of Things (IoT)-based smoke detection system that uses machine learning to achieve high accuracy by combining air temperature and humidity. The Third International Conference on Artificial Intelligence and Smart Energy (ICAIS) [IEEE] in 2023 is where this study was presented [1]. Bharathraj et al. (2022) introduced a Vehicle Pollution Monitoring System using IoT. By seamlessly integrating technologies for the real-time measurement of vehicle emissions, this system represents a substantial advancement in environmental monitoring. The study most likely examines the usefulness and practical application of an IoT-based technology, highlighting its ability to deliver precise and timely data on air quality affected by vehicle pollution [5]. An Internet of Things-based method for identifying and analyzing dangerous vehicle emissions is presented by Akhila et al. (2022) at the 4th International Conference on Smart Systems and Inventive Technology (ICSSIT) [IEEE] [8].

In their study of sustainable transit vehicle tracking services, Salazar-Cabrera, de la Cruz, and Molina (2020) make use of intelligent transportation systems and cutting-edge communication technologies. The research offers insights into the developments in transit tracking systems and was published in the Journal of Traffic and Transportation Engineering [27]. A survey and comparison of inexpensive sensing technologies for road traffic monitoring is carried out by Bernas et al. (2018). The article, which was published in Sensors, assesses the appropriateness of many low-cost technologies for applications including road traffic monitoring [29].

There are numerous surveys on the current systems for detecting gas leaks and fires. Smoke detection is crucial in fire safety since it provides early warnings and allows for quick response actions. Yamauchi et al. (2005) suggest a computation technique to forecast smoke and heat detector behavior. Their research, which was published in Fire Science and Technology, helps to build efficient fire detection systems by identifying the variables that affect detector response [14]. In 2018, Andrea, Abirami, Diviya, and Nancy

present a framework for IoT-based fire detection and mitigation. Their paper, which highlights the significance of IoT in boosting safety measures, outlines a holistic approach to fire detection and was published in the International Journal of Pure and Applied Mathematics [15]. An IoT-based intelligent modeling of a smart home environment for safety and fire prevention is presented by Saeed et al. (2018). The study, which was published in the Journal of Sensors and Actuator Networks, focuses on how IoT technologies might be integrated to build intelligent systems that improve home safety, particularly in the area of fire prevention [20]. An effective deep learning method for smoke and fire detection with less data is shown by Namozov and Cho (2018). The study, which was published in Advances in Electrical and Computer Engineering, focuses on applying deep learning techniques to improve the accuracy of fire and smoke detection [34].

Scholars have investigated the design and development of novel smoke detection systems intended for use in moving vehicles. Several studies emphasize how crucial it is for cars to have early and accurate smoke detection because of the potentially life-saving consequences. Kshirsagar et al. (2020) describes the development and testing of automated smoke monitoring sensors in cars in the IEEE Sensors Journal, making progress toward pollution control for automobiles [2]. With the goal of improving vehicle safety and lowering air pollution, Mr. Suthagar S, Uma, Sutha, and Vijayarani (2017) present a "Automated Monitoring and Control of Vehicles Based Air Pollution Level and Safety" system that integrates a microcontroller and a number of sensors [IJARTET][3]. In their 2002 study, "Exhaust gas sensors for automotive emission control," Riegel, Neumann, and Wiedenmann delve into the technology underlying these vital emissions management sensors [4].

For improved data collecting and gas emission monitoring, there are numerous surveys on digital communication, networks, and security. Kandris et al. (2020) illuminated the wide range of possible applications within the sensor network industry with their thorough investigation of wireless sensor network (WSN) applications; their study was published in "Applied System Innovation" [Appl. Syst. Innov.]. The research probably explores the various domains in which WSNs are essential. Because they enable the real- time collection of data on variables like temperature, humidity, and pollution levels, WSNs have become essential in environmental monitoring [10]. The use of wireless sensor networks for environmental monitoring in support of sustainable mobility is investigated by Ullo et al. (2018). In order to promote sustainable mobility initiatives, their study—which was presented at the IEEE International Conference on Environmental Engineering—investigates how sensor networks might be used for extensive data gathering and analysis [11]. The primary objective of Kaivonen and Ngai (2020) is the employment of sensors mounted on municipal buses for real-time monitoring of air quality. The deployment of sensors on buses as mobile monitoring units is covered in the paper, which was published in Digital Communications and Networks. This approach offers important insights into the dynamics of urban air quality [12]. Using a wireless sensor network and ZigBee technology, Wu et al. (2018) describe an intelligent smoke alarm system. Their work on the integration of wireless communication for effective smoke detection was published in Wireless Communications and Mobile Computing [16].

In the context of the Internet of Things (IoT), networks play a critical role as the fundamental infrastructure that facilitates smooth communication and cooperation amongst objects that are connected. Li and Zhang (2012) study which sensors to use in wireless visual sensor networks in order to improve target localization accuracy. The goal of their work, which was published in IET Wireless Sensor Systems, is to improve localization in visual sensor networks by strategically placing sensors [21]. In the IEEE Sensors Journal, Paul et al. (2017) offer cooperative cognitive intelligence for the Internet of Vehicles. In an effort to increase overall vehicular communication and safety, the project explores the use of cognitive intelligence to promote collaboration among cars in the Internet of Things [22]. Singh, Rawat, and Bonnin (2014) write in the EURASIP Journal on Wireless Communications and Networking on cognitive radio for vehicular ad hoc networks (CR-VANETs). The study examines methods and difficulties related to the application of cognitive radio in automobile networks [23]. Wei and colleagues (2019) have put forth a decentralized vehicle remote locating and tracking system that is economical and utilizes both mobile networks and the BeiDou navigation satellite system. The research aims to provide a workable and affordable method for vehicle tracking, and it was published in the EURASIP Journal on Wireless Communications and Networking [28].

Security is an important factor that IoT (Internet of Things) technology solve in field of car emission monitoring. There are several ways in which the addition of IoT to car emission monitoring systems improves security. Automotive safety and Internet of Things (IoT) technologies are merging to form a growing field, according to a literature review on IoT-based smoke detection in cars. A sensor-based application for smart cars is discussed by Arjun, Prithviraj, and Ashwitha (2017) in the International Journal of Latest Trends in Engineering and Technology. Their research examines how sensors can be used to increase car's intelligence for better functioning & safety [17]. Auxiliary safety systems for motorbikes are discussed by Pawne, Studies, and Deo (2017) in the International Journal of Novel Research and Development. Their research examines how adding more safety measures to two-wheeled vehicles can improve safety [19]. An outline of vehicular sensor networks, security, and intelligence in IoT-enabled smart cities is given by Al-Turjman and Lemayian (2020). The research, which was published in Computers & Electrical Engineering, addresses how sensor networks contribute to security in smart cities [32].

Maintaining the quality of the urban environment requires effective vehicle pollution control. Cities face two challenges at once: the growth in automobile traffic and the resulting rise in air pollution. For smoke detection, Maksimović and Milošević (2016) assess the best location for sensors in the Yugoslav Journal of Operational Research. Their study advances our knowledge of where to put sensors in smoke detection systems to get the best results [25]. The Ministry of Environment, Forests and Climate Change, Government of India, has published an official report titled "Status of the Vehicular Pollution Control Programme in India" (2010). The paper provides an overview of India's efforts and current state of vehicle pollution mitigation [26]. With reference to ovarian cancer, Misganaw and Vidyasagar (2015) investigate the use of ordinal class structure in multiclass categorization. The study, which was published in the IEEE Life Sciences Letters, aims to increase classification accuracy in applications related to medicine [31]. A framework for application-aware cloudlet adaptation and virtual machine selection in multicloudlet scenarios, CAVMS is introduced by Ramasubbareddy et al. (2020). The research on the difficulties of effective virtual machine selection in multicloudlet environments was published in the IEEE Systems Journal [33].

Furthermore, the literature highlights how these Internet of Things-enabled smoke detection systems fit into the larger picture of connected cars and smart transportation, helping to advance the development of clever and safer mobility solutions. Prospective pathways within this field of study are well-positioned to tackle issues concerning system scalability, power efficiency, and smooth integration with current car communication networks. The literature review as a whole shows a determined attempt to use technology to protect drivers and passengers, reflecting a growing understanding of the potential of IoT-based smoke detection systems to improve vehicle safety.

III. METHODOLOGY

Algorithm

a. Define the analog pins that are attached to the gas sensors(mq135, mq7, and mq2Pin). In the primary loop:

b. Read the MQ-135 sensor's analog value and save it in the variable mq135Value

c. Read the MQ-7 sensor's analog value and save it in the variable mq7Value.

d. Read the MQ-2 sensor's analog value and put it in the variable mq2Value

e. . Depending on the sensor specifications and calibration data, you can optionally execute calibration or further data processing on these raw analog values to convert them into useful gas concentration readings

f. . Print or use the values as needed (for example, printing to the serial monitor, sending data to a display, or sending across a network).

Architecture

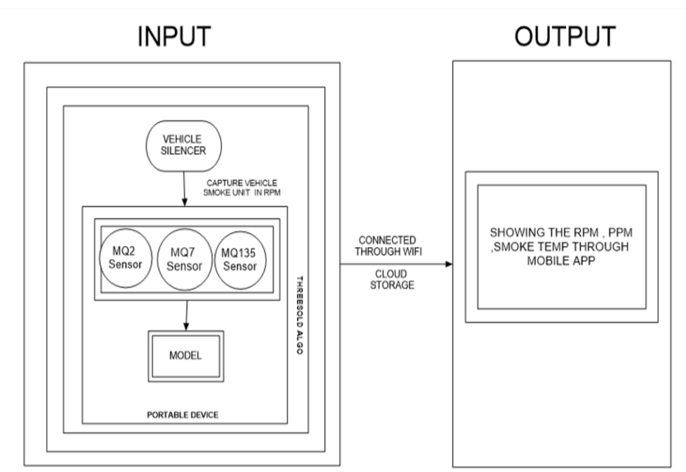

Figure 3.2.1 2 ESP 32 Dev Board with USB micro B cable

A portable instrument for determining the amount of vehicle smoke in parts per million (ppm) is depicted in the diagram you submitted. There are four sensors on the device: a smoke unit sensor, MQ2, MQ7, and MQ135 which measures the smoke and gas emitted by the vehicles. A microcontroller receives the sensor data and processes it before displaying the ppm value on a touchscreen display. Gas sensors, a microprocessor, and data processing components are all integrated into the system architecture for a gas monitoring project. Gas concentrations are detected and measured using gas sensors, such as those for hydrocarbons (HC), carbon dioxide (CO2), and carbon monoxide (CO). The raw data from these sensors is supplied into a microcontroller, which is in charge of signal conditioning and data collection. Sensor for vehicle smoke unit: This sensor finds smoke in a moving vehicle. The MQ2, MQ7, and MQ135 sensors are utilized for determining the levels of various gases in the atmosphere]

Where, MQ2 – For calculating smoke and combustible

Figure 3.2.1 1 MQ2 Sensor

MQ7 – Detect Carbon Monoxide

Figure 3.2.1.3 MQ7 Sensor

MQ 135 – Senses ammonia, sulfur dioxide, carbon monoxide.

Figure 3.2.1.4 MQ135 Sensor

Microcontroller: The microcontroller determines the vehicle smoke percentage (ppm) by processing sensor data. Device: The ppm value of the car smoke is shown on the touchscreen display Wi-Fi: The gadget can send the ppm value to a distant application thanks to the Wi-Fi module.

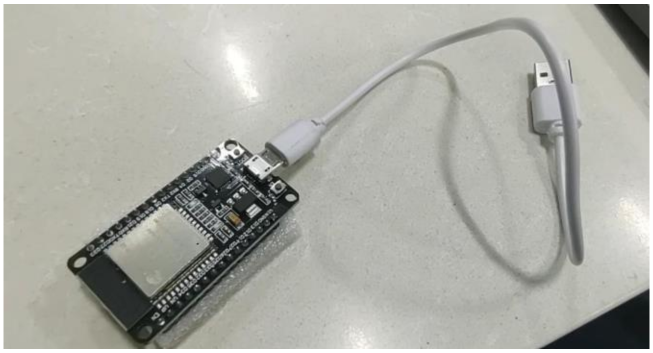

Figure 3.2.1.5 ESP 32 Dev Board with USB micro-B cable

Use case

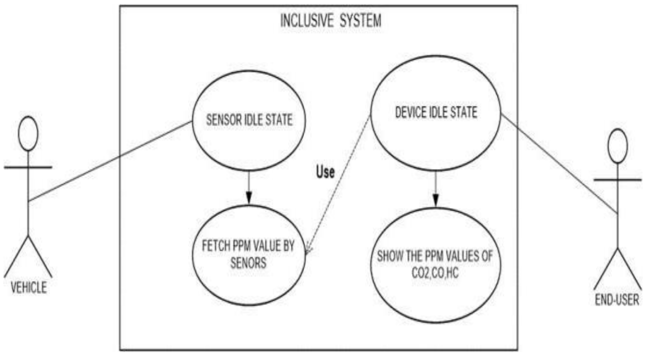

Figure 3.2.2. Use case Diagram

The use case is the overall description diagram of the scenario of the project. In the figure 3.2.2 It depicts the methodology applied in the system analysis to identify and organize the system of our vehicle emission monitoring and control using IOT. The Vehicle Emission Monitoring System with Internet of Things technology offers a real-time monitoring and analysis system that addresses environmental concerns associated with vehicle emissions. The major actors of this project are vehicle and end-user which performs the operations like sensor and device idle state, fetch and show the ppm values

The system's principal parts are:

Sensors: The sensors identify additional gases and smoke in the exhaust of the car. MQ2, MQ7, and MQ135 are common sensors found in car smoke detection systems.

Microcontroller: The system's brain is the microcontroller. It gathers information from the sensors, analyzes it, and uses that information to make decisions.

Display: The display provides the user with the outcomes of the smoke detection procedure.

Interface for communication: The interface for communication enables the system to speak with other gadgets, like a computer or smartphone.

Here's how the system operates:

The sensors identify additional gases and smoke in the exhaust of the car. The microcontroller receives data from the sensors. The concentration of smoke and other gases is computed by the microcontroller after processing the data. The microcontroller checks to see if the smoke content has risen above a predetermined level. The microcontroller triggers the alarm if the amount of smoke exceeds the predetermined threshold. The user is made aware of the existence of smoke in the car's exhaust by the alarm. Additionally, over time, the system can be used to gather information about the vehicle's emissions. This information can be used to track the success of pollution reduction measures and identify cars that areproducing excessive amounts of smoke.

Sequence Diagram

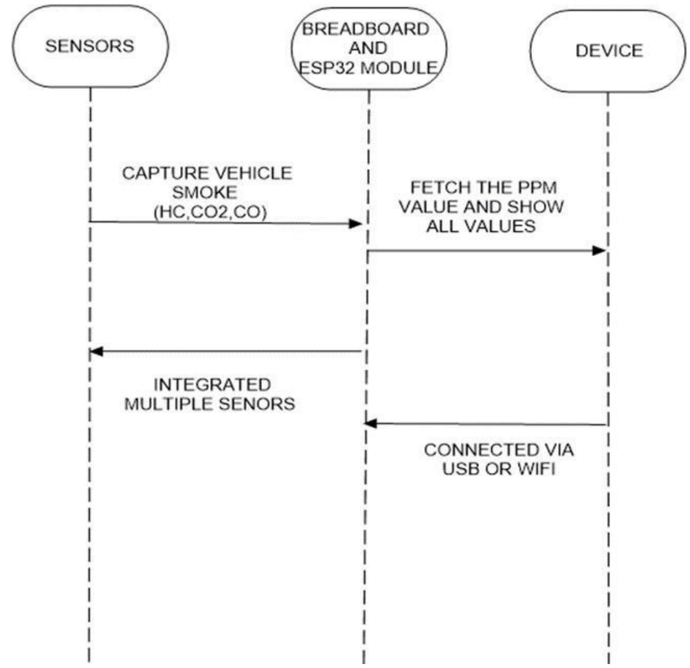

Figure 3.2.3 Sequence Diagram

The system for measuring and identifying car smoke is simplified in the figure 3.2.3. It consists of multiple parts that cooperate to monitor and sound an alert for elevated smoke levels. The diagram shows a useful method for detecting and monitoring vehicle smoke emissions, which promotes environmental safety and well-informed decision-making.

Multiple Sensors: The MQ2, MQ7, and MQ135 major sensors are used by the system. Certain gases that are frequently found in car smoke are detected by these sensors:

MQ2: Finds gases that can catch fire, such as hydrogen, propane, and methane.

MQ7: Monitors the concentrations of carbon monoxide (CO), a major part of automotive exhaust.

MQ135: Evaluates a range of gases that are involved in air pollution, including carbon dioxide (CO_2). The system's primary processing unit is made up of the ESP32 module and breadboard. A breadboard connects the sensors and microprocessor to provide a platform for prototyping. An integrated

microcontroller known as the ESP32 Module collects, processes, and exchanges data with other devices.

Capture Car Smoke: The breadboard-connected smoke unit sensor senses the presence of car smoke.

Obtain PPM Value: After receiving information from the sensors, the microcontroller determines each gas's concentration in parts per million (ppm).

Show All Values: A display device receives the ppm values from the microcontroller and displays the current smoke component levels.

USB or Wi-Fi Connection: The ESP32 module allows data transmission to other devices over USB or Wi-Fi, facilitating integration with distant systems or real-time monitoring.

IV. RESULT AND CONCLUSION

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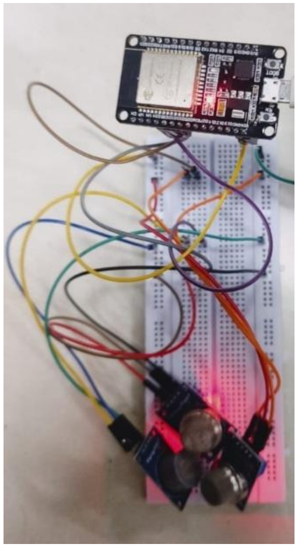

Figure 4.1.1 Prototype

```
11:40:14.452 -> MQ-2 Raw Value: 16
11:40:14.452 ->
11:40:15.411 -> MQ-135 Raw Value: 17
11:40:15.411 -> MQ-7 Raw Value: 213
11:40:15.443 -> MQ-2 Raw Value: 19
11:40:15.477 ->
11:40:16.410 -> MQ-135 Raw Value: 18
11:40:16.410 -> MQ-7 Raw Value: 212
11:40:16.443 -> MQ-2 Raw Value: 16
11:40:16.478 ->
11:40:17.410 -> MQ-135 Raw Value: 16
11:40:17.410 -> MQ-7 Raw Value: 209
11:40:17.441 -> MQ-2 Raw Value: 16
11:40:17.482 ->
11:40:18.394 -> MQ-135 Raw Value: 16
11:40:18.426 -> MQ-7 Raw Value: 263
11:40:18.426 -> MQ-2 Raw Value: 16
11:40:18.462 ->
11:40:19.410 -> MQ-135 Raw Value: 16
11:40:19.410 -> MQ-7 Raw Value: 208
11:40:19.443 -> MQ-2 Raw Value: 16
11:40:19.478 ->
11:40:20.388 -> MQ-135 Raw Value: 18
11:40:20.420 -> MQ-7 Raw Value: 244
11:40:20.456 -> MQ-2 Raw Value: 17
11:40:20.456 ->
11:40:21.409 -> MQ-135 Raw Value: 16
11:40:21.409 -> MQ-7 Raw Value: 238
11:40:21.442 -> MQ-2 Raw Value: 16
11:40:21.478 ->
```

Figure 4.1.22 Result of reading raw data with the help of prototype

V. CONCLUSION

Vehicle emissions play a major role in air pollution, which poses a substantial risk to both human and environmental health. Vehicle emissions may be tracked and managed using IoT-based technologies, which can also help to improve air quality. These systems can gather information on car emissions in run time, allowing for the identification of high-emitting vehicles and the development of focused emission reduction plans. The effectiveness of emission control measures can be monitored using IOT-based systems, which can also give information for the creation of regulations. IoT-based vehicle emission monitoring and control systems can be expanded further and improved in a variety of areas. To further cut emissions and enhance air ‘transportation, such as public transit and traffic management systems. These systems could also be employed to create fresh and cutting-edge pollution control technologies. Systems for monitoring and regulating vehicle emissions that are IoT-based have the potential to significantly aid the effort to reduce air pollution.Air pollution is largely caused by vehicle emissions, which endanger both the environment and human health. Heart disease, lung conditions, and even early death are among the negative consequences of air pollution. IoT-based car emission monitoring and control systems have become a viable approach to address this urgent problem.IoT-enabled solutions provide a thorough, real-time method of managing and tracking vehicle emissions. These systems gather information on several pollutants, including hydrocarbons and carbon monoxide and carbon dioxide, using a network of sensors and communication devices mounted in cars. After that, the gathered data is sent to a central cloud platform for display and analysis. IoT-based emission monitoring systems provide insights that allow for numerous practical ways to lower air pollution.Classification of High-Emitting Vehicles: Through the examination of emission data, regulatory bodies are able to discern automobiles that persistently surpass emission regulations. To reduce their emissions, these cars can be the focus of additional care and inspection.Targeted Emission Reduction Plans: With the use of comprehensive emission data, policymakers are able to create plans that are specifically designed to reduce emissions from a given class of vehicle, fuel, and driving behavior. This strategy makes sure that the biggest sources of pollution receive the most of the attention when it comes to emission reduction.Keeping an eye on the efficacy of emission control measures IoT-based systems can continuously track the impact of emission control measures, such as fuel standards, emissions testing, and traffic

Providing Information for Regulatory Policy Development: The information gathered from IoT systems' emissions can be very helpful in developing and improving emission standards. Policymakers can use this information to establish reasonable and attainable emission regulations for various car classes and fuel types. Connecting with Public Transportation and Traffic Management Systems: To encourage greener and more effective modes of transportation, IoT-based emission monitoring systems can be connected with public transit and traffic management systems. By promoting the use of public transit and improving traffic flow intergration can aid in the reduction of overall car emissions

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