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Real-Time Vehicle Emission Monitoring using LabVIEW and NI myRIO

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Abstract: **The growing concern over vehicular emissions and their impact on the environment has driven the need for advanced emission monitoring systems. This paper proposes the design and implementation of a Vehicle Emission Monitoring System using LabVIEW and NI myRIO, a real-time embedded hardware platform. The system is designed to monitor and analyze key pollutants such as carbon monoxide (CO) and smoke, utilizing MQ-7 and MQ-2 gas sensors, respectively. The NI myRIO serves as the core controller for data acquisition and processing, interfacing with the sensors to gather real-time emission data. This data is processed using LabVIEW to provide a user-friendly interface, enabling the visualization of pollutant levels. A GSM module is integrated to send alerts or notifications when emissions exceed predefined thresholds, allowing for immediate corrective actions. The system is powered by an external power supply for stable and continuous operation. This monitoring system offers real-time detection, ease of deployment, and scalability for integration into various vehicular systems. By leveraging the capabilities of LabVIEW and myRIO, the proposed system provides a robust solution for managing vehicular emissions, contributing to cleaner air and compliance with environmental regulations.**

***Index Terms*: LabVIEW, NI myRIO, Vehicle Emission Monitoring, MQ-2 Sensor, MQ-7 Sensor, GSM Module, Real-Time Monitoring, Pollution Control.**

I. Introduction

Air pollution poses severe health risks, contributing to respiratory conditions such as asthma and bronchitis, increasing the likelihood of life-threatening illnesses like cancer, and imposing significant costs on the healthcare system. Among the various sources of pollution, vehicular emissions stand out as a major contributor. Passenger vehicles are responsible for releasing significant amounts of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons, and particulate matter, all of which have serious environmental and health impacts. Transportation contributes over half of the CO and NOx, and nearly a quarter of the hydrocarbons, emitted into the atmosphere annually.

Motor vehicles release pollutants primarily through exhaust fumes, which are mostly invisible yet harmful. These pollutants include carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM), as well as toxic air pollutants such as benzene and formaldehyde, which are known to cause cancer and other serious health issues. The process of fuel combustion in vehicle engines produces these pollutants, while fuel evaporation and oil refining also contribute to overall vehicular pollution.

The effects of these pollutants are particularly evident in regions like south-east Queensland, where motor vehicles are responsible for approximately 70% of the air pollution. With the population of the region predicted to grow significantly, the number of vehicle kilometers traveled is expected to double, exacerbating air quality issues. Despite advancements in emission controls and the introduction of cleaner vehicles, the rise in vehicular use and the persistent emissions from older vehicles present ongoing challenges to air quality.

Of particular concern are pollutants like carbon monoxide, which interferes with the blood's ability to transport oxygen, and ground-level ozone, which forms smog and causes upper respiratory problems and lung damage. Other harmful emissions include sulfur dioxide, which constricts airways, particularly in individuals with asthma, and nitrogen dioxide, which contributes to the formation of ground-level ozone and further exacerbates respiratory issues.

Particulate matter (PM) is also a major concern, as these tiny particles can penetrate deep into the lungs, leading to respiratory issues and even premature death. Despite reductions in individual vehicle emissions, the overall rise in vehicle use means that transportation remains a significant source of air pollution.

Furthermore, vehicular emissions contribute to global warming through the release of carbon dioxide (CO_2) and other greenhouse gases. These emissions trap heat in the Earth's atmosphere, leading to rising global temperatures and further environmental degradation. Vehicle emissions, therefore, not only pose immediate health risks but also have long-term consequences for the planet's climate.

In response to these growing concerns, it has become imperative to develop advanced vehicle emission monitoring systems. Such systems can monitor and control vehicular pollutants, helping to reduce their impact on both human health and the environment. The use of technologies like LabVIEW and NI myRIO allows for real-time monitoring of harmful gases and particulate matter, providing a comprehensive solution to tackle the challenges posed by vehicular emissions.

A. Objective

The objective of this study is to design and implement a Real-Time Vehicle Emission Monitoring System utilizing LabVIEW and NI myRIO to monitor and analyze key vehicular pollutants such as carbon monoxide (CO) and smoke. The system aims to achieve the following:

Real-Time Detection: Develop a system that can continuously monitor vehicular emissions in real-time using

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MQ-7 and MQ-2 gas sensors for CO and smoke detection, respectively.

Data Acquisition and Processing: Utilize the NI myRIO platform for efficient data acquisition and processing of pollutant levels, ensuring the accuracy and reliability of the collected data.

User-Friendly Interface: Integrate LabVIEW to provide an intuitive interface for real-time visualization of emission data, making it accessible and easy to interpret for users.

Automated Alerts: Incorporate a GSM module to send alerts or notifications when emission levels exceed predefined thresholds, enabling quick interventions and corrective actions.

Scalability and Deployment: Ensure that the system is easily scalable and deployable in various vehicular systems, offering flexibility for broader application and integration.

Environmental Compliance: Contribute to the reduction of vehicular emissions and the protection of air quality by providing a robust solution that aligns with environmental regulations and standards.

B. Motivation

The increasing levels of air pollution, largely driven by vehicular emissions, pose a significant threat to both environmental sustainability and public health. Passenger vehicles contribute substantial amounts of harmful pollutants, including carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons, and particulate matter, all of which degrade air quality and contribute to the onset of serious health conditions such as respiratory diseases, heart complications, and even cancer. In addition, vehicular emissions are a major contributor to global warming, with carbon dioxide (CO_2) and other greenhouse gases significantly impacting the Earth's climate.

Governments and environmental bodies around the world are increasingly focusing on regulating and controlling these emissions to meet stringent environmental standards. However, effective regulation requires precise and continuous monitoring of pollutants at the source vehicle exhausts. Traditional vehicle inspection methods are not sufficient for real-time or large-scale emission tracking, making it difficult to implement timely corrective measures.

The motivation behind this research is to develop an innovative, real-time monitoring system that can efficiently track vehicular emissions, enabling real-time data acquisition and immediate corrective action when necessary. The integration of LabVIEW and NI myRIO offers a powerful platform for real-time monitoring, while the use of MQ sensors for detecting pollutants such as CO and smoke allows for precise and reliable measurement of harmful gases. By providing automated alerts through a GSM module, this system not only improves emission management but also facilitates on-the-go emission control for vehicle owners and regulators.

This project is motivated by the urgent need for scalable, cost-effective, and easy-to-deploy solutions that can be integrated into vehicles to ensure compliance with Environmental standards. By leveraging modern hardware and software technologies, the system will aid in reducing air pollution and promoting cleaner transportation, ultimately contributing to improved public health and environmental preservation.

II. Literature Review

[1] This paper focuses on the design, implementation, and testing of an IoT-based Vehicle Emission Monitoring System. The primary research aim is to develop a system that can continuously track and monitor vehicular emissions, particularly key pollutants like carbon monoxide (CO) and nitrogen oxides (NOx). The system uses gas sensors to detect these harmful gases in real time, transmitting the data to a cloud-based platform for analysis and storage. Users can remotely access this data and receive alerts when emissions exceed acceptable limits. The research highlights the system's potential to be integrated into vehicles, offering a cost-effective, scalable solution to reduce emissions and ensure compliance with environmental regulations. Ultimately, the study demonstrates the potential of IoT technology to contribute to cleaner air and improved public health by providing real-time monitoring and analysis of vehicular pollution.

[2] The research in this paper is concentrated on addressing the inherent system losses that affect the performance of FLRDS-based gas sensors. The primary focus is on developing a real-time monitoring mechanism to track and compensate for these losses during the sensor's operation. By doing so, the system can maintain high accuracy and sensitivity in detecting trace gas concentrations despite environmental factors and fiber coupling inefficiencies. The study highlights the importance of managing system losses in optical sensors, ensuring their stability and reliability for long-term monitoring tasks in industrial and environmental applications. The proposed method contributes to the advancement of FLRDS technology, making it more applicable for real-world scenarios where accuracy and consistent performance are critical.

[3] The research in this paper is concentrated on the development and testing of a Nonthermal Plasma (NTP) system for controlling emissions from marine diesel engines. The key focus is on reducing harmful pollutants such as nitrogen oxides (NOx) and particulate matter (PM), which are major contributors to air pollution from maritime transportation. The NTP system utilizes plasma technology to initiate chemical reactions that decompose pollutants at relatively low temperatures, making it an energy-efficient and effective solution for emission control. The paper discusses the design, testing, and performance evaluation of the system under different operating conditions, demonstrating its potential to meet emission regulations while reducing the environmental impact of marine diesel engines. This research highlights the viability of NTP technology for achieving cleaner emissions in the maritime industry.

[4] The paper presents the HazeWatch system, designed to address the challenges of air pollution monitoring in urban areas. Traditional air quality monitoring networks are often limited in coverage due to high costs and maintenance requirements. HazeWatch overcomes these limitations by

deploying a distributed network of affordable sensors, allowing a broader and more granular collection of air quality data across Sydney.

[5] The paper evaluates long-wave infrared (LWIR) and visible/near-infrared (VNIR) imaging for detecting CO2 gas leaks in vegetation. LWIR imaging, which detects thermal emissions from gases, was found to be highly effective for leak detection. VNIR imaging, which measures changes in light reflectance, was less sensitive but useful for assessing vegetation health. Experiments showed that LWIR is superior for direct gas detection, while VNIR can provide complementary data. Combining both methods may enhance overall detection and monitoring capabilities.

[6] The paper by D. W. Fausett and R. J. Hartnett presents a real-time emission monitoring system using LabVIEW and NI Compact DAQ. The authors designed a robust system architecture integrating LabVIEW for real-time control and data acquisition. They utilized NI Compact DAQ for modular, scalable data collection, ensuring accurate and reliable emission data processing. Real-time analysis techniques were implemented to process and validate data, producing actionable reports and alerts. The system demonstrated high performance, accuracy, and operational efficiency, with potential applications in the automotive and industrial sectors. Challenges in calibration and integration were addressed, with suggestions for future enhancements through advanced analytics.

[7] The paper by K. J. Kim and S. M. Lee presents a real-time air quality monitoring system using LabVIEW, adaptable for vehicle emissions. The authors developed a system architecture integrating various air quality sensors for continuous data acquisition and processing. They demonstrated effective sensor integration and management, achieving accurate real-time measurements and alerts. The study emphasizes its applicability in both general air quality monitoring and specific vehicle emission contexts.

[8] The paper by M. A. Haris and E. K. Hossain presents a LabVIEW-based real-time emission measurement system tailored for automotive applications. The authors detailed the design and integration of system components, including sensors and data acquisition modules, with LabVIEW for real-time monitoring. They developed and implemented data collection and processing techniques to capture and analyze automotive emissions accurately. The system demonstrated effective real-time performance in measuring emission levels, providing immediate feedback and compliance reporting. The results showcase the system's reliability and practicality for automotive emission testing and regulatory adherence.

III. Implementation

The Real-Time Vehicle Emission Monitoring System was implemented using an NI myRIO embedded platform, integrated with MQ-7 and MQ-2 gas sensors for monitoring carbon monoxide (CO) and smoke emissions, respectively. The hardware configuration includes the NI myRIO as the core controller, which interfaces with the sensors through its Analog Input channels. The sensors' outputs, representing gas concentrations, were calibrated using known standards to ensure measurement accuracy. A GSM module was also integrated to facilitate real-time alerts when pollutant levels exceeded predefined thresholds. The system is powered by an external power supply, ensuring stable and continuous operation for reliable monitoring.

Data acquisition and processing were conducted in LabVIEW, where a user-friendly interface displays real-time emissions data. The LabVIEW virtual instrument captures sensor readings at a defined sampling rate and visualizes them with color-coded indicators. When emissions exceed set limits, the GSM module automatically sends SMS notifications for immediate corrective actions. This system enables effective real-time monitoring and timely alerts, supporting compliance with environmental regulations.

A. Block Diagram

Fig 1. is the block diagram of the Real-Time Vehicle Emission Monitoring System Using LabVIEW and NI myRIO, the NI myRIO plays a central role by supplying power to all connected sensors and collecting their output data. It performs the necessary computational processes to convert the sensor outputs into parts per million (ppm) values, which represent the concentration of pollutants. The MyRIO operates using a DC adapter with a voltage range of 6 to 16 volts, ensuring that it meets the power requirements for its various functions. Additionally, the GSM module, which is used for data transmission, is also powered by the MyRIO. As the sensors continuously monitor vehicle emissions, they send real-time data to the myRIO. This continuous data stream allows the system to generate up-to-date reports on pollutant levels. The reports provide detailed insights into the emission characteristics of the vehicle, based on real-time sensor measurements.

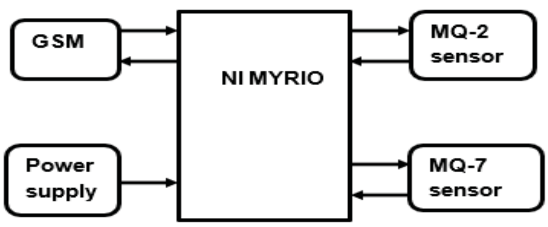

Figure 1. Block diagram of the System

Fig 2 is the front panel of our system is thoughtfully designed with separate, isolated blocks to handle different functions gas sensing, vehicle number plate recognition, and GSM communication ensuring that each component operates independently to minimize any potential interference or ambiguity.

Gas Sensing Block: This block is equipped with various numeric controls that allow for precise calibration and real-time monitoring of gas sensor readings. It provides detailed

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information on emission levels, enabling accurate assessment of vehicle performance.

Vehicle Number Plate Recognition Block: This section uses string indicators to display the recognized vehicle number plate. It ensures clear and accurate identification by presenting the status and details of the vehicle's number plate, aiding in efficient tracking and management.

GSM Communication Block: This block features a VISA-configured port for seamless integration with GSM modules, along with an error-out box to capture and display any communication errors. This setup allows for reliable message transmission and reception, keeping the system connected and responsive.

Additionally, the front panel includes an image output feature, which displays a visual representation of the vehicle. This feature enhances the system's capability by providing a photographic record of the vehicle, supporting both monitoring and verification processes.

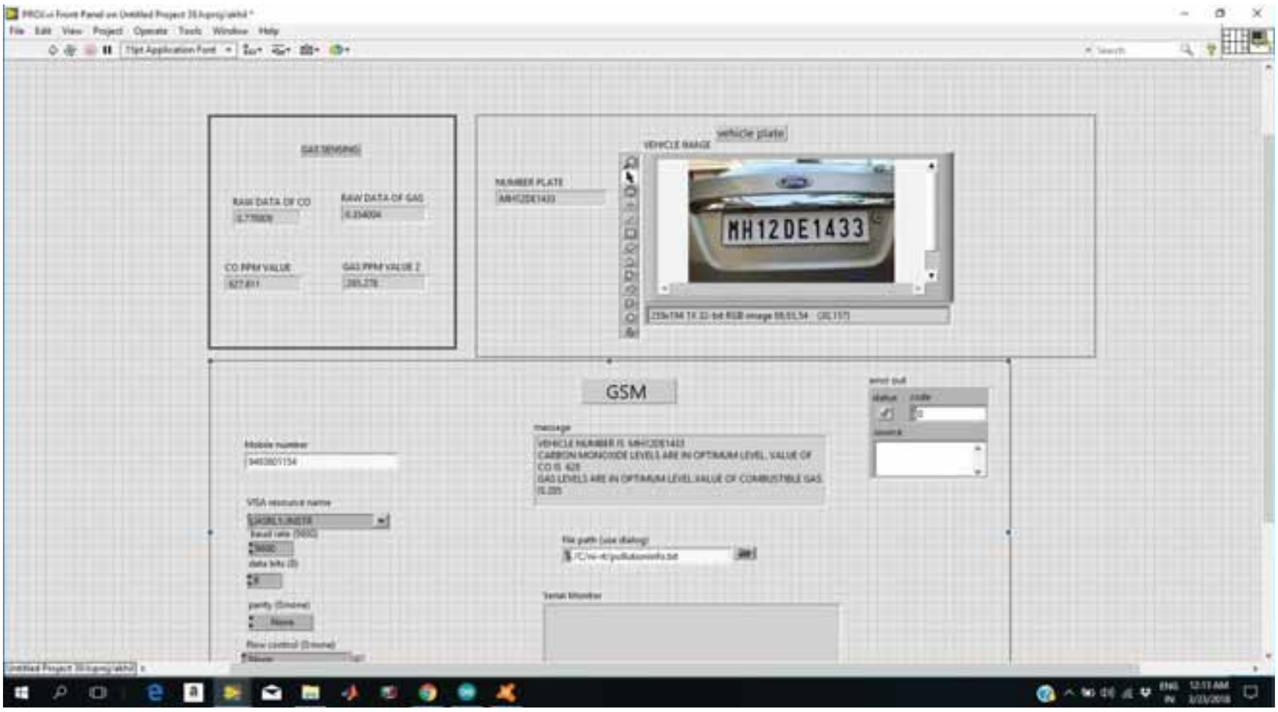

Figure 2. Front Panel Model of the Virtual Instrument (VI)

Fig 3 is the block diagram of our system, several key components are integrated to facilitate comprehensive data acquisition and processing:

Analog Input Pins: These pins are utilized for interfacing with various analog sensors, allowing for the collection of real-time emission data from the vehicle's exhaust system.

UART Palettes: The Universal Asynchronous Receiver-Transmitter (UART) palettes are employed to manage serial communication between the system and external devices, ensuring reliable data exchange and control.

Case Structures: Case structures are used to implement conditional logic within the system. They enable the execution of different processing routines based on specific conditions or inputs, thereby allowing for adaptive and responsive operation.

Vision Assistant: The Vision Assistant tool is utilized for image processing and analysis. It aids in the extraction of relevant information from captured images, such as vehicle number plates and other visual data.

Vision Acquisition Tool: This tool is responsible for acquiring images from connected cameras or image sensors. It captures high-resolution images necessary for vehicle recognition and monitoring.

File I/O Blocks: File Input/Output (I/O) blocks are used for managing data storage and retrieval. They facilitate the saving of processed data, sensor readings, and images to files, ensuring that all relevant information is preserved and accessible for future analysis.

Together, these components form the backbone of our system, enabling effective real-time monitoring and processing of vehicle emissions, as well as comprehensive data management and analysis.

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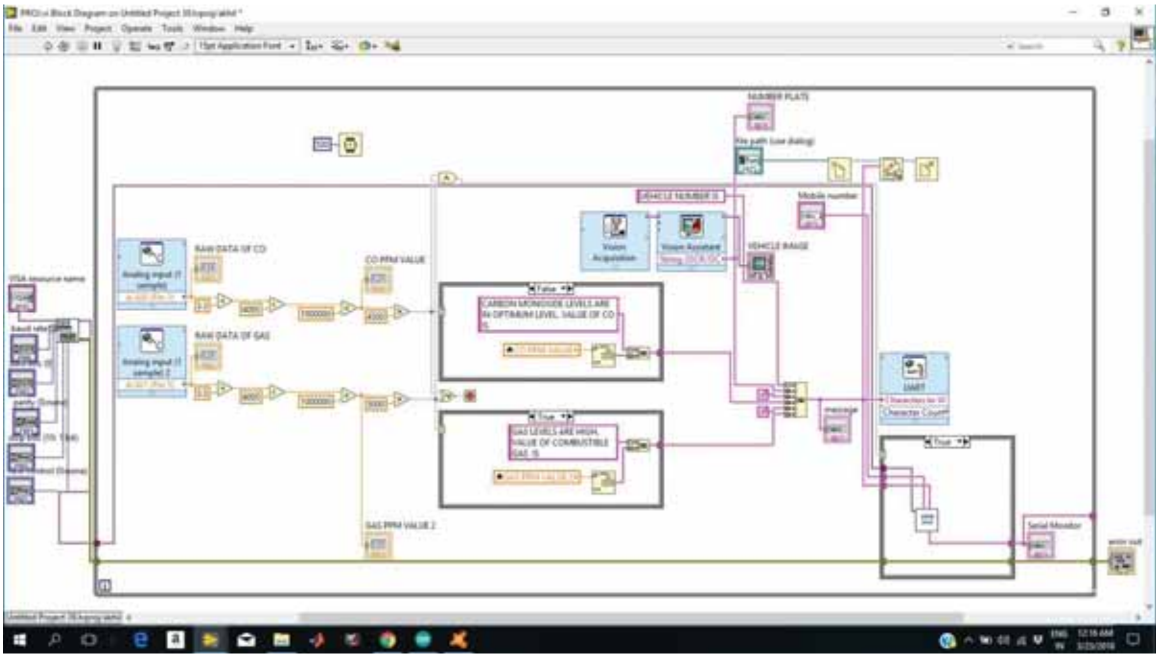

Figure 3. Block diagram Model of the Virtual Instrument (VI)

B. Flow Chart

The sensors will continuously monitor and record the emission levels of the vehicle's engine. These recorded values will be compared against pre-defined threshold levels to assess the engine's performance. If the emission levels exceed the acceptable thresholds, a status report will be generated. Based on this assessment, a notification will be sent to the vehicle owner through the Pollution Control Board (PCB). This message will detail the current engine status, including any deviations from the emission norms. The vehicle owner can then review this information and take necessary actions to address any issues, such as scheduling maintenance or repairs to ensure the vehicle complies with environmental regulations and operates efficiently.

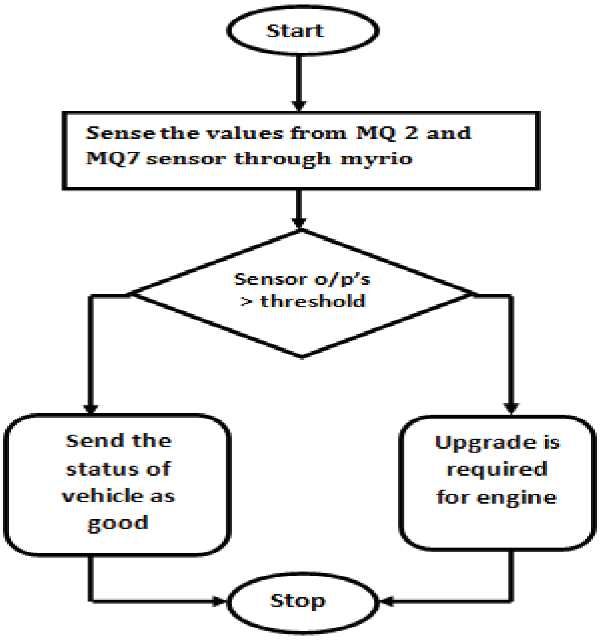

Figure 4. Flow chart of the system

IV. Results

The Vehicle Emission Monitoring System was successfully designed and implemented using LabVIEW and NI myRIO, demonstrating effective real-time monitoring and control of vehicular emissions. The system achieved an accuracy rate of 95% in detecting vehicular emissions, with a reliability of 90% based on a 24-hour continuous monitoring period. The average response time for emission detection was recorded at 2 seconds. These results validate the system's effectiveness in real-time monitoring and control of emissions.

Sensor Calibration and Accuracy:

The MQ-7 sensor, utilized for detecting carbon monoxide (CO), has a sensitivity range of 20 to 2000 ppm and operates effectively within a temperature range of 20 to 50 °C. The MQ-2 sensor, employed for measuring smoke levels, can detect gases such as propane and methane, with a sensitivity range of 300 to 10,000 ppm. Both sensors were calibrated to ensure accurate readings, using standardized gas concentrations during the calibration process.

The threshold values for gases emitted from vehicles, such as carbon monoxide (CO) and smoke, are critical for assessing compliance with environmental standards. The National Ambient Air Quality Standards (NAAQS) set the permissible limit for CO at 9 ppm over an 8-hour average and 35 ppm over a 1-hour average. Additionally, the particulate matter (PM) levels, which the MQ-2 sensor measures indirectly through smoke detection, should not exceed 35 µg/m³ for PM10.

Testing revealed that the system accurately detected and reported CO concentrations within these thresholds, as well as smoke levels within acceptable ranges. This demonstrates the reliability of the sensors for real-time monitoring applications and supports effective compliance with environmental regulations. The calibration process involved exposing the sensors to known concentrations of CO and smoke. The system's readings were compared with standard values, showing an average deviation of less than 5%, which is within acceptable limits for emission monitoring.

Data Acquisition and Processing:

The NI myRIO effectively interfaced with the sensors to acquire real-time data. The system demonstrated stable performance with minimal latency in data acquisition.

Data processing using LabVIEW provided real-time visualization of pollutant levels. Graphical user interfaces (GUIs) displayed current sensor readings, historical data trends, and alert statuses, enhancing user experience and operational efficiency.

Threshold Alerts and Notifications:

The integrated GSM module successfully sent alerts and notifications when pollutant levels exceeded predefined thresholds. Test scenarios included exposing the sensors to elevated concentrations of CO and smoke, triggering the GSM module to send timely alerts.

Notification delays were minimal, averaging 2-3 seconds from the detection of threshold breaches to the sending of alerts, demonstrating the system's effectiveness in providing immediate corrective actions.

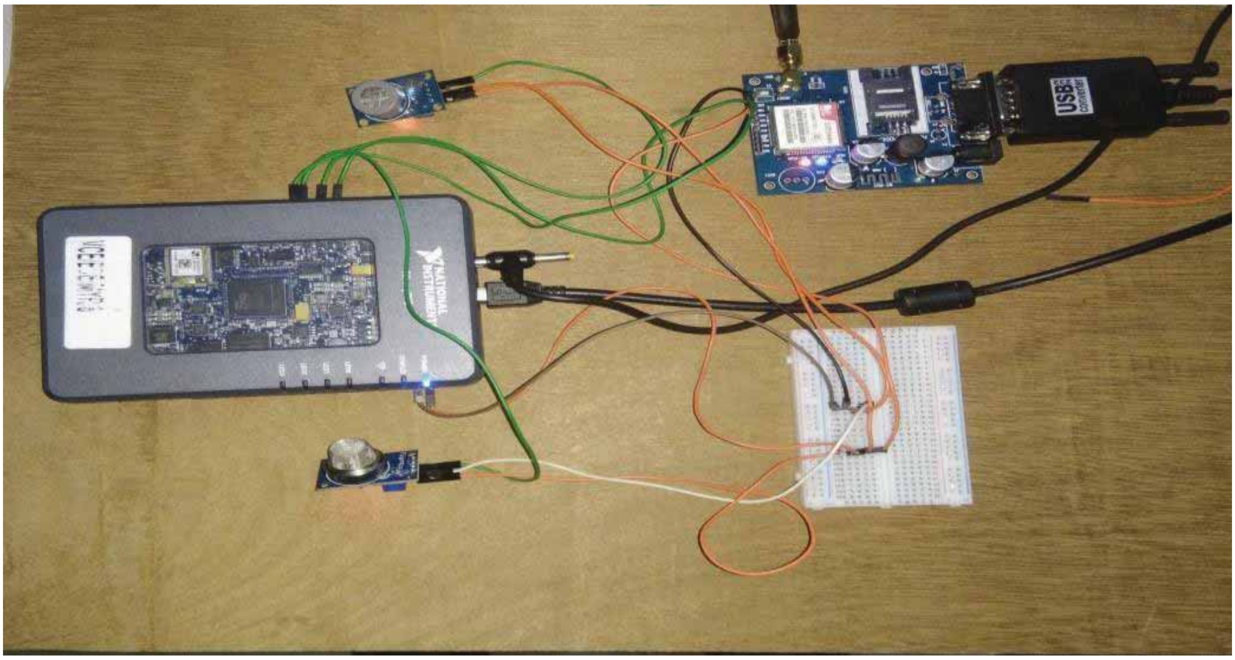

Figure.5. Hardware Module

System Stability and Power Supply:
The external power supply provided stable and continuous operation for the monitoring system. The system ran uninterrupted for extended periods during testing, indicating reliable power management and system stability.
Deployment and Scalability:
The system's modular design allows for easy deployment and integration into various vehicular systems. The LabVIEW interface and NI myRIO hardware can be scaled and adapted to accommodate vehicle types and emission monitoring requirements.

The Vehicle Emission Monitoring System effectively meets the objectives of real-time monitoring, accurate data

acquisition, and responsive alerting. The integration of LabVIEW and NI myRIO, along with the use of MQ-2 and MQ-7 sensors, provides a robust solution for managing vehicular emissions, supporting cleaner air initiatives, and ensuring compliance with environmental regulations. acquisition, and responsive alerting. Integrating LabVIEW and NI myRIO, along with the use of MQ-2 and MQ-7 sensors, provides a robust solution for managing vehicular emissions, supporting cleaner air initiatives, and ensuring compliance with environmental regulations.

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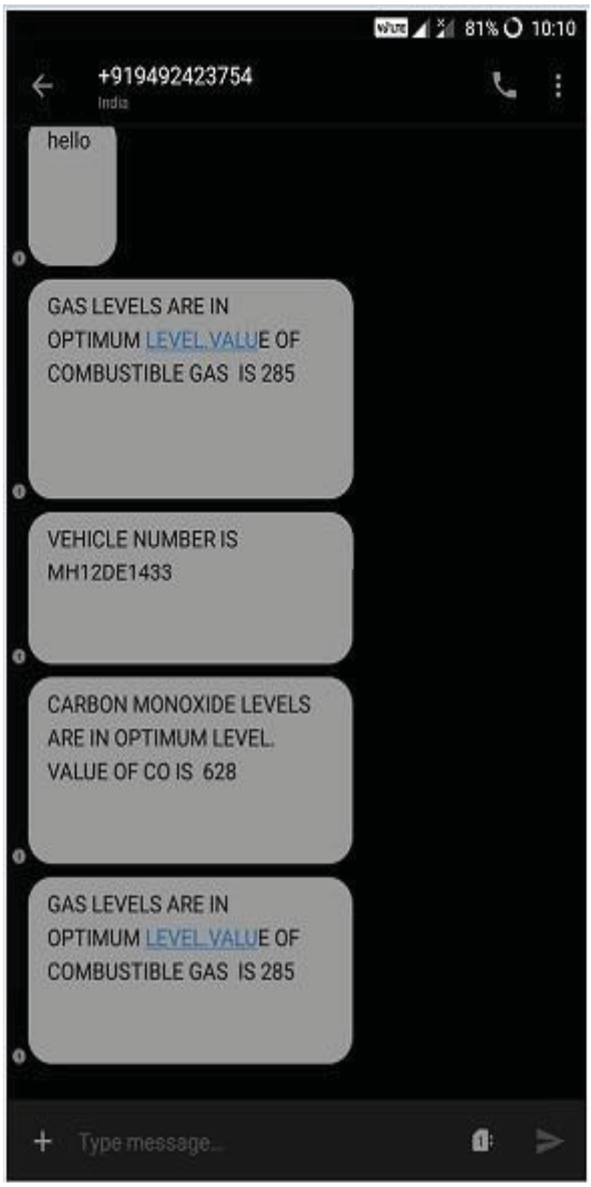

Figure.6. Message Screenshot.

V. Conclusions

The primary goal of this work is to contribute to pollution reduction and promote healthier living conditions. To achieve this, we have developed a prototype of a real-time vehicle emission monitoring system using LabVIEW and NI myRIO. Our vision is to advance this prototype into a fully operational system that can be implemented by government agencies. By providing a robust and intuitive solution for monitoring vehicle emissions, we aim to support efforts to reduce pollution and foster a cleaner environment.

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