Real-Time Detection and Reporting of Vehicle Emissions using Arduino and GSM

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ABSTRACT:

Given the worrying increase in environmental pollution associated with variables such as urbanization, industrialization, increased vehicle emissions, and population growth, effective monitoring methods are urgently needed to protect public health. This project aims to develop an Internet of Things (IoT)--based air pollution monitoring system that can detect and notify users of poor air quality.
Many factors, such as population growth, increased automobile use, industrialization, and urbanization, have contributed to increased environmental pollution over time. These factors hurt human well-being as they directly affect the health of those exposed to them. To monitor air quality, this project uses an Internet-based web server to monitor air quality. If the quality falls below a set threshold, an alarm will sound. This system is an IoT-based air pollution monitoring system.

To measure the concentration of hazardous gases in the atmosphere, the system uses a network of sensors including MQ6 (LPG, propane), MQ7 (carbon monoxide), and MQ135 (NH3, benzene, alcohol, smoke). Maus. These sensors continuously monitor air quality while transmitting data to a central control unit.

To improve the performance of the system, a GSM module is also integrated, which triggers an alarm when the air quality exceeds a predetermined value. This feature provides timely notifications so users can take immediate action to reduce exposure to hazardous contaminants. This allows the user to know information when receiving her SMS/Text messages when the limit is exceeded. This allows users to confirm that metrics exist and that alerts and actions can be taken. This feature will create great awareness all over the world and will help you even more.

I. INTRODUCTION

Identifying gases emitted by vehicles using gas sensors such as MQ-6, MQ-7, and MQ-135 is the first step toward implementing vehicle pollution monitoring. These gases include volatile organic compounds (VOCs), nitrogen dioxide (NO2), and carbon monoxide (CO). Each sensor is important for monitoring emissions from different vehicles, increasing our understanding of air quality and pollution levels in metropolitan areas.

The MQ-6 gas sensor can identify various flammable gases such as alcohol and methane. It is used to detect the presence of these gases in exhaust gases when monitoring vehicle pollution. Methane and alcohol are common byproducts of incomplete combustion in car engines, and their detection can reveal inefficiencies in the combustion process that threaten public health and contribute to air pollution.

The MQ-7 gas sensor, on the other hand, is specifically designed to detect levels of carbon monoxide (CO). Dangerous gas released from car exhaust. Carbon monoxide (CO) is typically produced by the incomplete combustion of fossil fuels. High concentrations of the gas can have harmful health effects, so monitoring carbon dioxide levels in the atmosphere can help determine how vehicle emissions impact public health and air quality. important in making decisions.

The MQ-135 gas sensor can detect ammonia, nitrogen oxides (NOx), benzene, and volatile organic compounds (VOCs) with a wider gas sensitivity range. When monitoring vehicle pollution, the MQ-135 can identify gases such as NO2 and VOCs emitted by vehicle exhausts. Nitrogen dioxide (NO2) is an important component of nitrogen oxides (NOx), which has negative effects on human health and causes air pollution. VOCs, on the other hand, contribute to the production of smog and ground-level ozone, exacerbating air quality problems.

The functionality of these sensors is based on the theory of gas detection by resistance change. The conductivity of the sensor material changes in response to exposure to the target gas, resulting in a significant resistance change. Target gas concentrations are associated with this change and provide useful information for assessing air quality.

These sensors can be conveniently integrated into fixed monitoring stations or mobile units strategically placed next to highways or in metropolitan areas. Data collected by these sensors can be examined to assess air quality, identify pollution hotspots, and track the effectiveness of pollution control measures. Policy makers, urban planners and environmental authorities can use real-time monitoring to take targeted actions to improve air quality and reduce vehicle emissions.

However, to maintain the accuracy and reliability of sensor readings over time, issues such as calibration, cross-sensitivity to other gases, and environmental variables such as humidity and temperature must be resolved. Regular calibration and maintenance are required to keep vehicle pollution monitoring systems functioning and alleviate these problems. Adding MQ Series gas sensors such as MQ-6, MQ-7, and MQ-135 to your vehicle pollution monitoring system provides a cost-effective way to assess and monitor the impact of vehicle exhaust emissions on public health and air quality degradation. provides a highly scalable method.

Integrate these sensors into your project to monitor the overall status in real time. These sensors detect gases present in the atmosphere.

The rest of this document is organized as follows. Section II is about the first phase of implementing vehicle pollution monitoring, which involves detecting specific gases emitted by vehicles using gas sensors such as MQ-6, MQ-7, and Identify MQ. 135. In Section III, you will get an Arduino UNO board and start doing electronics and coding. The operation of GSM networks with specific features and implications, such as Global System for Mobile Communications or GSM 900A, is one of the more traditional GSM models operating in the 900 MHz frequency range in Section IV. Section V describes the Arduino IDE, which is used to write, compile, and upload code on Arduino devices. Section VI describes real-time vehicle emissions and air quality monitoring through an operational system using GSM technology, an integrated vehicle monitoring system using MQ-6, MQ-7, and MQ-135 gas sensors. In Section VII, the integration of GSM technology with MQ-6, MQ-7, and MQ-135 gas sensors provides reliable vehicle monitoring systems with the capabilities of these sensors and the communication infrastructure provided by the GSM network. We have discussed the conclusion that high and useful options are provided. These systems offer many benefits for real-time air quality assessment and vehicle emissions tracking.

II. LITERATURE SURVEY

The first step in implementing vehicle pollution monitoring is to identify specific gases emitted by vehicles using gas sensors such as MQ-6, MQ-7, and MQ-135. These gases include carbon monoxide (CO), nitrogen dioxide (NO2), and volatile organic compounds (VOCs). All the sensors are essential for tracking the emissions of different vehicles and learning more about the air quality and pollution levels in cities.

Methane and alcohol are just two of the many dangerous gases that the MQ-6 gas sensor can detect. When monitoring vehicle pollution, it is used to detect the presence of these gases in the exhaust gas. Methane and alcohol are common byproducts of incomplete combustion in car engines, and measuring them can reveal inefficiencies in the combustion process that threaten public health and worsen air pollution.

In contrast, the MQ-7 gas sensor is specifically designed to measure carbon monoxide (CO) levels. Carbon monoxide (CO) is a dangerous gas emitted from vehicle exhaust, mostly from the incomplete combustion of fossil fuels. Air quality and public health monitoring is essential to understanding how vehicle emissions affect air quality, as increased CO concentrations can have negative health effects.

The MQ-135 gas sensor has a wider gas sensitivity range and can detect volatile organic compounds (VOCs), ammonia, nitrogen oxides (NOx), and benzene. The MQ-135 can detect gases such as NO2 and VOC from vehicle exhaust gases and monitor vehicle pollution. Nitrogen dioxide (NO2) is an essential component of nitrogen oxides (NOx), which is harmful to health and causes air pollution. VOCs, on the other hand, contribute to the formation of ozone and smog on the ground, exacerbating air quality problems.

These sensors work on the principle of gas detection by resistance change. When exposed to the target gas, the conductivity of the sensor material changes, resulting in a significant resistance change. This change is related to the concentration of the target gas and provides valuable information for assessing air quality.

In practice, these sensors can be integrated into mobile or fixed monitoring stations strategically placed along roads and in urban areas. The data collected by these sensors can be analysed to assess air quality, identify pollution hotspots, and monitor the effectiveness of pollution prevention efforts. Using real-time monitoring, policymakers, urban planners, and environmental authorities can take targeted actions to improve air quality and reduce vehicle emissions. However, to ensure sensor readings remain accurate and reliable over time, issues such as calibration, cross-sensitivity to other gases, and environmental factors such as humidity and temperature must be addressed. Automotive pollution monitoring systems require regular calibration and maintenance to keep them operational and reduce these problems.

Expand your vehicle pollution monitoring system by adding MQ series gas sensors such as MQ-6, MQ-7, and MQ-135 to assess and reduce the impact of vehicle emissions on public health and air quality., can be more cost-effective. We integrate these sensors to monitor the overall status of the project in real time. Gases in the atmosphere are detected by these sensors.

Examining the literature on MQ-6, MQ-7, and MQ-135 gas sensor-based vehicle pollution monitoring systems to address air quality issues, understand emission patterns, and develop effective pollution control strategies. reveals a wealth of research initiatives. Significant discoveries and advances in sensor calibration, data analysis techniques, system architecture, and application of sensor networks for comprehensive pollutant assessment were summarized from the existing literature. Numerous verification and calibration strategies have been investigated to increase the accuracy and reliability of gas sensors. Studies have shown that field validation against reference equipment and laboratory calibration using standard gas mixtures are essential to ensure accuracy and consistency of contamination measurements. Additionally, data processing plays a key role in extracting useful insights from sensor inputs. Techniques such as statistical modelling and machine learning algorithms are used to analyse sensor data and identify pollution trends. Temporal and regional changes in pollution levels are frequently investigated, and time series analysis, clustering algorithms, and spatial interpolation techniques are used to provide data relevant to pollution control measures.

System integration and design are essential to developing an effective pollution monitoring system. The researchers developed an integrated system with a communication module, additional environmental sensors, and an MQ series gas sensor for real-time data exchange. Both fixed monitoring stations in urban and industrial areas and mobile vehicle emissions test monitors on roads are being developed to assess pollution hotspots and compliance with air quality regulations.

Furthermore, the use of sensor data for the management and control of environmental pollution is a recurring theme in the literature. Real-time monitoring data allows targeted interventions to mitigate the negative effects of pollution and allows policymakers to make informed decisions about the effectiveness of emission reduction programs. Integration with Geographic Information Systems (GIS) enables spatial visualization of pollution data to facilitate targeted public health interventions by identifying pollution sources, emission trends, and vulnerable population areas.

Despite significant advances, problems remain with sensor accuracy, cross-sensitivity to interfering gases, and environmental effects on sensor performance. Future research areas include sensor miniaturization, development of high sensitivity and sensor materials, and construction of sensor networks for comprehensive coverage of pollution monitoring. Developing robust pollution monitoring systems that can address these challenges and provide actionable insights for pollution control and public health protection requires collaboration between environmental scientists, engineers, data analysts, and policy makers. Interdisciplinary collaboration is essential.

The literature review concludes that there is a need to integrate MQ-6, MQ-7, and MQ-135 gasoline sensors into vehicle pollution monitoring systems to combat declining air quality and its negative impacts on the environment and public health. is emphasized. Ongoing research efforts are underway to improve sensor technologies, data analysis techniques, and system integration strategies to support evidence-based decision-making and promote sustainable urban development. This includes expanded monitoring to enable rapid determination of contamination levels. This information can be used in the future to protect the environment and to take various measures to prevent these acts from occurring.

The project used various sensors to detect the various gases present and notified the public via SMS when pollution limits were exceeded and the readings were reached. GSM technology transmits the values to be transmitted and provides real-time data that is continuously monitored. This creates a record of your data that you can save and review if needed. This means your data is always accessible. Those with access can view the data and report the situation to stop excessive usage.

III. ARDUINO UNO

UNO is the perfect board to try your hand at electronics and coding. The most durable board for platform beginners to try is he UNO. Of all the Arduino boards, UNO is the most used and best documented.

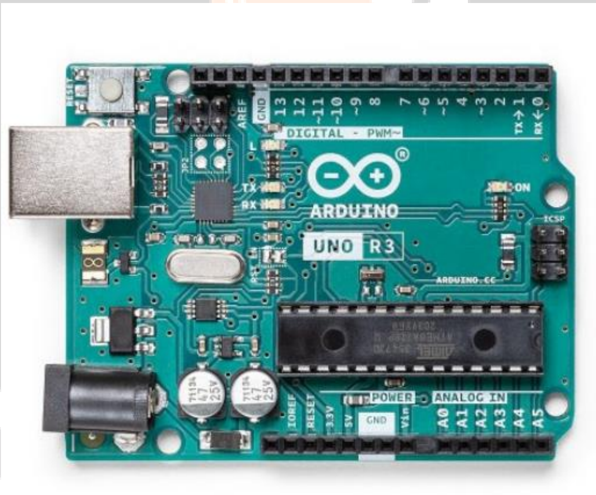

Fig 1: Arduino uno

- The microcontroller board called Arduino Uno is based on the ATmega328P (datasheet). There are six analogue inputs, a 16 MHz crystal, a USB port, a power jack, an ICSP header, a reset button, and 14 digital input/output pins, six of which can be used as PWM outputs. The scope of delivery includes all the components necessary to support the microcontroller. Simply power it with a battery or AC-DC adapter, or connect it to your computer with a USB cable. UNO allows you to experiment without worrying about making mistakes. In the worst-case scenario, you can replace the chip and reboot for a few dollars. "uno" means "one" in Italian, so it was chosen to commemorate the release of Arduino Software (IDE) 1.0. The Arduino reference version, which is now being developed into a new version, was version 1.0 of the Uno board and Arduino software (IDE). The basic model of the Arduino platform, the Uno board, is the first in the USB Arduino board series. See the Arduino Board Index for a comprehensive list of all board's available past and present.

IV. GSM 900A

The global mobile network uses Global System for Mobile Communications (GSM) as its standard. Among the various GSM versions, GSM 900A is one of the older models that uses the 900 MHz frequency band. To thoroughly explore the complexities of GSM 900A, we examine its background, technical details, network design, development, advantages, disadvantages, and impact on the telecommunications field.

Fig 2: GSM 900A

A. HISTORICAL CONTEXT

To enable smooth cross-border communications, European telecommunications authorities began developing standardized mobile communications systems in the 1980s. It was at this time that GSM was first developed. The European Telecommunications Standards Institute (ETSI) created the GSM standard based on this project. One of the first versions of this standard was GSM 900A, which was primarily used in regions where the 900 MHz frequency band was introduced.

B. TECHNICAL SPECIFICATIONS

Compared to higher frequency bands, GSM 900A operates in the 900 MHz frequency range, allowing effective long-distance propagation and improved obstacle penetration. Variants marked "A" are typically adapted to specific regional requirements or adaptations.

C. KEY TECHNICAL SPECIFICATIONS OF GSM 900A INCLUDE:

- Frequency bands: 890-915 MHz for uplink (mobile radio to base station) and 935-960 MHz for downlink operation (base station to mobile device).
- Modulation: Gaussian Minimum Shift Keying (GMSK) modulation is used to make effective use of the radio spectrum.
- Channel Bandwidth: Each carrier channel uses a bandwidth of 200 kHz.
- Data rates: Provides circuit-switched data rates of up to 9.6 Kbit/s. Later, technologies such as General Packet Radio Service (GPRS) were able to support higher data rates. To fully understand how GSM 900A works, you need to study various topics such as network architecture, signalling, call setup, handover procedures, and security protocols. Let us take a closer look at each part.
- **1. NETWORK ARCHIETECTURE:**

The GSM 900A network architecture consists of several interconnected parts, each with a specific purpose**.**

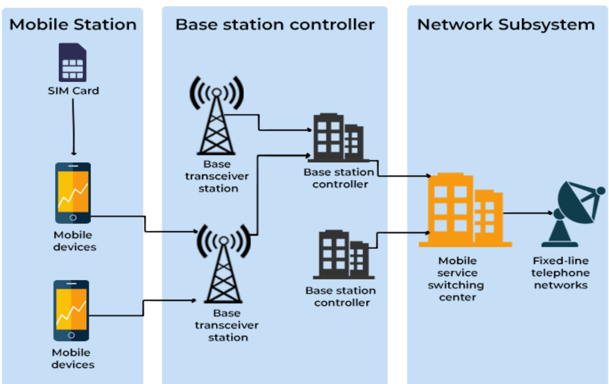

Fig 3: Working of a gsm network

Mobile Station (MS): Cell phones and smartphones are examples of mobile devices used by users. The system consists of a subscriber identity module (SIM) that stores subscriber data and a mobile device (ME).

Base Station Subsystem (BSS): Base Transceiver Station (BTS) and Base Station Controller (BSC) are his two main components of BSS. In its coverage area, mobile devices are used for radio transmission and reception, which is taken over by the BTS. The BSC monitors multiple BTSs and handles tasks such as frequency allocation and handovers. The Mobile Switching Centre (MSC) is part of the NSS and serves as the main hub for mobility management and call routing.

Network Switching Subsystem (NSS): Communicates with databases and external networks such as Visitor Location Register (VLR) and Home Location Register (HLR) to verify subscribers and track their location.

Authentication Centre (AuC): To prevent unauthorized access to the network, AuC authenticates participants and stores security-related data, including encryption keys. Equipment Identity Register (EIR): To track stolen devices, EIR tracks mobile device identifiers (IMEIs) in a database.

Gateway Mobile Switching Centre (GMSC): To route calls between GSM and non-GSM networks, the GMSC interfaces with external networks such as the Public Switched Telephone Network (PSTN) and other cellular networks.

2. SIGNALLING:

GSM 900A uses various signalling techniques to establish and maintain communication sessions.
Physical Layer Signalling: Time division multiple access (TDMA) is used by GSM to allocate time slots at the physical layer, allowing multiple users to effectively share a single frequency band. User data or signalling information is sent in each time slot.

Control Channel Signalling: In GSM, certain control channels are intended for signalling purposes. These channels include the Paging Channel (PCH) for paging subscribers, the Random-Access Channel (RACH) for initial access, and the Broadcast Control Channel (BCCH) for transmitting system information.

Common Channel Signalling: Call setup, handover, and other control operations are performed over common channels such as Dedicated Control Channel (DCCH) and Common Control Channel (CCCH).

Channel Associated Signalling: Signalling data is sent on the same physical channel as user data during a conversation using a protocol such as the Signalling System 7 (SS7) protocol stack.

3. CALL ESTABLISHMENT:

Several processes are involved when initiating a call in GSM.

Location Update: When a mobile device is powered on or moved to a new location, it registers with the network and begins the location update process. The Participant's position within the VLR will be updated accordingly by the MSC.

Call Setup: A mobile device uses the BTS and BSC to request the network to initiate a call. After retrieving the subscriber profile from the HLR, the MSC sends a call setup request to the destination MS.

Call Routing: The MSC establishes a circuit-switched connection between the caller and the called party as soon as the destination MS responds. This requires assigning a specific traffic channel (TCH) during the call.

Call Release: Once the call is complete, either side may disconnect, thereby freeing up allocated resources and notifying the network that the call has ended.

4. HANDOVER MECHANISMS:

The handover process involves moving a call or data session from one BTS to another. This allows mobile devices to maintain seamless connectivity while moving between cells.

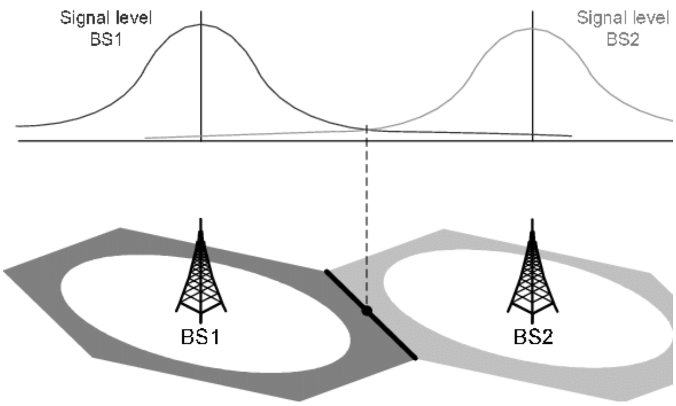

Fig 4: BS1 to BS2

Handover Types: GSM facilitates handover in several ways. B. Intracell (within the same BTS), intercell (between adjacent BTSs), and inter BSC (between BTSs under the control of different BSCs).

Handover Triggers: Signal strength, signal quality, load balancing, and other variables can all cause handoffs to occur. The BSC decides the handover time according to the countermeasures reported by the surrounding cells and the MS.

Handover Execution: The BSC ensures that calls are routed from the originating BTS to the destination BTS during handoff. This includes connecting to the desired BTS, adjusting the time, and smoothly transmitting user data and signals.

Handover Completion: Once the handover is complete, the BSC updates the MS with the new channel parameters and releases the resources associated with the source BTS.

5. SECURITY PROTOCOLS:

GSM includes several security features to protect user confidentiality and prevent unauthorized access.

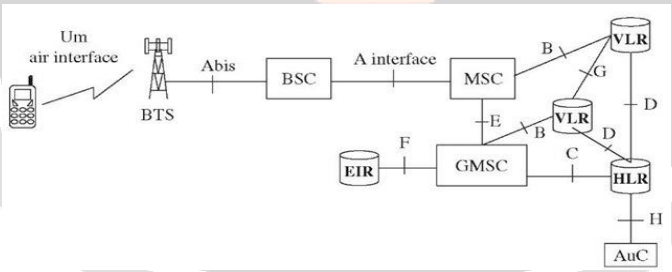

Fig 5: Security protocols

Authentication: In network registration, the network and the MS authenticate each other using a challenge/response procedure. Using the SIM card's private key, the AuC generates an encryption key (Ki) and a unique authentication token (RAND). Based on RAND and Ki, the MS calculates a response (SRES) and sends it to the network for verification.

Encryption: After authentication, the network and the MS establish a secure connection using encryption technology such as the A5 family. This means that data transfers and voice calls are reliably encrypted and protected from manipulation and eavesdropping.

Subscriber Identity Confidentiality: GSM replaces permanent IMSI with Temporary Mobile Subscriber Identity (TMSI) and Local Mobile Subscriber Identity (LMSI). These are updated and communicated regularly to avoid surveillance of the subscriber's location.

Evolution and Improvements: GSM 900A supported subsequent mobile communication technologies such as Enhanced Data Rates for GSM Evolution (EDGE) for higher data rates and packet-switched data, General Packet Radio Service (GPRS) for packet-switched data, and eventually 3G. We have set the stages of, 4G and later. These developments have improved multimedia capabilities, reduced latency, and increased data rates.

ADVANTAGES:

1. Global Standard: The widespread adoption of GSM 900A as an international standard ensures that users can effortlessly roam across different networks and countries.

2. Effective Spectrum Utilisation: GSM 900A optimizes the utilization of the scarce radio spectrum resources through efficient modulation techniques and frequency allocation.

3. Reliability: GSM networks are well-known for their robustness and reliability, offering reliable voice and data services even in challenging environments.

4. Security: To guarantee the privacy and safety of communication, GSM includes encryption and authentication features.

DISADVANTAGES:

1. Limited Data Speeds: The GSM 900A technology is not ideal for applications that require a lot of bandwidth because it has slower data speeds compared to more advanced technologies such as 3G and 4G.

2. Capacity Constraints: Due to the original design of GSM networks, there can be capacity problems in busy areas or during peak usage times.

3. Technological Obsolescence: The GSM 900A technology may become outdated as mobile technologies rapidly advance, necessitating network upgrades and the adoption of newer standards.

4. Vulnerabilities: Despite security measures, GSM networks have vulnerabilities, such as the potential for specialized equipment to intercept calls and text messages.

IMPACT ON TELECOMMUNICATIONS INDUSTRY:

GSM revolutionized the telecommunications industry by establishing a universal standard for cellular communication and promoting competition, innovation, and global connectivity. Its impact extends beyond voice calls to encompass texting, internet browsing, mobile transactions, and various other applications.

In summary, GSM 900A, which offers reliable voice and data connections within the 900 MHz frequency range, represents a significant milestone in cellular network advancement. Despite newer technologies surpassing it in terms of speed and capabilities, GSM's widespread adoption and standardization continue to shape the modern telecommunications landscape, influencing how people worldwide communicate and engage with each other. One key aspect of GSM 900A worth exploring further is its frequency bands and their crucial role in network connectivity.

1. UPLINK BAND (MOBILE TO BASE STATION):

Frequency Range: 890-915 MHz

Mobile devices are only allowed to transmit voice calls, text messages, and data uploads within this specific frequency range.

This frequency range is utilized by mobile phones in GSM 900A networks to connect with nearby base stations.

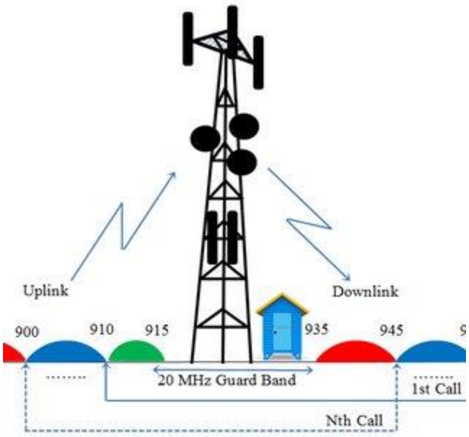

Fig 6: Mobile to base station

2. DOWNLINK BAND (BASE STATION TO MOBILE):

The frequency range of 935-960 MHz is used by base stations to transmit signals to mobile devices within their coverage area.

This includes sending voice calls, text messages, data downloads, and control signals from the base station to the mobile devices.

SIGNIFICANCE OF FREQUENCY BANDS:

1. Propagation Characteristics: The GSM 900A network benefits from operating in the 900 MHz frequency band due to its favourable propagation characteristics. Signals in this band can easily penetrate obstacles like trees and buildings and cover long distances, providing enhanced coverage and better indoor reception in both urban and rural areas.

2. Interference Mitigation: By operating at a lower frequency, GSM 900A networks can minimize certain types of interference, ensuring more reliable communication in challenging environments where higher frequencies may be affected by building materials and weather conditions.

3. Coexistence and Compatibility: Additionally, the use of the 900 MHz frequency spectrum allows GSM 900A networks to coexist with other services and technologies that utilize nearby frequency bands, as regulatory authorities allocate frequency ranges to prevent interference and spectrum congestion.

4. Capacity and Spectrum Efficiency: In contrast to higher frequency bands, lower frequency bands typically have narrower bandwidth but may offer benefits in terms of penetration and coverage. This can lead to capacity challenges for GSM 900A networks in areas with dense populations and high mobile service demand. To address this issue, network operators deploy additional base stations and employ advanced techniques such as sectorization and frequency reuse to optimize spectrum efficiency.

V. SOFTWARE TOOL

INTRODUCTION TO ARDUINO IDE:

When it comes to creating, compiling, and transferring code to an Arduino device, the software provided by Arduino.cc is known as the IDE, or Integrated Development Environment. This program is open-source and can be easily installed for immediate code compilation.

It works with almost all Arduino modules. In this article, we will guide you through a brief overview of the software, how to install it, and setting it up for your specific Arduino module. Join us as we delve into the details of this software.

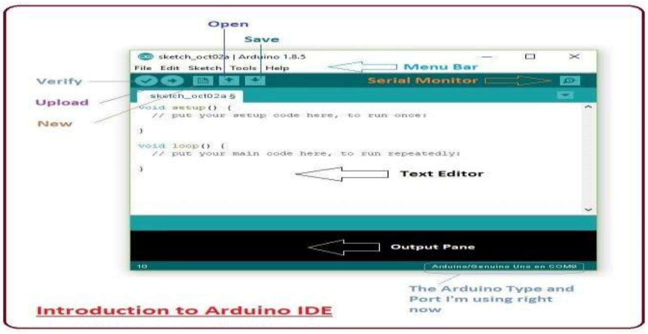

FIG 7. INTRODUCTION TO ARDUINO IDE

- The main purpose of the open-source Arduino IDE software is to write and compile code for the Arduino Module.
- It is an official Arduino program that simplifies code generation, making it accessible even to beginners without technical experience.
- The software runs on the Java Platform, compatible with MAC, Windows, and Linux operating systems, providing essential functions for debugging, editing, and compiling code.
- Various Arduino modules like Uno, Mega, Leonardo, and Micro come with a microcontroller for programming and processing code input.
- The IDE platform creates a main code, known as a sketch, which generates a Hex File uploaded to the board's controller.
- The IDE environment consists of an Editor for writing code and a Compiler for compiling and uploading it to the Arduino Module, supporting languages like C and C++.

VI. WORKING

An all-in-one solution for monitoring vehicle emissions and air quality in real-time involves a vehicle monitoring system that utilizes MQ-6, MQ-7, and MQ-135 gas sensors along with GSM technology. The system typically operates in the following manner:

Sensor Placement: Gas sensors are positioned near the exhaust pipe outlet or within the car's exhaust system. These sensors, such as MQ-135 for various gases like nitrogen dioxide (NO2) and volatile organic compounds (VOCs), MQ-6 for flammable gases, and MQ-7 for carbon monoxide (CO), continuously track the levels of specific gases emitted by the vehicle.

Data Collection and Processing: The sensors identify fluctuations in gas levels and convert them into electrical signals. These signals are then analysed by a microcontroller unit (MCU) or another specialized processing device.

The sensors monitor the levels of specific gases emitted by the vehicle continuously. Data acquisition and processing involve the sensors detecting changes in gas concentrations and converting them into electrical signals. These signals are then processed by a microcontroller unit (MCU) or a specialized processing unit.

Data Transmission via GSM: The processed sensor data is transmitted to a central server or cloud-based platform using GSM technology. The GSM module within the system facilitates wireless communication between the server and the monitoring system via cellular networks. The data transmission can occur in real-time or at scheduled intervals, depending on the system's specifications and settings.

To ensure accurate real-time information transmission, users have the option to insert a SIM card with GSM technology into the system. The frequency of data transmission can be adjusted according to the system's specifications and configuration settings.

On the server side, complex data analysis and visualization tasks are carried out after receiving sensor data. This includes generating real-time updates on air quality, pinpointing pollution hotspots, and analysing trends.

Notifications and alerts are configured to be sent out in case of unusual changes in gas levels or if predetermined thresholds are exceeded. For instance, the monitoring system can send notifications via SMS or email to the fleet manager, car owner, or relevant authorities if carbon monoxide levels go beyond acceptable limits, prompting them to take immediate action. The GSM data, such as text messages, is managed and executed by the code, with sensors being activated and assigned specific threshold values.

Remote Monitoring and Control: Through an easy-to-use web or mobile application interface, stakeholders can monitor air quality and vehicle emissions in real time from a distance. They can remotely adjust system settings like sample frequency and warning levels, as well as access past data and track trends over time.

Data Logging and Analysis: The monitoring system saves sensor data in a centralized database for compliance reporting and historical analysis. Data logging capabilities allow for long-term trend analysis and data-driven decision-making for urban planning and pollution management initiatives.

Maintenance and System Health Monitoring: The system has self-diagnostic features that allow it to monitor its own performance and the status of its sensors. Automated alerts can be configured for maintenance tasks like sensor replacement or calibration, ensuring the accuracy and reliability of the monitoring system going forward. Sensor data is stored in a centralized database by the monitoring system for regulatory compliance reporting and historical analysis. Data logging capabilities support long-term trend analysis and data-driven decision-making for urban planning and pollution management initiatives.

The code is executed to activate sensors and establish a threshold value, with the ability to send text and GSM data. By integrating MQ series gas sensors with GSM technology, the vehicle monitoring system offers a comprehensive approach to tracking vehicle emissions, evaluating air quality, and implementing proactive measures to mitigate pollution's impact on human health and the environment.

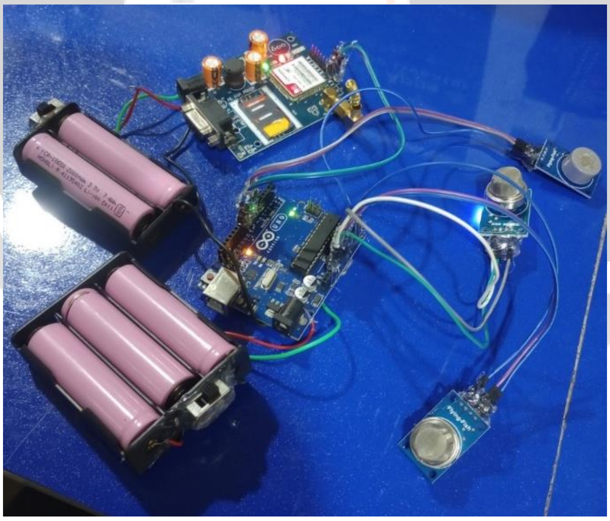

Fig 8: Hardware kit1

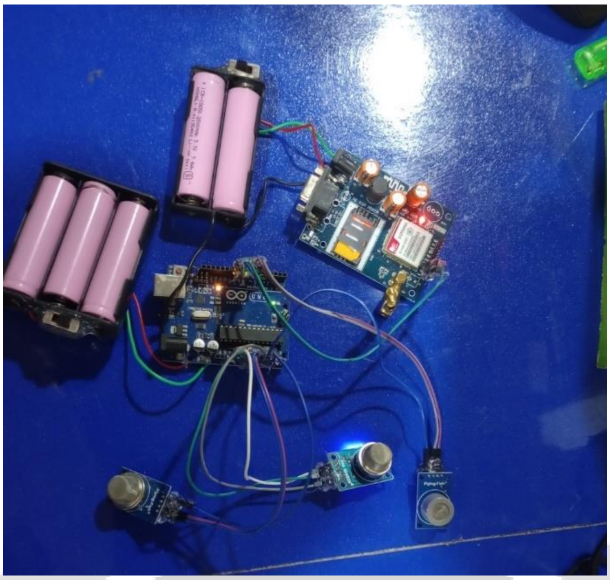

Fig 9: Hardware kit 2

VII. CONCLUSION

In summary, combining GSM technology with MQ-6, MQ-7, and MQ-135 gas sensors presents a reliable and practical option for monitoring vehicle systems. By leveraging the capabilities of these sensors and the communication infrastructure of GSM networks, these systems offer numerous advantages for assessing air quality in real-time and tracking vehicle emissions.

This integrated approach enables the monitoring of specific gases emitted by vehicles regularly, providing valuable insights into pollution levels and trends. By taking proactive measures and making informed decisions, stakeholders can reduce the negative impacts of vehicle emissions on the environment and public health by utilizing this live data.

Moreover, the system's ability to issue alerts and warnings based on preset thresholds or unusual changes in gas concentrations allows for swift interventions and corrective actions. These notifications help mitigate pollution risks and enhance air quality by enabling stakeholders to address potential issues promptly.

Overall, the integration of MQ series gas sensors with GSM technology offers a comprehensive and adaptable solution for vehicle monitoring systems. Using networking and sensor technologies, these solutions contribute to creating a healthier and cleaner environment for both current and future generations.

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