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Precision Gas Leakage Detection System with Integrated Sensors

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Abstract: Gas leaks pose significant safety risks in both residential and industrial settings, making gas leakage detectors essential safety devices for many years. These detectors serve the crucial function of identifying the presence of hazardous gases, such as carbon monoxide, and activating an alarm system to promptly alert occupants of the building. This innovative gas leak detection system leverages mobile technology, integrating phone calls, SMS, WhatsApp, and GPS location services. Additionally, it features a unique capability to shut off the power supply in the affected area, providing a real-time and effective means of gas leak detection and containment. This gas leakage detection system prototype has been successfully developed and tested with gases such as BUTANE and PROPENE. The experimental results demonstrate that the system can detect gas leaks in less than a minute. The primary objective of this gas detection project is to implement a security system for identifying gas leaks in closed environments. It utilizes MQ-2 sensors designed to function effectively within enclosed spaces. Furthermore, this system can be seamlessly integrated with other security and safety systems for enhanced overall protection.

Keywords-Gas Leakage, Integrated Sensors, Precision.

I. INTRODUCTION

Detecting gas leaks early is crucial, whether you are in an industrial facility, a residential area, or a gas-powered vehicle. Failing to do so could result in devastating fires or explosions, posing significant risks to both human life and the environment. Typically, gas leaks are identified through on-site alarms. However, this paper introduces an innovative approach to gas leak detection. We will demonstrate how leakage information can be swiftly transmitted to the first response team via GSM communication, allowing for immediate preventive measures even in the absence of individuals on-site. Additionally, our detection system utilizes a specialized sensor known as the MQ2 SENSOR, which can automatically detect gas leaks and initiate a warning call.

The release of LPG (liquefied petroleum gas) and propane emissions in industrial settings carries significant consequences that are a cause for serious concern [1][3]. Inadequate management and control of these emissions can result in a wide array of severe outcomes, encompassing risks to human health, degradation of air quality, and detrimental effects on the environment. Gas leaks represent a substantial concern for various contexts, including businesses, residences, and vehicles powered by gas. Timely detection of gas leaks can prevent catastrophic fires and explosions, as failure to detect such leaks could lead to explosions and result in extensive damage to both life and the environment.

Unlike the conventional gas leakage detection system which relies on on-site alarms for warnings. However, in this paper, we propose an alternative leakage detection method that takes a more advanced approach. This method involves transmitting leakage information to the first response team using GSM communication, ensuring that preventive actions can be taken promptly, even when there are no individuals present on-site. The detection system utilizes MQ-2 sensors to

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identify gas leaks and automatically triggers a warning call and sends an SMS with the current GPS location through GSM communication.

Traditional methods of detecting gas leaks often rely on manual checks or stationary sensors, which can be time-intensive and may not promptly identify real-time leaks. Consequently, there is a need for a cost-effective and user-friendly approach to swiftly detect gas leaks. As technology has progressed, conventional gas leakage detectors have been substituted by more intelligent systems that can be managed and supervised via mobile devices. By incorporating features such as phone calls, SMS, WhatsApp, and GPS location within gas leakage detectors, the capability for swift alerts and immediate responses in the event of a gas leak has been realized. The precision and efficacy of gas detection systems can be greatly improved using deep learning techniques. Gas has been identified in photos using deep learning techniques such as item detection and semantic segmentation. Deep learning algorithms can be used to analyse infrared and hyperspectral images to find subtle patterns in gas leaks, but they have drawbacks such data requirements, domain adaption, and dependence on high-quality data.

Infrared cameras can detect gas leaks as plumes of gas in real time [1]. Because of the difference in temperature between the gas and the surrounding environment, these plumes are frequently visible in the IR spectrum. As a result of ability to identify and image gases that produce specific infrared radiation, long-wave infrared (LWIR) and mid-wave infrared (MWIR) imaging systems play critical roles in gas leakage detection. The working of infrared imaging [1] is based on the fact that gases absorb and emit infrared radiation at specified wavelengths. This helps in identifying where gas leak occurs, gas molecules are released into the surrounding environment. The unique absorption wavelengths exhibited by each gas enable IR cameras to differentiate between different types of gases effectively. This ability is particularly useful in industrial environments where a wide range of gases is commonly utilized or generated.

Hyperspectral imaging involves capturing and processing information from the electromagnetic spectrum that is typically beyond the human eye's ability to perceive. It is a multi-step process is involving the use of hyperspectral imaging to detect gas leaks. To begin, hyperspectral cameras or sensors capture images of the scene in a variety of narrow and contiguous spectral bands covering a wide range of wavelengths, including those where gases may exhibit distinct absorption or reflection characteristics. Different gases exhibit distinct absorption or reflection patterns in various parts of the electromagnetic spectrum, which are known as spectral signatures. By analysing how specific gases interact with light, these spectral signatures can be used to identify their presence. Gas detection algorithms are used to process the captured hyperspectral data and identify gases with specific spectral signatures. To match the collected data with known spectral signatures of gases, machine learning techniques such as spectral unmixing or classification algorithms can be used. Convolutional Neural Networks (CNNs) and hyper spectral imaging [4] are two distinct technologies that can be used in conjunction for a variety of applications such as object recognition and classification in hyperspectral data.

II. LITERATURE SURVEY

Study	Year	Method/Approach	Techniques Used	Gases Detected	Key Findings/Contributions
enyang Li et al[5]	2022	Sngle-fiber photoacoustic (PA) sensor	A photoacoustic sensor is a device that detects and measures the concentration of gases and particulate matter by utilizing the photoacoustic effect. Thissensor design allows for both interferometric measurements and photoacoustic detection, specifically tailored for detecting trace amounts of methane gas.	Methane	Methane gas detection is achieved through the photoacoustic effect, where the absorbed laser energy generates an acoustic signal.
Bin et al[7]	2023	Gas Detection Fusion Methodology based on concentration of foreground	This method combines the reliability of BGS-based techniques in recognizing static backgrounds and the robustness of DNN-based	LNG	The proposed FFBGD hybrid framework demonstrates substantial enhancements in both accuracy and robustness for detecting LNG leaks

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			approaches in handling complex dynamic environments		
Zhang et al[8]	2023	Transferable Visual Representation Model	By combining transfer learning with deep neural networks, it becomes possible to transfer knowledge, which in turn enhances the efficiency and performance of neural networks, particularly in situations involving limited data.	Gas pipeline defects	Addresses challenges in magnetic flux leakage (MFL) defect detection for oil and gas pipelines, focusing on both defect type identification and the estimation of defect size and shape.

III. METHOD AND MATERIALS

3.1 GAS EMISSION DETECTORS

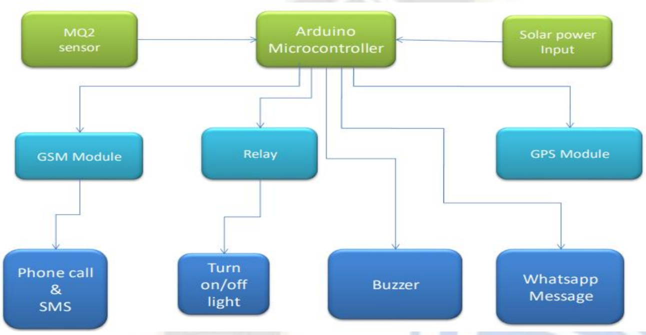

Fig 1. Flow Chart using Light Relay

Gas leaked-> Gas is being sensed by MQ2 sensor in the form of Analog Signal-> The Analog Signal from the MQ2 sensor transmitted into the Arduino Board converts into Digital Signal->Microcontroller embedded in the Arduino Board which is used to store the code this controller takes only digital signal->This code alerts the user through SMS,WHATSAPP MESSAGES and PHONE CALL- >The GPS module is connected beside Arduino Board sends the gas leaked location to Police Station, Fire Service, Ambulance and to the user.

3.2 MQ -2 GAS SENSOR

Fig 2. MQ2 Gas Sensor

The MQ-2 sensor, known for its user-friendliness, popularity, and cost-effectiveness, is utilized in applications such as gas leak detection, air quality monitoring, and industrial safety systems. Operating on the principle of resistance changes in response to specific gases, this sensor utilizes a sensing element composed of metal oxide semiconductor material, which demonstrates varying electrical resistance when it comes into contact with different gases. It finds wide usage in various applications, including household applications for alerting occupants to potential gas hazards like natural gas or propane. In industrial settings, its rapid response time makes it valuable for tasks such as air quality monitoring and the detection of hazardous gases like carbon monoxide and hydrogen.

3.3 ARDUINOATMEGA328 MICROCONTROLLER

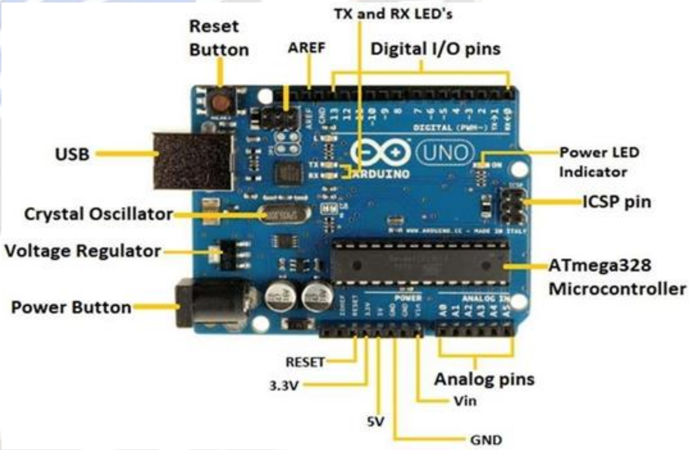

Fig. 3. Arduino UNO

The Arduino Mega 328 microcontroller, based on the ATmega328P, holds a central position in the world of microcontrollers. It boasts 32KB of flash memory, 2KB of SRAM, and 1KB of EEPROM, running at a clock speed of 16MHz. This microcontroller serves as the heart of the Arduino Uno board, offering a multitude of digital and analog I/O pins, facilitating a wide spectrum of applications. Its adaptability is underscored by its compatibility with an extensive range of sensors, actuators, and modules, making it indispensable in projects spanning from robotics and automation to IoT devices and electronic gadgets. Its affordability and user-friendliness have contributed to its popularity among hobbyists, students, and professionals alike. Additionally, the Arduino Mega 328 is

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renowned for its open-source nature, fostering a vibrant community of developers and enthusiasts. With its remarkable capabilities and comprehensive support, it remains a cornerstone in the field of microcontrollers.

3.4 GSM 800L MODULE:

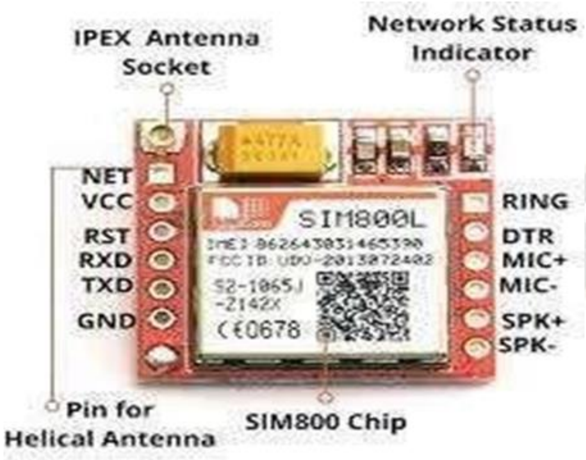

Fig. 4. GSM 800 L Modules

A GSM (Global System for Mobile Communications) module plays a crucial role in contemporary communication technology, serving as a vital link between electronic devices and the cellular network. It enables these devices to transmit and receive data through SMS, calls, and internet connectivity. Typically, the module features a SIM card slot for authentication and a set of AT (Attention) commands for communication with the host microcontroller. It operates across various frequencies, ensuring international compatibility. GSM modules have a wide range of applications, including remote monitoring, tracking systems, IoT devices, and security systems.

3.5 NEO-6M GPS MODULE:

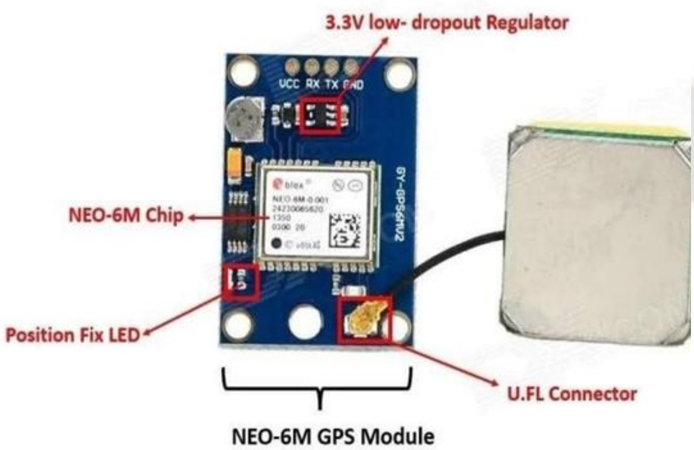

Fig. 5. NEO-6M GPS Module

The NEO-6M GPS module offers a range of key features that make it an attractive choice for various tracking applications. With its high sensitivity, it excels at accurate location tracking. Its low supply current of around 45mA ensures efficient power consumption. The module boasts an impressive tracking capability of up to 5 locations per second with a horizontal accuracy of approximately 2.5 meters. Additionally, the module incorporates Power Saving Mode (PSM), a feature that intelligently manages power consumption by toggling the module on and off as needed. The NEO-6M's remarkably low power consumption of around 11mA makes it an ideal candidate for integration into smartwatches as a GPS tracker.

3.7 LIGHT RELAY:

Fig.6. Light Relay

A light relay is an electronic device designed to manage lighting systems by functioning as a switch that responds to a low-voltage signal, thus enabling the control of high-voltage lighting circuits. This technology is extensively employed in a variety of applications, serving both residential and commercial needs. The primary role of a light relay is to automate the operation of lighting systems based on specific conditions or triggers. For instance, in home automation systems, it can be programmed to activate outdoor lights at dusk and deactivate them at dawn, enhancing security and convenience. In industrial environments, light relays serve purposes such as triggering emergency lighting during power outages or regulating lighting in response to motion sensors.

IV. RESULT

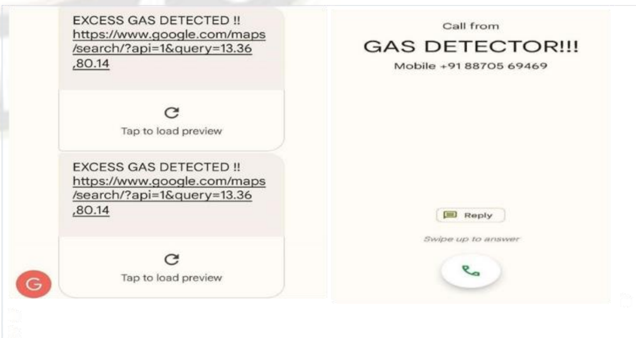

Fig 7.Message Notification along with Location

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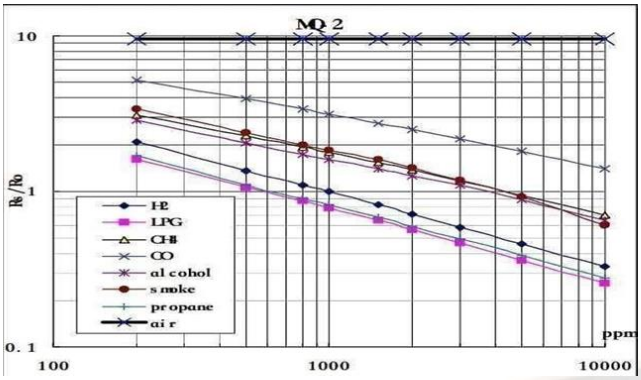

Fig 8. Reporting Gas Levels

As intended, the MQ2 gas sensor performs its function by detecting the presence of gas and promptly relaying this information to the Arduino board. The Arduino then performs its function by efficiently transmitting the signal to the specified software. The sequence of events is seamlessly organized within the software's programming. This orchestration culminates in an audible alert, discernible through the buzzer's resonating sound. The message's information isn't just informative; it's also precise, indicating the exact location where the gas leak was discovered. Simultaneously, a critical command is sent to a relay, effectively cutting the main power connection. This quick intervention is a decisive measure to avert any potential danger. In Figure 7, we observe the dynamic representation of real-time measurements of LPG and other potentially harmful gases as captured directly at the sensor Fig. 8 affirm the system's capacity for precise gas leakage detection, underscored by its ability to furnish dependable and punctual gas concentration reports. This visual representation substantiates the seamless efficacy of our end-to-end sensor-based framework in ensuring both accurate gas detection and the consistent delivery of critical gas concentration information.

V. CONCLUSIONS

The Precision Gas Detection System with integrated sensors plays a crucial role in the detection of gas leakage, and it has been tested successfully in real-time environments to monitor and promptly alert to poisonous gas leaks. Moreover, there is potential for further refinement to enhance the system's performance, ensuring its effectiveness in preventing accidents and mitigating environmental damage arising from gas leaks. The system has consistently demonstrated high accuracy and reliability, allowing for the swift identification of gas presence while remaining cost-effective and featuring user-friendly interfaces. To advance the system, the integration of AI and machine learning algorithms can be explored further to improve its performance. Additionally, conducting extensive field testing and validation in various application scenarios remains pivotal for fine-tuning the system's functionality and ensuring its efficacy in averting accidents and minimizing environmental harm caused by gas leaks.

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