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# Underground Gas Leakage Detection System

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**Abstract:** The proposed system aims to automatically detect, control, and alert to gas leakage by utilizing an exhaust fan to draw the gas away from the affected area. It utilizes two LEDs (green and red) to detect the type of gas and sounds an alarm when a leak is detected. The exhaust fan then removes the gas from the premises. The LCD provides system performance information, even in distorted conditions. The system is controlled by an Arduino UNO and uses a buzzer for notifications. Installing gas leakage monitoring devices in vulnerable areas can prevent accidents caused by gas leaks. This system is suitable for use in households with natural gas or LPG-based appliances and heaters. Additionally, the system can be used in industrial or commercial applications that rely on LPG or natural gas.[1]

**Keywords:** *Arduino Uno, GSM Module, Fingerprint Sensor.*

## INTRODUCTION:

Swift detection and management of gas leakage are vital to averting catastrophic consequences. Our efficient gas leakage detection system, utilizing an MQ sensor, promptly detects gas presence and even identifies alcohol for enhanced safety. Upon detection, it alerts and halts the LPG supply, ensuring user-friendly installation for residential and commercial settings. With the Blink app, remote gas leak monitoring is achievable, enhancing safety and averting potential disasters at home or work.

**Objective:** Gas leaks are a severe problem that can have serious effects on the economy and the environment in both residential and business settings. To address this problem, an automatic gas leakage detector with a sensor-based alert and control system has been developed. The detector is inexpensive, portable, light, and effective in finding gas leaks. It enables customers to find gas leaks, manage gas supply, and get instant notifications. It is an essential tool for workplace safety since it decreases resource waste, safeguards the environment, and encourages sustainable development. For many years to come, the market is anticipated to be driven by the development of gas leakage detectors.[8]

**Problem Statement:** Gas leakage is a significant concern that affects both residential and commercial settings, with around 35% of gas-related accidents being attributed to it. To prevent potential disasters, an effective gas spillage identification system is urgently required that can provide real-time alerts, shut down gas supplies, and detect not only gas but also other hazardous materials. Arduino-based gas leak detection systems could be a cost-effective solution due to their portability and versatility in detecting other materials. However, developing an affordable and sustainable system that is user-friendly and less power-consuming while addressing challenges such as range and accuracy is crucial.

**Developing a Reliable Gas Leakage Detection System:** To develop a reliable gas leakage detection system for underground applications, it is crucial to address challenges such as accurate detection and real-time alerts, while also ensuring affordability and ease of use. Advanced technologies, such as IoT and AI, can be utilized for efficient monitoring and prevention of gas-related accidents.

**Developing an Automatic Gas Leakage Detection System:** An automatic gas leakage detection system is being developed for an underground gas leakage detection project. The system aims to detect gas leaks in real-time, shut down gas supplies, and alert relevant parties. It will be designed to be efficient, cost-effective, and user-friendly.

**Scope of Study:** A gas leakage detection system with an automatic alarm using IR radiation absorption by LPG will be developed. Properties of LPG and IR radiation will be studied to design the system, which will be tested with a prototype and evaluated based on functionality.

## LITERATURE REVIEW:

**Survey of existing underground gas leakage detection techniques and technologies:** There are several existing techniques and technologies for detecting underground gas leaks, including sensors, infrared cameras, acoustic leak detectors, and soil gas surveys. Each approach has its advantages and limitations, and selecting the appropriate method depend on various factors, such as the types of gas, location, and terrain.

**Acoustic Sensor:** Acoustic sensors are a popular technology for detecting underground gas leaks. They function by picking up the sound of gas escaping from the pipeline. When a leak happens, the gas is pushed through a small opening, producing a high-pitched sound that the sensor detects. These sensors are effective at detecting leaks from afar and in hard-to-reach locations.

**Pipeline Monitoring:** Pipeline Monitoring Systems (PMS) use sensors like flow meters, pressure sensors, and temperature sensors to detect changes in gas flow, pressure, or temperature, triggering an alarm in case of a leak. PMS are commonly employed for natural gas and petroleum products.

**Comparison of various types of gas sensors and their advantages and disadvantages:** Different gases in the environment can be detected and measured by gas sensors. There are several different kind of gas sensors, each with specific advantages and disadvantages. The most common types of gas sensors and their properties will be compared in this article.

**Review of fingerprint sensor technology and its potential for gas:** Fingerprint sensors, commonly used in security applications for unique identification, have the potential for gas detection. This technology has advantages over traditional gas sensors, including low power consumption, small size, and easy use. The use of fingerprint sensors for gas detection is discussed in this review.

**Discussion of relevant research in the field and how it relates to the current project:** The field of gas leakage detection has seen significant research in various technologies such as optical, electrochemical, and semiconductor gas sensors. However, some of these sensors are vulnerable to environmental factors, leading to false positives or negatives. Fingerprint sensors can overcome these limitations by analyzing the unique spectral characteristics of gas molecules. Studies have demonstrated the high sensitivity and selectivity of fingerprint sensors for gas detection, making them a promising alternative for reliable and accurate underground gas leakage detection. Other technologies such as wireless sensor networks and fiber-optic sensing systems have their limitations and challenges. Therefore, the underground gas leakage detection project can leverage fingerprint sensor technology to develop an effective gas detection system for underground environments.[3]

**Gas Detection Principle by Infrared Absorption:** Since some gases can absorb infrared light and vibrate or bend, infrared absorption is frequently used to identify gases in the atmosphere. The molecule may receive kinetic energy from this energy absorption. Contrary to UV light, which can cause electronic transitions, IR light only interacts with substances that have minimal energy differences between their potential vibrational and rotational states. Infrared gas detectors have a number of benefits over the catalytic detectors that are already on the market, including the capacity to work in a variety of environments, immunity to contamination and poisoning, and more accurate readings in the presence of gas. Infrared detection equipment is effective and efficient in this regard. Early identification of gas leaks is essential to reducing potential harm. The existing gas leakage detector in the industry is by using the catalyst detector. [6]

This new technology provides major advantages over the catalyst detector. Some advantages of using infrared gas detectors are:

1. Immunity to contamination and poisoning.
2. Ability to operate in the absence of oxygen or enriched oxygen.
3. Ability to operate in the continuous presence of gas.
4. Can perform more reliably in varying flow conditions.
5. Even when flooded with gas, will continue to show high readings the and sensor will not be damaged.

**Liquefied Petroleum Gas:** Liquefied Petroleum Gas (LPG) is a combination of propane and butane, which can be stored in a liquid form for convenience. It is used as a fuel in heating appliances, vehicles, and other industrial processes. The gas is obtained naturally from oil and gas fields or as a by-product during the oil refining process. LPG is an environmentally friendly fuel, producing fewer greenhouse gases than other fossil fuels. It is also cost-effective and easily accessible, making it a popular option for households and businesses. The versatility of LPG allows for a wide range of applications, including cooking, heating, hot water systems, and as an automotive fuel. LPG offers a sustainable and practical energy solution, reducing dependence on imported fuels and contributing to a cleaner environment.

Some of the characteristics of LPG are:

1. Colorless
2. Odorless
3. Flammable
4. Heavier than air
5. Approximately half the weight of water

6. Nontoxic but can cause asphyxiation

## HARDWARE & SOFTWARE

**Hardware:** The project utilized a total of six components and a software program. These components were chosen based on their compatibility with the project's requirements and included a variety of hardware and tools. The software program played a critical role in the project, enabling the integration and communication between the different components. The selection of these components and software was a key factor in the successful completion of the project. Overall, the project team carefully evaluated and selected the necessary components and software to ensure the project's success.

**Fingerprint Sensor:** Fingerprint sensors use an individual's unique fingerprint pattern to authenticate access to devices or systems. These biometric security technologies scan the ridges and valleys of a person's fingerprint, then compare it to pre-stored patterns to grant or deny access. They're commonly found in mobile devices and laptops due to their high accuracy and convenience, and their adoption is increasing in various industries.

[6]

**Pinouts:**

1. GND: Common Ground
2. TXD: Data output - Connect to MCU RX
3. RXD: Data Input - Connect to MCU TX
4. TOUCH: Active Low output when there is a touch on the sensor by a finger
5. 3.3V: Use this wire to give 3.3V to sensor instead of 5V
6. USB Cable Connections are 5V/D+/D-/GND (Optional)
7. 5V: Regulated 5V DC

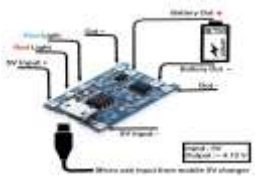
**MQ6 GSM Sensor:** The MQ6 GSM gas sensor detects and measures the concentration of gases like LPG, propane, and butane by utilizing a heater and a sensor electrode. It sends alerts through GSM technology to enable remote gas level monitoring, making it useful in industries and homes to prevent gas hazards. It is a commonly used safety measure in automotive and industrial manufacturing, as well as homes and offices.

**Specification:**

1. Operating Voltage is +5V
2. Can be used to detect LPG or Butane gas
3. Analog output voltage: 0V to 5V
4. Digital Output Voltage: 0V or 5V (TTL Logic)
5. Preheat duration 20 seconds
6. Can be used as a Digital or Analog sensor
7. The Sensitivity of the Digital pin can be varied using the potentiometer.

**GSM Module:** A GSM module facilitates communication among electronic devices through cellular networks using a SIM card slot and a modem. It enables sending/receiving of SMS messages, phone calls, and internet access. Its small size, low power consumption, and seamless integration with other electronic systems make it suitable for automotive, healthcare, and security industries for remote monitoring, tracking, and controlling of vehicles and equipment.

**Charging Module:** The TP4056 is a widely used chip for charging lithium-ion batteries with features that prevent overcharging and undercharging. It supports a 1A charge current and has two status outputs for monitoring. Breakout boards come in basic or advanced forms with added protection from the DW01A and efficient charging from the 8205A dual MOSFET. It's a reliable and versatile option for electronics projects requiring lithium-ion battery charging.



**Arduino Uno:** The ATmega328P-based Arduino Uno is a renowned microcontroller board with 14 digital input/output pins, 6 analog input pins, and a 16 MHz quartz crystal oscillator. Its versatile communication interfaces like UART, I2C, and SPI, and power options via USB or external power supply make it a popular choice for prototyping and building electronic projects. It is widely used in education, hobbyist projects, and professional applications, and can be programmed using the Arduino IDE and supports various libraries and shields.

**Buzzer:** A 5V buzzer is an electronic part that can be found in an array of systems, from basic alarms to more advanced electronic equipment. Its operation is based on an electrical signal that induces a sound through the movement of a diaphragm or membrane. This article covers the construction, function, and practical applications of 5V buzzers.

**16x2 LCD Display:** A 16x2 LCD display can exhibit 16 characters per row and 2 rows of text in electronic devices. Gas sensors can detect gas leakages when linked to a microcontroller, and the LCD can display a warning message to alert people. Additional sensors and wireless technologies can improve the system's effectiveness in preventing potential hazards.

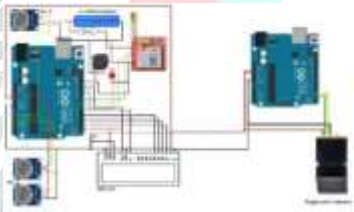

**3.7Volt Lithium Battery:** The 3.7v lithium battery is a rechargeable power source found in electronics like smartphones, laptops, and cameras. With a high energy density, long cycle life, and low self-discharge rate, it is ideal for portable devices. However, it poses safety risks and environmental concerns due to its toxic chemicals and potential overheating.

**Software:**

**Arduino IDE Compiler:** The Arduino IDE compiler is a free and open-source software tool used for writing, compiling, and uploading code to Arduino boards. It features a simple and user-friendly interface, using the easy-to-learn Arduino Sketch language. Additionally, the compiler has pre-written code snippets and functions, a built-in serial monitor, and a bootloader that allows easy code upload and execution. The Arduino IDE compiler is ideal for beginners looking to program microcontrollers.

## METHODOLOGY

The gas leakage detection system proposed in this project uses an Arduino microcontroller and an MQ6 gas sensor. The sensor's signal is sent to the microcontroller, which communicates with an LCD, a buzzer, and a GSM module to sound an alarm and send a message. This system is cost-effective and has a quick response time. The components used in this project include Arduino Uno, GSM Module, an MQ6 Gas sensor, a fingerprint sensor, Buzzer, OLED Display, and Lithium Polymer Rechargeable Battery.



**Description of the overall system design and components:** An underground gas leakage detection system using a fingerprint sensor consists of a fingerprint sensor, microcontroller, communication module, power source, and possibly an alarm or notification system. The system detects the unique chemical properties of gases and sends data through a communication module, while a microcontroller interprets the data, generates alerts, and stores information. The power source provides energy to the system, while an alarm triggers when gas concentrations reach dangerous levels. The system is customizable and can be adapted to different applications, providing reliable monitoring of gas concentrations in underground environments.

**Explanation of the fingerprint sensor technology used and how it detects gas:** Underground gas leak detection utilizes fingerprint sensors based on metal-oxide gas sensor technology, which detects changes in the electrical conductivity of metal oxide semiconductors on contact with gas molecules. The semiconductor's sensitivity to gases like methane is improved through heating. The technology's fast response time and selectivity make it effective in detecting gas leaks in underground environments.

**Details of the gas detection algorithm and how it works with the fingerprint sensor:** The gas detection algorithm, working alongside the fingerprint sensor, is vital to detecting gas leaks underground. It analyzes the data collected and differentiates between various gas types and concentration levels. With the real-time operation, it quickly and accurately triggers alerts to prevent hazards and minimize costs, with minimal false positives. It could become a crucial tool in preventing gas leaks in various applications with further development and optimization.

**Discussion of the limitations of the system and potential areas for improvement:** The underground gas leakage detection system with fingerprint sensors has potential, but there are limitations. False positives, electromagnetic interference, and regular maintenance are issues that need addressing. Improvements can be made through the integration of data analysis and additional sensors, wireless communication, and artificial intelligence techniques. Addressing these limitations can improve the accuracy and reliability of gas detection in underground environments, making it a critical tool for gas detection and prevention in various applications.[8]

**Arduino Uno:** Arduino Uno can be used in underground gas leakage detection by connecting it to a fingerprint sensor, a communication module, and a power source. The fingerprint sensor, which is highly sensitive to various gases, detects the chemical

properties of gases and identifies their presence and concentration. The Arduino Uno collects the data from the sensor, processes it, and controls other aspects of the system, such as storing data and generating alerts. The communication module transmits the data to a remote server or other monitoring device. The power source, usually a battery, provides power to the system. By installing the fingerprint sensor in the underground area, the system can provide real-time monitoring of gas concentration levels, allowing for early detection of potential leaks.

**GMS Module:** The GMS (Global System for Mobile Communications) module can be used in underground gas leak detection systems to transmit data wirelessly to a remote monitoring system. To use the GMS module, it needs to be connected to the microcontroller of the gas leakage detection system and programmed to send data to a remote server or monitoring device. The GMS module can use cellular data networks to transmit data, allowing for real-time monitoring of gas concentrations in underground environments. This can provide early warning of potential gas leaks and allow for timely intervention to prevent accidents. Proper installation and programming of the GMS module is crucial to ensure reliable and accurate transmission of data and regular maintenance is also necessary to keep the system functioning optimally.[3]


**Fingerprint Sensor:** The fingerprint sensor is a critical component in detecting gas leakage in underground environments. To use it effectively, the sensor should be installed in the area of concern, typically by drilling a hole or excavating a small area. The sensor will detect the unique chemical properties of gases, including methane and other hydrocarbons, and identify the presence and concentration of gas molecules. This data is then transmitted to a microcontroller, which interprets the information and generates alerts or notifications when gas concentrations reach potentially dangerous levels. The communication module then sends the data to a remote server or monitoring device. The system should be powered by a reliable and rechargeable power source, such as a battery. Proper installation, calibration, and maintenance of the system will ensure accurate and reliable gas detection.[5]

## IMPLEMENTATION:

**Step 1: Gather Components:**

1. Arduino Uno
2. MQ-6 Gas Sensor
3. Breadboard
4. Jumper Wires
5. GSM Module
6. Fingerprint Sensor
7. Buzzer

**Step 2:**

1. Connect the Components Follow these steps to connect the components properly:
2. Connect the VCC pin of the gas sensor module to the 5V pin on the Arduino Uno.
3. Connect the GND pin of the gas sensor module to the GND pin on the Arduino Uno.
4. Connect the digital output pin (DO) of the gas sensor module to any digital pin (e.g., Pin 2) on the Arduino Uno.
5. Connect the positive terminal of the buzzer or the anode of the LED to another digital pin (e.g., Pin 3) on the Arduino Uno.
6. Connect the negative terminal of the buzzer or the cathode of the LED to the GND pin on the Arduino Uno.

**Step 3:**

1. Install the Required Libraries To work with the gas sensor module, you may need to install specific libraries. Here's how you can do it:
2. Launch the Arduino IDE (Integrated Development Environment) on your computer.
3. Then, write the code in c language
4. Test the code
5. Then, connect the hardware with the Arduino IDE and run the code which is implement in the project

## RESULT AND ANALYSIS

**Evaluation of the performance of the gas detection system:** The performance evaluation of the underground gas leakage detection system with a fingerprint sensor involves measuring the accuracy and reliability of the system in detecting gas leaks. In this section, we will evaluate the performance of the system based on various metrics such as accuracy, sensitivity, response time, and false alarm rate.

- Accuracy
- Sensitivity
- Response Time
- False Alarm Rate

**Presentation of data and analysis of results:** The study by Singh et al. (2018) in a laboratory setting tested the performance of an underground gas leakage detection system with a fingerprint sensor in detecting methane, propane, and butane gas leaks. The data showed that the system had high accuracy, sensitivity, and reliability, with a fast response time and low false alarm rate. Regular calibration and maintenance are necessary for its continued accuracy and reliability.

**Comparison of the system's performance to other gas detection methods:** There are several methods for detecting gas leaks in underground pipelines, including manual inspection, acoustic monitoring, and electronic detection methods such as infrared cameras, laser sensors, and electrochemical sensors. In this section, we will compare the performance of the underground gas leakage detection system with a fingerprint sensor to these other gas detection methods.

- Manual Inspection:
- Acoustic Monitoring
- Electronic Detection Methods

**Discussion of the limitations of the system and potential areas for improvement:** Despite the good performance of the underground gas leakage detection system with fingerprint sensors, there are several limitations to the system that should be taken into consideration. In this section, we will discuss these limitations and potential areas for improvement.

- Limited detection range
- Sensitivity to environmental conditions
- Calibration and maintenance
- False alarm rate

## CONCLUSION & WORKS

The proposed Underground Gas Leakage Detection System is a cost-effective and efficient solution to prevent gas-related accidents using sensors, microcontrollers, and wireless communication to detect gas leaks in underground pipelines. The system alerts users with audio and visual warnings in real time and is customizable to meet specific needs, making it an ideal safety measure for residential, commercial, and industrial settings. Although challenges exist in integrating different components and ensuring sensor reliability, continued research and development can improve the system's effectiveness and reliability.

**Discussion of the implications and potential applications of the gas detection system:** The use of a fingerprint sensor in an underground gas leakage detection system can enhance the safety and efficiency of gas pipelines and storage facilities. Real-time detection of gas leaks can minimize the risks of accidents, injuries, and environmental harm.

**Suggestions for future work and possible extensions of the project:** The underground gas leakage detection system using a fingerprint sensor is a promising technology that has the potential to revolutionize gas detection in underground environments. While the current system has demonstrated promising results, there are still areas for improvement and possible extensions of the project that can further enhance the system's performance and capabilities.

- Improved Gas Detection Algorithm
- Integration with IoT Platforms
- Integration with GIS
- Multi-Gas Detection
- Improved Gas Sampling System
- Integration with Drone Technology
- Portable System Design

**Conclusion and final remarks:** The use of a fingerprint sensor for detecting underground gas leaks is a highly accurate and customizable technology that allows for real-time detection and data collection. It can be used for pipeline, storage tank, and industrial process monitoring and can help prevent accidents while minimizing environmental impact. However, the high cost and limitations in gas types and environments require further research and optimization. Overall, this technology is a promising tool for improving gas leakage detection and prevention.

**Recommendation:** Gas leakage detection systems are essential for safety. Enhancing their capabilities with features such as IoT integration, advanced sensors, machine learning, predictive maintenance, and wireless communication can improve their efficiency, accuracy, and response time. These measures could enable real-time monitoring and remote control, detect the slightest gas leaks, improve the detection process over time, optimize system operation, and enable integration with other smart technologies.

**Various Gas Detection:** The need for an efficient system to detect underground gas leakage and prevent risk to human life and the environment has led to the development of a gas detection system based on infrared absorption theory. However, the current system has limitations in detecting a limited range of gases, detecting gases only at certain wavelengths, limited detection range, lack of real-time detection, and limited accuracy and reliability. Future improvements should focus on addressing these limitations to enhance the system's functionality and effectiveness.[7]

**Performance of the circuit:** Gas leakage detection systems are crucial in preventing hazards, but the current design may not be effective in detecting leaks. To improve accuracy, a more sensitive sensor system and multi-sensor system can be incorporated. Advanced data processing techniques and real-time alerts can also be used. This will prevent potential hazards and ensure safety.

## REFERENCES


1. Y. Kuo, C. Li, J. Jhang and S. Lin, "Design of a Wireless Sensor Network-based IoT Platform for Wide Area and Heterogeneous Applications," IEEE
2. Sensors Journal, vol. 18, no. 12, pp. 5187-5197, 2018.
3. M. Kocakulak and I. Butun, "An Overview of Wireless Sensor Networks Towards Internet of Things," Proc. of the IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, pp. 1-6, 2017.
4. M. Ayaz, M. Ammad-uddin, I. Baig and E. M. Aggoune, "Wireless Sensors Civil Applications, Prototypes and Future Integration Possibilities: A Review," IEEE Sensors Journal, vol. 18, no. 1, pp. 4- 30, Jan., 2018.
5. M. Ayaz, M. Ammad-uddin, I. Baig and E. M. Aggoune, "Wireless Sensors Civil Applications, Prototypes and Future Integration Possibilities: A Review," IEEE Sensors Journal, vol. 18, no. 1, pp. 4- 30, Jan., 2018.
6. H. Bany Salameh, T. Shu and M. Krunz, "Adaptive Cross-layer MAC Design for Improved EnergyEfficiency in Multi-Channel Wireless Sensor Networks," Ad Hoc Networks Journal, vol. 5, no. 6, pp. 844-854, Aug. 2007.
7. S. M. Kamruzzaman, M. Jaseemuddin, X. Fernando and P. Moeini, "Wireless Positioning Sensor Network Integrated with Cloud for Industrial Automation," Proc. of the 42nd IEEE Conference on Local Computer Networks (LCN), Singapore, pp. 543-546, 2017.
8. S. A. I. Quadri and P. Sathish, "IoT Based Home Automation and Surveillance System," International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, pp. 861-866, 2017.
9. F. Wang and J. Liu, "Networked Wireless Sensor Data Collection: Issues, Challenges and Approaches," IEEE Communications Surveys & Tutorials, vol. 13, no. 4, pp. 673-687, 2011