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Intelligent Gas Leak Detection and Alarm System

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Abstract: - ***Gas leakage poses a significant risk in industrial facilities, residential areas, and gas-powered vehicles. One effective preventive measure against accidents caused by gas leaks is the installation of gas leakage detection systems. This work focuses on proposing a device capable of detecting gas leaks and alerting owners promptly to prevent potential hazards. The system utilizes a microcontroller integrated with a gas sensor, GSM module, LCD display, and buzzer. It is designed to monitor gas leakage and send alerts via SMS using an Arduino microcontroller in combination with an MQ2 gas sensor and buzzer. The setup includes a microcontroller, MQ2 gas sensor, buzzer, LCD screen, and GSM module. When the sensor detects a gas leak, it sends the data to the microcontroller, which processes the information and immediately dispatches a warning message through SMS to the user's mobile phone, enabling timely action. The outcome of this research is expected to play a crucial role in preventing issues related to gas leaks both now and in the future.***

Index Terms—Gas Leakage Detection, GSM Module, Gas Leak Detector, Gas Sensor, Arduino.

Index Terms — Gas Leak Detection, GSM Communication Module, Gas Leakage Monitoring Device, Gas Sensors.

I. INTRODUCTION

Gas leakage represents a critical challenge across the industrial sector, residential areas, and gas-powered vehicles such as CNG (Compressed Natural Gas) buses and cars, where gas serves as a vital energy source (STET, 2012). Incidents involving Liquefied Petroleum Gas (LPG) leakages have been devastating, often leading to significant loss of lives and damage to property valued at millions of dollars globally. Nigeria, in particular, has witnessed several catastrophic pipeline explosions resulting in numerous casualties and severe property destruction [1].

Given that gas is the primary fuel source for many homes and industries in Nigeria, it is imperative to implement strategic safety measures to guard against accidents like suffocation and explosions. LPG, a highly flammable blend of butane (C_4H_{10}) and propane (C_3H_8) along with small amounts of other hydrocarbons like butylene and propylene, is naturally odorless. Therefore, ethyl mercaptan is added to provide a detectable smell as a precaution [2]. However, in cases of minimal leakage, individuals with reduced olfactory sensitivity may fail to detect it, necessitating the use of reliable and effective gas detection devices in homes, industries, and vehicles to prevent explosions.

Gas leaks can result from various factors, including faulty piping, improperly attached hoses, loose valves, or audible hissing sounds around cylinders. Although existing LPG

detectors typically sound alarms when leakage is detected, advancements can enhance these systems further. Incorporating a microcontroller allows for automatic alarm activation and SMS notifications to responsible personnel, improving response time.

The core objective of this paper is to design a device capable of detecting LPG leaks, triggering an immediate alarm, and sending an SMS to designated contacts, thereby preventing gas wastage, explosions, and associated disasters [3]. Specifically, the project aims to develop a system based on the Arduino Uno microcontroller, with an integrated alarm system to alert nearby individuals and a GSM-based SMS notification system to inform property owners or safety organizations for quick intervention.

Objectives of the Proposed System:

To prevent the loss of lives and properties during gas leakage incidents.

To facilitate prompt action by property owners and safety organizations in response to gas leaks.

To empower individuals near leakage sites to take necessary precautions and mitigate damages.

2. Literature Review

This section provides a review of existing studies on gas leakage detection.

2.1 Liquid Petroleum Gas (LPG) Detection

LPG is a flammable hydrocarbon gas mixture used in heating, cooking, and as an automotive fuel (often referred to as autogas). Since LPG is naturally odorless, ethyl mercaptan is added to make leaks easily detectable. Produced through petroleum refining or natural gas processing, LPG's explosive potential under pressure classifies it as hazardous. Earlier detection methods involved chemically treated papers that changed color upon gas exposure. The evolution of electronic gas detectors marked a major leap in ensuring human and property safety. Various approaches such as optical sensing, cable sensors, negative pressure detection, vapor sampling,

signal processing, mass-volume analysis, and pressure point analysis have been adopted for gas leakage detection [4].

2.2 Classification of Leakage Detection Methods

Leakage detection techniques are generally categorized into:

Automated Detection: Systems autonomously detect and respond to leaks without human intervention, often integrated with control panels like SCADA.

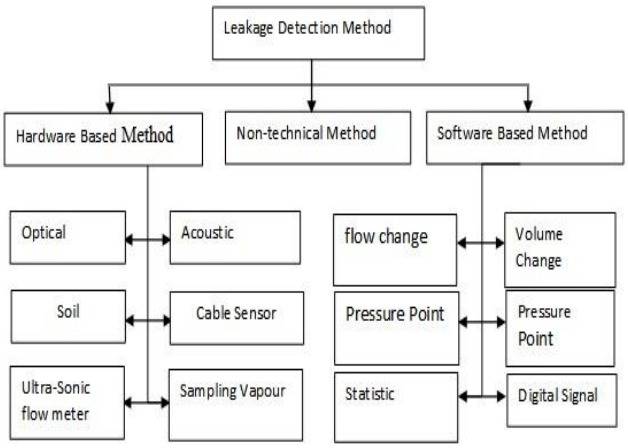
Manual Detection: Human-operated methods, utilizing tools like thermal imagers or LIDAR.

Semi-Automated Detection: Systems requiring some human interaction, such as using digital signal processing for leak identification (Batzias et al., 2011).

Detection technologies are further classified into:

Direct Methods: Involving manual patrols using handheld devices or aerial optical imaging for pipeline inspections.

Indirect Methods: Analyzing pressure, flow, or volume changes to infer leakages [5,6].



(Figure 1: Gas Leakage Detection Methods Based on Technical Nature)

2.3 FPGA-GSM Based Gas Leakage Detection

[7] developed an FPGA-based gas detection system using an MQ6 sensor to detect LPG leaks. Upon detection, an automatic warning call is sent to the first responders through GSM. However, the system lacks remote monitoring and automatic gas shut-off mechanisms.

2.4 Embedded Real-Time Systems for Gas Leakage Detection

An embedded real-time system for household applications was proposed, where multiple sensor nodes communicate with a central node. Upon detecting a leak, an alarm sounds, and notifications are sent to designated personnel through MAC-addressed RF modules. While the system mitigates risk by activating exhaust fans, it does not fully prevent disasters [8,9].

2.5 Wireless Modularization of Gas Safety Devices

A wireless smart home gas safety system was developed based on Micom meters with integrated microcontrollers and cutoff valves. While the system integrates fire detection and extinguishing modules, it depends heavily on existing infrastructure, limiting standalone deployment [10]. Another study [11] emphasized the use of Wireless Sensor Networks (WSNs) for detecting leaks in petrochemical industries and the importance of centralized data collection to locate leaks precisely.

2.6 Automatic Safety Gas Stove and LPG Booking Monitoring

An automatic gas stove safety system was created using infrared (IR) sensors to detect utensil presence. If absent, the system turns off the gas supply using motorized knobs. However, this system does not detect leaks in supply pipes, limiting its effectiveness [12]. Additionally, a microcontroller-GSM based LPG booking and monitoring system was introduced where gas levels are monitored using weight sensors, leak detection through MQ series sensors, and automatic cylinder booking is enabled. Solenoid valves and exhaust fans enhance its safety response [13].

3. METHODOLOGY, MATERIALS, AND DESIGN

The proposed system utilizes an Arduino Uno microcontroller integrated with an MQ2 gas sensor to detect the presence of gas leaks. The sensor's signal is processed by the microcontroller, which simultaneously triggers an alarm via a buzzer, displays a warning on an LCD screen, and sends an SMS alert through a GSM module. This GSM module (SIM800) connects directly to the mobile network without relying on internet connectivity or Wi-Fi, making it more reliable and accessible compared to IoT-based detection methods, particularly in low-income settings where internet infrastructure may be poor or costly.

The hardware components used in this project include:

- **Arduino Uno Microcontroller**
- **GSM Module (SIM800)**
- **MQ2 Gas Sensor**
- **Buzzer**
- **Power Module**
- **Stripped Vero Board**
- **Female and Male Pin Headers**
- **OLED Display**
- **3D Printed Casing**
- **Power Switch**
- **LEDs and Connectors**

- **Lithium-Polymer Rechargeable Battery**

The overall design of the proposed system is depicted in the block diagram (Fig. 2). \

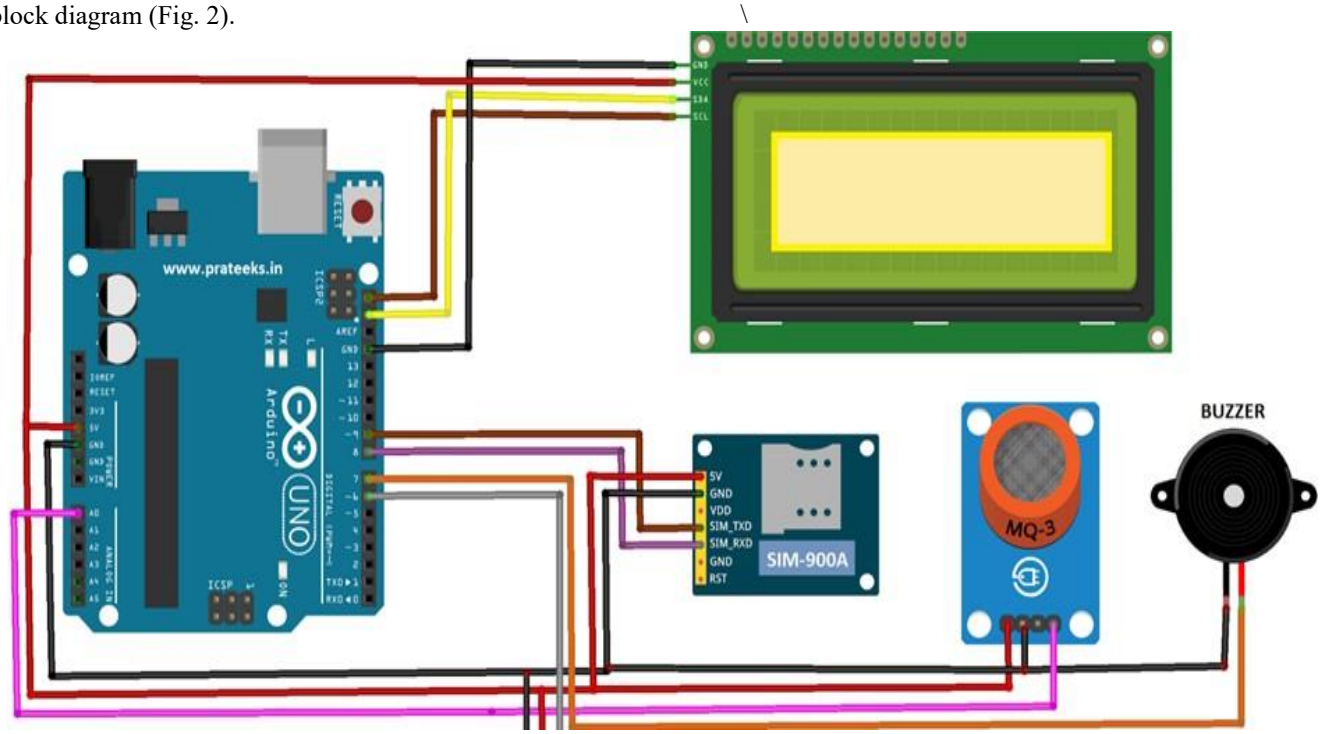


Fig. 2. Block diagram of the proposed system

The operational workflow of the system is further illustrated through a flowchart (Fig. 3).

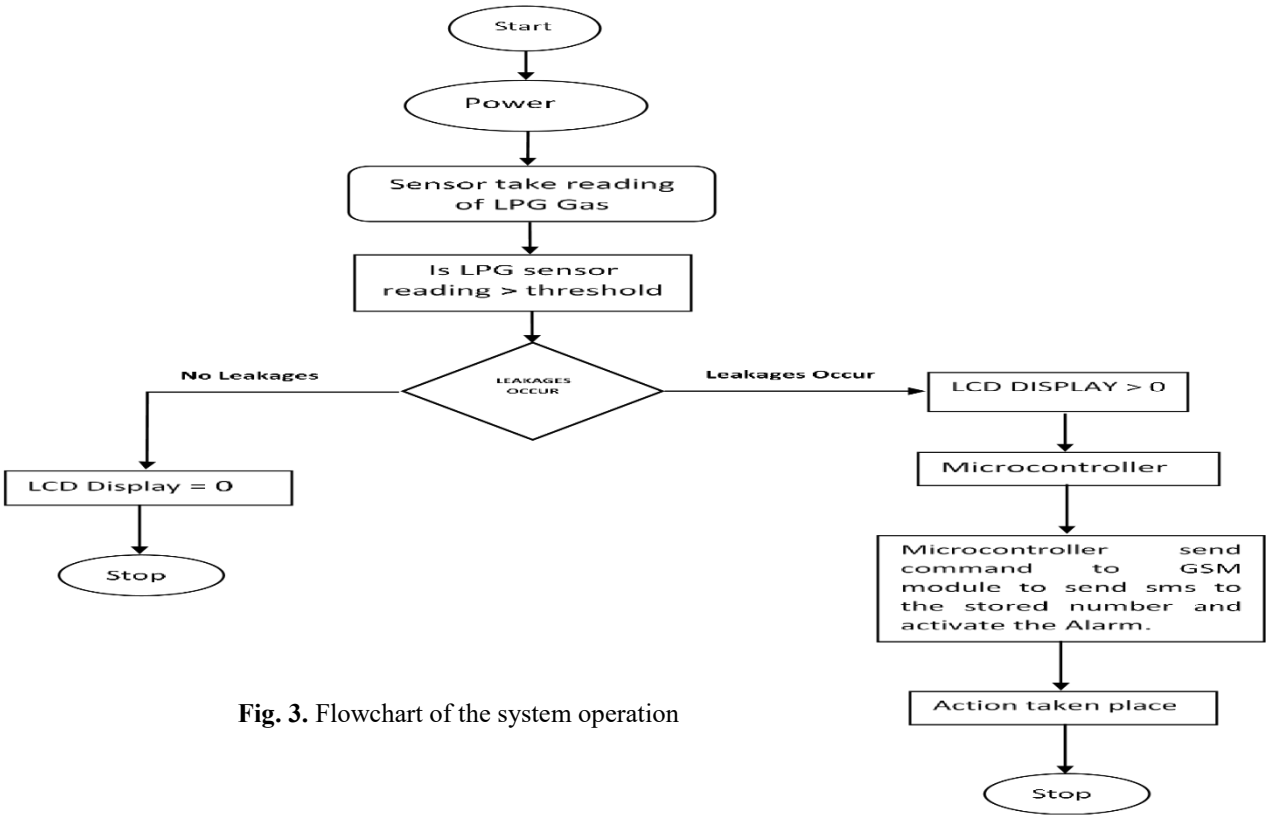


Fig. 3. Flowchart of the system operation

4. IMPLEMENTATION

4.1 Construction

Stage 1: Circuit Construction

The hardware assembly began with soldering all components onto a stripped Vero board. Proper connections were established and verified before proceeding to the next stage, as shown below.

Fig. 4. Circuit built on the Vero board

Stage 2: Computer-Aided Design (CAD)

The casing for the device was designed using *Fusion 360*, a CAD software known for its user-friendliness and free access for personal projects. Once the enclosure was modeled, it was sliced using *CURA* software to prepare the model for 3D printing.

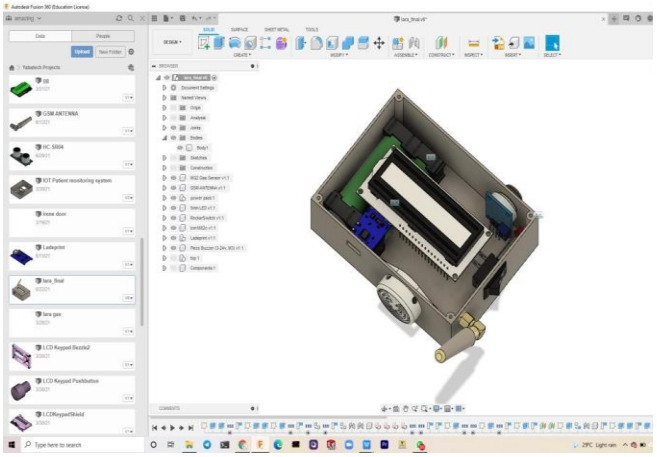


Fig. 5. Design of the casing on Fusion 360

Fig. 6. Final rendered design

Stage 3: Assembly

After 3D printing, all electronic components were carefully assembled into the custom-made casing, ensuring proper fit and protection.

Fig. 7. Installation of components into the casing

Fig. 8. Assembled prototype of the proposed system

5. CONCLUSION

This research presents the design and implementation of a gas leakage detection system. A review of various existing gas leakage detection systems was conducted,

revealing that many prior works did not adequately consider cost-effectiveness or the ease of modifying systems for individual or domestic use.

This study contributes to advancing knowledge in the field by developing an embedded system that alerts users through both an audible buzzer and SMS notifications sent to multiple mobile phones. This ensures timely awareness and response when a gas leak is detected. The device uses a highly sensitive MQ-2 gas sensor to identify the presence of gas, activates a buzzer to alert nearby individuals, and utilizes a SIM800 GSM module to send a "Gas Leakage Detected" message as a backup alert to authorities or facility owners.

Due to its low cost, high effectiveness, and reliability without the need for internet access, this system has strong potential for real-world application. It could be adopted, funded, and implemented to significantly reduce accidents and hazards associated with LPG gas leakage in both residential and commercial settings.

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