Detection Of Household Gas Leak And Alerting the User a.k.a. Leak Pro

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***Abstract*—Household gas leaks pose significant safety hazards, with existing technologies primarily focusing on alerting users but lacking immediate preventive action. Our project, Leak Pro, aims to detect gas leaks and automatically cut off the gas supply, minimizing human intervention during emergency situations. The prototype integrates a 2G GSM module for SMS alerts, an MQ-2 gas sensor for leak detection, and an Arduino Uno as the control hub. A servo motor is used to automatically shut off the gas source when a leak is detected. Due to limited 5V pins on the Arduino, the servo motor requires an external power source. For testing, a butane/propane lighter was used as a gas source in place of LPG. A key challenge was maintaining GSM connectivity, as 2G networks are limited, causing frequent connectivity disruptions. This hardware-based solution ensures both notification and automatic response, enhancing safety and reducing risks associated with household gas leaks. As we work towards refining our prototype, we aim to achieve zero gas leak incidents by offering a comprehensive and reliable solution, especially in regions like India where such leaks are common. Although safety concerns have slowed our prototype development, *Leak Pro* presents a significant step forward in gas leak prevention technology, with future plans to scale and implement in real-world applications.**

I. Introduction

The widespread use of gas in households for purposes such as cooking and heating introduces an increasing safety risk due to potential leaks. Gas leaks can lead to fires, explosions, and toxic exposure, posing serious health hazards and even life-threatening situations if not addressed promptly. While existing gas detection systems are capable of alerting users to potential leaks, they lack automated preventive actions, relying solely on users to intervene. This delay in response can result in severe incidents, particularly when users are unable to respond quickly or are unaware of the leak due to absence from home.

Leak Pro aims to bridge this gap by integrating both leak detection and automated prevention into a single, cohesive system. By combining real-time alerts with an automatic shut-off mechanism, Leak Pro provides a proactive solution to household gas safety. The system utilizes an Arduino-controlled servo motor to immediately close off the gas supply when a leak is detected, while a GSM module simultaneously sends an SMS notification to alert users, ensuring they remain informed even if they are not present. This dual-layered approach enhances the effectiveness of gas leak response, reducing dependency on human intervention and minimizing risks associated with leaks.

This paper details the design and development of the Leak Pro prototype, with a focus on its hardware components, system architecture, and built-in safety mechanisms to address household gas leak risks. By offering both notification and automatic shut-off capabilities, Leak Pro demonstrates a comprehensive solution for enhancing household safety and reducing the likelihood of gas-related incidents. [2][3].

II. System Overview

A. Objectives

The primary objective of the Leak Pro project is to create an automatic gas leak detection system that minimizes risks by shutting off the gas supply immediately upon detection. Additionally, it aims to provide real-time SMS notifications to users, ensuring they remain informed and can take action if necessary. This project also seeks to enhance safety protocols in households and develop a functional prototype for practical implementation.

B. Key Features

Leak Pro is a comprehensive solution designed to enhance household safety by addressing the risks associated with gas leaks. Unlike traditional systems that only notify users, Leak Pro offers automated preventive action. When a leak is detected, the system immediately shuts off the gas valve using an Arduino-controlled servo motor, cutting off the gas supply. At the same time, a GSM module sends an SMS alert to the user, and a buzzer sounds continuously until reset via SMS, providing clear, persistent warnings. With integrated detection, notification, and remote reset capabilities, Leak Pro offers a user-friendly and effective approach to minimizing household gas leak risks, combining convenience with critical safety.

III. HARDWARE COMPONENTS

The Leak Pro system comprises several essential hardware components that work together to detect gas leaks and initiate preventive actions. Each component plays a vital role in ensuring the system's reliability and effectiveness.

a. GSM Module: The GSM Module(SIM900A) serves as the interface of the system, enabling real-time notifications to users via SMS. It operates using a sim card (2G/3G/4G), allowing the system to send alerts when a gas leak is detected, thereby keeping users informed even when they are not present at home.

b. Arduino Uno: The Arduino Uno acts as the central control unit of the *Leak Pro* system. It processes inputs from the gas sensor, controls the GSM module for alert notification, and operates the servo motor that shuts off the gas supply. Its flexibility and ease of programming make it an ideal choice for prototyping.

c. Servo Motor: The servo motor is responsible for closing the gas valve when a leak is detected. Controlled by the Arduino, the motor provides precise movement, ensuring that the valve is securely shut to prevent any further gas flow.

d. Gas Sensor: The MQ2 gas sensor module is crucial for detecting the gas in the environment. It continuously monitors gas levels and sends signals to the Arduino Uno when concentrations exceed safe thresholds, triggering the alert and shut-off mechanisms [4].

e. Jumper Cables and Breadboard: Jumper cables and a breadboard are used for prototyping and connecting the various components without soldering. This setup allows for easy adjustments and modifications during the development phase.

f. Gas Source (for testing): A controlled gas source, such as a lighter, is used during prototype testing to simulate gas leak conditions. This component is critical for validating the system's effectiveness and response capabilities.

These hardware components collectively enable the *Leak Pro* system to function efficiently, ensuring timely detection and response to household gas leaks while prioritizing user safety.

IV. SYSTEM ARCHITECTURE

The architecture of the *Leak Pro* system can be visualized as a modular design that integrates various hardware components to achieve efficient gas leak detection and prevention. Below is a high-level overview of the system architecture:

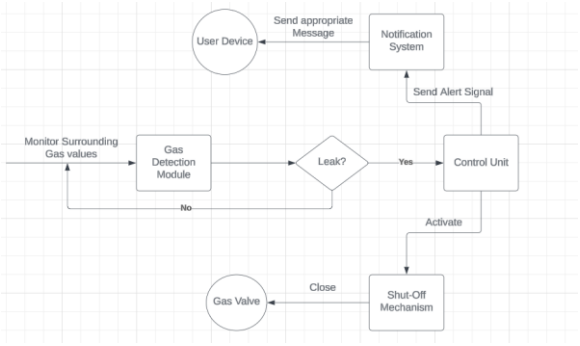
a. **Gas Detection Module**: Continuously monitors the surrounding environment for the presence of gas. When gas levels exceed a predefined threshold, it sends a signal to the Arduino Uno for further processing.

b. **Control Unit**: Arduino Uno acts as the central processing unit that receives input from the gas sensor. It executes the logic for detecting gas leaks, controlling the GSM module, and activating the servo motor.

- Input from Gas Sensor: If a gas leak is detected, the Arduino triggers the appropriate response.
- Control Commands to Servo Motor: Commands the servo motor to close the gas valve when a leak is detected.

c. **Notification System:** Upon receiving a signal from the Arduino that a gas leak has been detected, the GSM module sends an SMS alert to the user's mobile phone. This ensures the user is informed in real-time, even if they are not present at home.

d. **Shut-off Mechanism:** Once the gas leak is detected, the Arduino activates the servo motor, which then mechanically closes the gas valve, preventing further gas flow and enhancing safety.



Data Flow:

Step 1: The gas sensor continuously monitors gas levels.

Step 2: If gas is detected, the sensor sends a signal to the Arduino Uno.

Step 3: The Arduino processes the signal, activates the servo motor to close the gas valve, and sends an alert via the GSM module.

Step 4; The GSM module sends an SMS notification to the user.

Visual representation:

Gas Sensor (Input) → Arduino Uno (Control unit) → GSM Module (Notification) → Servo Motor (Shutoff Mechanism)

Power Supply connects to all components, indicating that they share a common power source.

This architecture illustrates how each component interacts within the system to ensure timely detection and response to gas leaks, highlighting the integrated approach of the *Leak Pro* project.

V. SOFTWARE IMPLEMENTATION

1. Detection Algorithm for Gas Leakage

- Initialization: At the start of the program, the necessary libraries for the GSM module and the gas sensor are included. The serial communication is initialized for debugging purposes.

- Sensor Reading: The gas sensor's analog output is read continuously in a loop. The analog value is compared to a predefined threshold that indicates a gas leak.
- Threshold Comparison
  a. If the sensor reading exceeds the threshold:
     - A flag is set to indicate a gas leak has been detected.
     - The system proceeds to trigger the GSM alert and activate the servo motor.
  b. If the reading is below the threshold:
     - The system remains in a monitoring state, waiting for the next reading.
- GSM Alert Triggering: The GSM module is activated using the appropriate commands. The Arduino sends a formatted SMS alert to the predefined phone number, notifying the user of the detected gas leak.
- Servo Motor Operation: After sending the alert, the Arduino sends a signal to the servo motor to close the gas valve. This is achieved by specifying the angle position that corresponds to the closed valve (typically 0 degrees). A delay is included to ensure the servo has enough time to complete the action before the system resumes monitoring.

Sample Code Snippet:

```
#include <Servo.h>
#include <SoftwareSerial.h>

Servo s1;
int ledPin = 4;
int initLed = 10;
SoftwareSerial SIM900A(2, 3);
int isSent = 0;
int resetReceived = 0;

void setup() {
  SIM900A.begin(9600);
  Serial.begin(9600);
  s1.attach(9);
  pinMode(ledPin, OUTPUT);
  pinMode(initLed, OUTPUT);
  SIM900A.println("AT+CNMI=2,2,0,0,0");
  delay(1000);
}

void SendMessage() {
  Serial.println("Sending Message please wait....");
  SIM900A.println("AT+CMGF=1");
  delay(1000);
  SIM900A.println("AT+CMGS=\"+919177082210\"\r");
  delay(1000);
  SIM900A.println("CRITICAL ALERT! Gas leak detected!");
  delay(100);
  SIM900A.println((char)26);
  Serial.println("Message sent successfully");
}
```

The above snippet is a very simplified version of our Arduino code demonstrating and highlighting the key functionalities of our system.

VI. Prototype Development

Assembly of the Components:

a. Component Integration: The Arduino Uno, GSM module, and gas sensor have been successfully merged on a breadboard using jumper cables. This setup allows for easy connectivity and testing of the individual components. The Arduino serves as the central control unit, processing signals from the gas sensor and controlling the GSM module for alert notifications [6].

b. Gas Source Construction: To simulate real-world conditions for testing the system, a controlled gas source is being developed. This will likely involve a simple setup using a lighter or similar gas-producing device, allowing us to generate gas leaks safely during testing.

c. The servo motor is connected externally to another USB A port due to lack of availability of 5V pin on the Arduino board. The external power socket provides the right amount of power to the servo motor so that it can perform its actions correctly. [7].

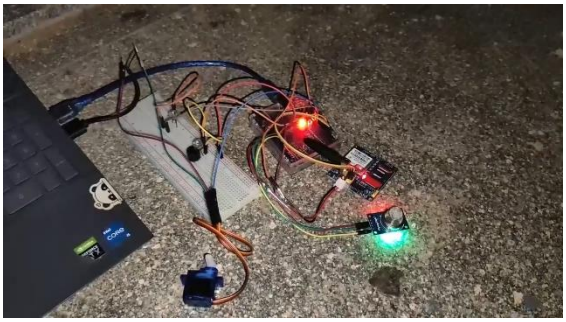


Figure 1. Working Prototype

Prototype Hazards:

a. The combination of electrical components and flammable gases creates a significant fire hazard.
b. Using a gas source, such as a lighter or any combustible gas, poses a risk of exposure to harmful gases.
c. Conducting tests without proper safety measures or emergency procedures can lead to dangerous situations.
d. As a prototype, the *Leak Pro* system may not have the durability and reliability of a commercial product. Further testing and development are necessary before deployment in real-world environments.

VII. Results

The Leak Pro prototype successfully demonstrated the ability to detect gas leaks, alert users via SMS, and initiate an automatic shut-off of the gas source. Testing was conducted under controlled conditions using a butane/propane lighter to simulate gas leak scenarios. Below are the key findings from the tests:

a. Gas Detection Accuracy:

The MQ-2 gas sensor accurately detected gas presence, with typical readings ranging from 120-50 in a normal environment and increasing significantly when gas from the lighter was introduced. The sensor responded quickly to elevated gas levels, enabling prompt leak detection.

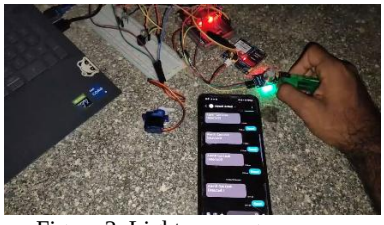


Figure 2. Lighter as a gas source

b. SMS Alert notification:
The GSM module, connected to a 2G network, was able to send SMS alerts to the user's phone. However, due to limited 2G network availability, connectivity issues were encountered, resulting in occasional delays or failures in message transmission.

Figure 3. Successful SMS notification

c. Automated Shut-Off Mechanism:
Upon detecting a gas leak, the system activated the servo motor, which successfully simulated closing the gas valve. This automatic shut-off mechanism demonstrated the system's ability to intervene and prevent further leakage without human input.

d. Safety:
Using a butane/propane lighter as a gas source enabled safe testing without involving LPG, confirming the system's effectiveness in a practical, controlled environment.

VIII. LIMITATIONS

a. **GSM Connectivity Issues**: The GSM module relies on mobile network coverage to send SMS alerts. In areas with poor network coverage or during network outages, notifications may not be sent, leaving users uninformed about potential leaks.

b. **Dependence on Sensor Accuracy**: The effectiveness of the *Leak Pro* system is heavily reliant on the accuracy and sensitivity of the gas sensor. If the sensor is not calibrated correctly or fails to detect certain gas types, it may lead to undetected leaks or false alarms.

c. **Single point of failure:** If any single component, such as the gas sensor, Arduino, or GSM module, fails, the entire system's functionality may be compromised. Redundancy measures may need to be implemented for critical applications.

d. **Limited Range of Detection:** The gas sensor may have a limited range for detecting gas concentrations. High concentrations may be detectable, but low concentrations may go unnoticed, potentially posing safety risks in certain scenarios.

CONCLUSION

The Leak Pro system offers a significant advancement in household gas safety by integrating both detection and automated prevention mechanisms. Traditional gas leak detectors are limited by their reliance on user intervention, which may delay responses in emergencies. In contrast, Leak Pro's automated shutoff capability addresses this critical gap, ensuring that gas leaks are detected and managed immediately, thereby reducing the risk of accidents and enhancing user safety. The system's proactive approach, combining real-time SMS alerts with an automatic shutoff mechanism, demonstrates its practicality for everyday use and showcases its potential as a reliable household safety solution.

Through the development and testing of the Leak Pro prototype, the project highlighted the effective collaboration of core components, including the Arduino Uno, GSM module, MQ-2 gas sensor, and servo motor. Each element played a vital role in achieving the desired functionality, from leak detection to real-time notifications and shutoff activation. Despite challenges such as the limited availability of 2G networks for the GSM module and the need for external power for the servo motor, the prototype successfully demonstrated its intended capabilities in a controlled testing environment. These constraints also provided insights into areas for future improvement, particularly around network compatibility and power management.

Looking forward, refining the Leak Pro system will focus on addressing the existing limitations and expanding its applicability in real-world settings. Enhancements such as upgrading to a 4G-compatible GSM module, exploring alternative power solutions, and calibrating sensor sensitivity can help improve reliability and responsiveness. With these advancements, Leak Pro holds considerable potential to make a substantial impact on gas leak safety, especially in regions where such accidents are prevalent. By automating the response to household gas leaks, Leak Pro represents a critical step toward safer homes and communities.

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