

Smart Gas Leak Detector with Automatic Shut-off System

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Abstract - Gas leakage is one of the most common and dangerous accidents that occur in domestic, industrial, and commercial environments. Leaks of combustible gases such as LPG, methane, or propane can lead to explosions, fires, and severe health hazards if not detected and controlled in time. To address this issue, this project presents the design and development of a 'Smart Gas Leak Detector with an Automatic Shut-Off System' using 'Arduino technology'.

The proposed system employs an 'MQ-2 gas sensor' to continuously monitor gas concentration in the surrounding atmosphere. When the gas concentration exceeds a predefined safety threshold, the 'Arduino Uno microcontroller' immediately activates an alarm system, which includes a buzzer and LED indicators, to alert the occupants.

Key Words: Smart gas leak detector, IoT gas leakage detection, Automatic gas Shutoff, LPG gas leak sensor, Lenoid valve cutoff.

1. INTRODUCTION

In modern homes, industries, and laboratories, the risk of gas leakage poses a serious threat to life and property. Gases such as LPG, methane, and propane are highly flammable and can cause explosions if not detected in time. Traditional gas leak detection systems rely heavily on manual supervision and often fail to respond promptly during emergencies. To address these challenges, this project proposes a 'Smart Gas Leak Detector with an Automatic Shut-Off System' using 'Arduino'. The system integrates gas sensors, an Arduino microcontroller, a solenoid valve, and communication modules (like GSM or Wi-Fi) to ensure early detection and preventive action. When gas leakage is detected, the system not only alerts users via buzzer and message but also automatically cuts off the gas supply, thus minimizing the risk of explosion or fire. Should match with the list of references at the end of the paper.

1.1 Literature Review

Early Systems-Traditional gas detectors relied on basic sensors like MQ-2 for LPG detection, paired with microcontrollers such as Arduino or PIC to trigger alarms and simple relays for shutoff valves. These addressed limitations of manual monitoring but often lacked remote access or AI analysis.

IoT Integration-Recent studies emphasize ESP32 or Node MCU modules for Wi-Fi connectivity, enabling real time alerts via SMS, apps, or cloud platforms. Systems now include GPS for leak location and GSM for notifications, improving response in homes and industries.

AI and Advanced Features-AI-enhanced detectors, like those using machine learning on sensor data, predict leaks and automate exhaust fans or solenoid valves. Prototypes test detection under one minute, integrating flame sensors for comprehensive safety.

Gaps and Trends-Literature highlights scalability for industrial use and low false alarms, though challenges remain in low-level detection and power efficiency. Future work points to wireless networks and edge computing for broader adoption.

1.2 Methodology

The methodology for a smart gas leak detector with automatic shutoff follows a structured engineering approach, combining hardware prototyping, software development, and iterative testing. It draws from established IoT-based research practices.

System Design

Select core components like MQ-2/MQ-5 gas sensors for detecting LPG/propane leaks, ESP32 or Node MCU for IoT connectivity, a solenoid valve for automatic shutoff, buzzer/LED for alarms, and optional flame/temperature sensors. Use a microcontroller (e.g., Arduino/PIC) as the central processor to read analog sensor data, apply thresholds (e.g., >500ppm triggers alert), and control outputs via relays. Implementation Steps

1. Hardware Assembly: Wire sensors to microcontroller analogue pins, connect relay to digital pins for valve/fan control, and integrate GSM/Wi-Fi module for SMS/app alerts.

2. Firmware Development: Code in Arduino IDE or Micro Python to sample sensor data every 1-5 seconds, filter noise with averaging algorithms, and activate shutoff if levels exceed safe limits (<1 minute response).

3. IoT Integration: Upload data to cloud platforms (e.g, Blynk/Thing Speak) for remote monitoring; implement ML anomaly detection if advanced.

4. Testing and Validation: Conduct lab tests with controlled gas releases to measure sensitivity (91% detection rate target), false positives, and shutoff latency. Field-test in simulated home/industrial setups, refine based on feedback, then deploy with power optimization for reliability.

2. Working Principle

Detection Phase: A gas sensor (typically MQ-2 or MQ-5) continuously monitors air for LPG, methane, or propane by measuring changes in electrical resistance when target gases interact with its tin dioxide surface—resistance drops sharply above safe thresholds (e.g., 500-1000 ppm). The microcontroller (e.g., Arduino or ESP32) samples this analog data every few seconds, applies calibration curves, and filters noise via averaging to confirm a leak.

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Alert and Shutoff-Upon detection, the controller activates outputs: a buzzer/LED for local alarms, optional GSM/WiFi for SMS/app notifications, and a relay to trigger a solenoid valve or servo motor that physically closes the gas line in under a second, halting flow. Additional logic may engage exhaust fans or cut power to appliances via relays, entering a safe mode until levels normalize.

Recovery-Sensors recheck air quality post-shutoff; if concentrations fall below safe limits, the system can reset manually or via app, with logs stored for analysis. This closed-loop principle ensures rapid mitigation, reducing explosion risks.

Table -1: Sample Table format

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Step	Condition	Action	Outcome”
1	Normal gas level	Monitor only	Gas flows normally
2	Gas > threshold	Trigger relay + alerts	Valve closes, gas supply cuts off
3	Flame detected (optional sensor)	Enhance alerts	Prevents ignition risks
4	Gas drops < threshold	Auto-reset valve + silence alerts	System resumes monitoring

The sample table outlines the sequential operation of a smart gas leak detector with automatic shut-off. In normal conditions, the system simply monitors gas levels without interference, allowing normal flow. When gas concentration exceeds a safe threshold, it triggers the relay to close the solenoid valve while activating alerts like buzzers or LEDs, immediately cutting off the supply to prevent hazards. An optional flame detection step heightens warnings if fire risks emerge. Finally, once levels drop below the threshold, the system auto-resets the valve and silences alerts, returning to continuous monitoring.

system initialization and continuous gas level monitoring via an MQ-2 sensor. If levels remain below the threshold

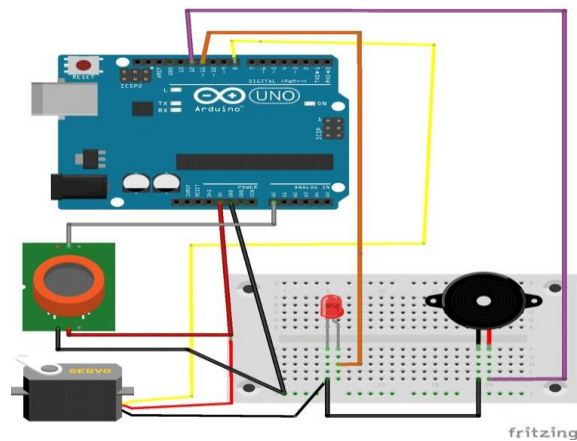
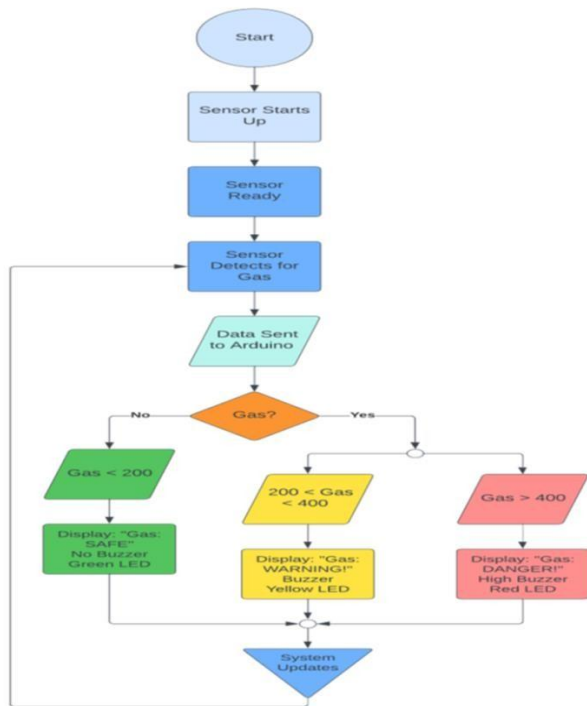


Fig -1: Block Diagram of Smart Gas Leak Detector with Automatic Shutoff System

Chart -1: Name of the chart

A typical smart gas leak detector project connects an MQ gas sensor to a microcontroller like ESP8266 or Arduino, which monitors air for LPG leaks. Upon detection above a threshold, it triggers a relay to close a solenoid valve on the gas line, sounds a the gas checks a flame sensor for extra alerts. Power comes from a V supply, with wires linking components as follows: sensor output to microcontroller analog pin, relay input todigital pin, buzzer/LED to GPIO pins, and valvia relay

The flowchart illustrates the operational logic of a smart gas leak detector with automatic shut-off. It starts with monitoring loops indefinitely; exceeding it triggers alerts like buzzers or LEDs, activates the relay to close the solenoid valve, and cuts off gas supply, with an optional flame sensor check for escalated warnings. Once levels normalize, the valve resets, alerts silence, and the system returns to monitoring, forming a safety-focused cycle.

Components Used:

Core Components

- 1. Gas Sensor (MQ-2 or MQ-5):** Detects LPG, methane, or other leaks by sensing concentration changes in the air.
- 2. Microcontroller (Arduino Uno or ESP8266/ESP32):** Processes sensor data, runs logic, and controls outputs.

Actuators and Controls

- 1. Relay Module:** Switches the solenoid valve on/off to cut gas supply automatically.

2. Solenoid Valve: Physically blocks gas line when activated by relay.

Alert and Displays

1. Buzzer: Emits audible alarm during detection.

2. LED (or RGB LED): Provides visual indication of status or leak.

Power and Connectivity

1. Power Supply (12V adapter or 9V battery): Powers the entire setup.

2. Optional Add-ons: GSM module for SMS alerts, Wi-Fi for app notifications, flame sensor, or DC fan for ventilation.

3. LCD Display (optional): Shows real-time gas levels

3. CONCLUSIONS

The smart gas leak detector with automatic shut-off effectively enhances home safety by continuously monitoring for leaks using an MQ-2 sensor and promptly cutting off supply via a solenoid valve upon detection. This project demonstrates a cost-effective, Arduino/ESP-based solution with alerts and optional IoT features, reducing fire/explosion risks in kitchens or industrial settings. Overall, it provides reliable, real-time protection that's easy to assemble and scalable for broader applications.

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