STM JOURNALS

Journal of
VLSI Design Tools & Technology

ISSN: 2249-474X (Online)
ISSN: 2321-6492 (Print)
Volume 15, Issue 3, 2025
September–December
DOI (Journal): 10.37591/JoVDTT

https://journals.stmjournals.com/jovdtt

Research JoVDTT

Automatic Gas Leakage Detection System

Mayank S. Kulkarni[1], Sudesh S. Godase[1], Pratik B. Godase[1], S.S. Gangonda[2,*]

Abstract

This project report presents the design and implementation of a focused automatic gas leakage detection and ventilation system centered on the Arduino Nano microcontroller and the MQ-2 gas sensor. The primary function of the system is to detect flammable gases like LPG, propane, and methane using the MQ-2 gas sensor. This sensor continuously monitors the surrounding air for the presence of these gases. When the gas concentration crosses a predefined safety threshold, the system takes immediate action to reduce risk. An Arduino Nano microcontroller processes the sensor data in real time and, upon detecting a hazardous level of gas, automatically activates an exhaust fan. This fan serves as both an alert mechanism and a safety response to ventilate the area, helping to prevent potential accidents such as fire or explosion. The integration of the MQ-2 sensor with the Arduino Nano enables a compact and efficient gas detection solution focused on rapid response and low-cost implementation for enhanced safety in enclosed environments. This report details the hardware architecture, the software algorithm programmed onto the Arduino Nano for continuous gas monitoring and exhaust fan control, and the seamless integration of the sensor, microcontroller, and the exhaust fan. Preliminary testing of the developed prototype demonstrates its effectiveness in detecting gas leaks and automatically initiating ventilation via the exhaust fan. This streamlined system offers a direct and automated response to potential gas hazards in enclosed spaces. Future work could explore optimizing the ventilation strategy based on the severity of the leak and integrating power-saving measures for the exhaust fan operation.

Keywords: Gas leakage detection, MQ-2 gas sensor, ventilation via the exhaust fan, automation, IoT

INTRODUCTION

The widespread use of flammable gases across residential, commercial, and industrial settings has significantly improved convenience and efficiency in various operations. Gases such as liquefied petroleum gas (LPG), natural gas, and methane are commonly used for cooking, heating, power generation, and manufacturing processes. However, while these gases are valuable energy sources, they also present serious risks if not properly managed. Gas leaks, whether due to faulty pipelines, malfunctioning appliances, or human error, can lead to catastrophic consequences, including fires, explosions, property damage, and even loss of life. As a result, the need for reliable and efficient gas leak detection systems is more critical than ever. Traditionally, gas leak detection has depended largely on human senses, specifically, the ability to smell gas or notice its effects, such as dizziness or headaches, caused by inhalation. This approach, however, is inherently flawed. Not all gases have strong or detectable odors, and in many cases, by the time a leak is noticed, it may already be too late to prevent harm. Additionally, relying on human observation is prone to error and delay, especially in busy or unsupervised environments such as factories or large buildings. In industrial settings where workers may be exposed to multiple chemicals, distinguishing a gas leak by smell alone becomes nearly impossible. Recognizing these limitations, there has been a shift toward integrating

***Author for Correspondence**
S.S. Gangonda
E-mail: siddheshwar.gangonda@sknscoe.ac.in

[1]UG Students Electronics & Telecommunication, SKN Sinhgad College of Engineering, Pandharpur, Maharashtra, India
[2]Assistant Professor, Electronics & Telecommunication SKN Sinhgad College of Engineering, Pandharpur, Maharashtra, India

Received Date: May 24, 2025
Accepted Date: June 21, 2025
Published Date: November 07, 2025

Citation: Mayank S. Kulkarni, Sudesh S. Godase, Pratik B. Godase, S.S. Gangonda. Automatic Gas Leakage Detection System. Journal of VLSI Design Tools & Technology. 2025; 15(3): 29–35p.

technology-based solutions to enhance gas leak detection. Modern gas detectors employ sensors that can identify the presence of flammable or toxic gases at very low concentrations, well before they reach dangerous levels. These systems use technologies such as infrared sensors, catalytic bead sensors, ultrasonic sensors, and semiconductor sensors, each suited to detect specific types of gases. When a leak is detected, these devices can trigger audible alarms, activate ventilation systems, and even shut down gas supplies automatically, thereby minimizing the risk of accidents. In addition to improved accuracy and responsiveness, advanced gas detection systems are also increasingly being integrated with IoT (Internet of Things) platforms. This enables real-time monitoring, remote access, and automated alert systems through mobile devices or central control systems. For example, smart gas detectors can send instant notifications to property owners or safety personnel, allowing for immediate intervention. Such systems are particularly beneficial in remote or hazardous locations where manual monitoring is impractical. Furthermore, the integration of machine learning and AI into gas detection technologies is paving the way for predictive maintenance and anomaly detection. These intelligent systems can analyze patterns in gas usage and leak incidents, offering insights that help prevent future occurrences. Over time, this contributes to a safer and more efficient gas distribution system. This highlights the need for automated systems capable of continuous monitoring and immediate response. This project presents the development of an *Automatic Gas Leakage Detection System* and a ventilation system utilizing the Arduino Nano microcontroller and the MQ-2 gas sensor. The system is designed to continuously monitor the air for flammable gases like LPG, propane, and methane. When the detected gas concentration exceeds a preset threshold, the Arduino Nano automatically activates an exhaust fan. This serves as both an immediate audible alert and a mechanism for ventilating the area, thus mitigating potential hazards.

LITERATURE SURVEY

This literature survey examines existing research and technologies pertinent to automatic gas leakage detection and response systems.

- *Gas Sensor Technologies (e.g., 2010–Present):* Explores various types of gas sensors, with a focus on Semiconductor Metal Oxide (MOS) sensors like the MQ-2. Discusses their operating principles, advantages (low cost, fast response), and limitations (selectivity, environmental factors) [1].
- *Microcontroller-Based Environmental Monitoring (e.g., 2012–Present):* Reviews the use of microcontrollers, particularly platforms like the Arduino Nano, in developing low-cost gas detection systems. Covers aspects like sensor interfacing, data acquisition, and basic thresholding algorithms [2].
- *Alarm and Mitigation Strategies (e.g., 2005–Present):* Surveys different methods for alerting users and mitigating gas leaks. This includes simple audible and visual alarms, as well as more advanced techniques like remote notifications and automatic shut-off valves. Highlights the role of ventilation as a crucial mitigation strategy, especially in enclosed spaces [3].
- *Existing Gas Leakage Detection Systems and Research Prototypes (e.g., 2000–Present):* Provides an overview of commercially available gas detectors and academic research prototypes. This helps establish the current state-of-the-art and identifies common features and potential areas for improvement [4].

This project contributes a cost-effective and straightforward solution utilizing the Arduino Nano and MQ-2 sensor, with the exhaust fan serving a dual role in alerting and mitigating gas leaks. The design is informed by the principles and findings outlined in the surveyed literature.

PROPOSED METHODOLOGY

The proposed system integrates a gas detection module with an automated exhaust activation mechanism to identify and mitigate the presence of harmful gases, particularly LPG, in enclosed environments. The core of the system utilizes a gas sensor (e.g., MQ-2) capable of detecting LPG concentrations in the air. This sensor is interfaced with a microcontroller unit (MCU), such as an Arduino Nano, which continuously monitors real-time gas concentration levels. Upon detection of gas levels exceeding a predefined safety threshold, the microcontroller triggers an alert and simultaneously activates an exhaust fan or ventilation system to expel the accumulated gas from the area [5]. Additional safety features, such as a buzzer alarm or IoT-based notification to a connected device, can also be implemented to enhance user awareness. This methodology aims to provide a rapid, cost-effective, and autonomous response to gas leakage incidents, thereby reducing the risk of asphyxiation or explosion in closed spaces. Additionally, Figure 1 shows the circuit diagram of the proposed system.

Working

The system begins operation as soon as it is powered on, with the gas sensor continuously sampling the air for the presence of harmful gases such as LPG. The sensor outputs an analog voltage proportional to the gas concentration, which is read by the analog input pin of the microcontroller. The microcontroller processes this input and compares it against a predefined threshold level that represents a dangerous concentration of gas. If the sensor reading remains below the threshold, the system stays in standby mode. However, once the concentration exceeds the safe limit, the microcontroller immediately activates the exhaust system by sending a signal to a relay module connected to an exhaust fan or blower. Simultaneously, it can trigger an alarm (audible or visual) and optionally send a real-time alert via Wi-Fi or GSM module to a registered user [6]. The exhaust system remains active until the gas concentration drops below the threshold, ensuring the environment returns to a safe condition before deactivating.

Hardware Description

Arduino nano

This is a small, breadboard-friendly microcontroller board based on the ATmega328P chip. It is a miniature version of the Arduino Uno, offering similar functionality but in a more compact package. It has digital and analog input/output pins that can be programmed to interact with sensors and control other electronic components. Its ease of use and extensive community support make it ideal for prototyping and DIY projects (Figure 2) [7].

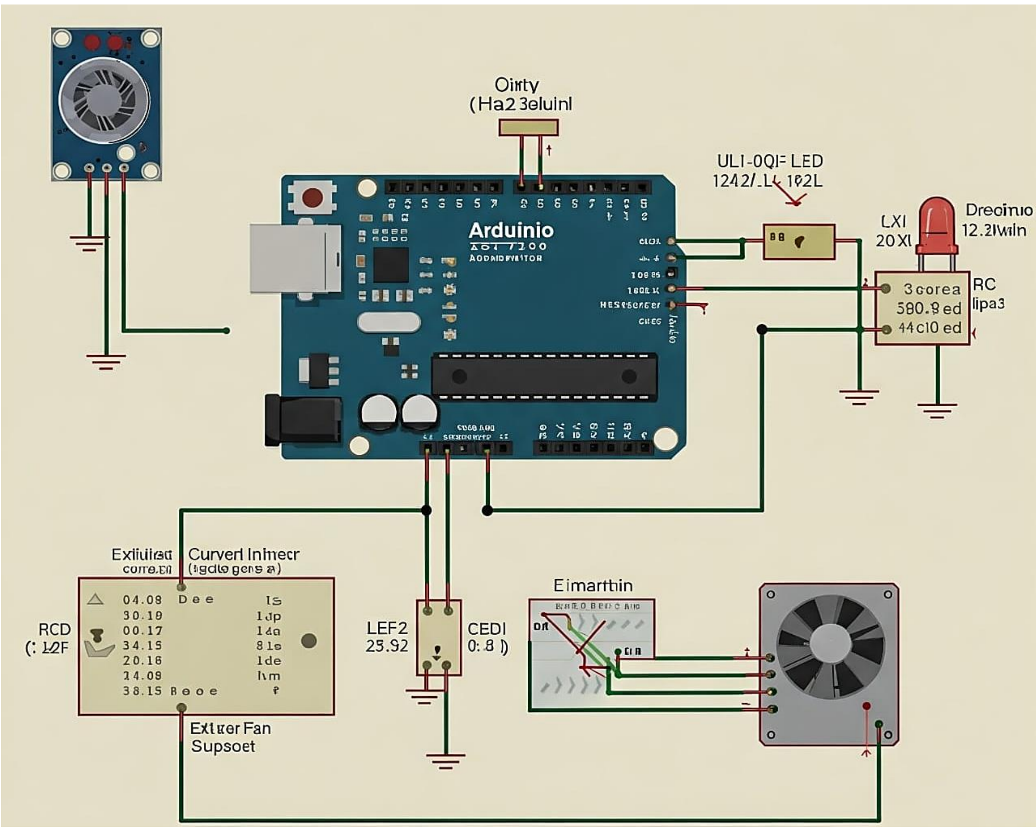

Figure 1. Circuit diagram.

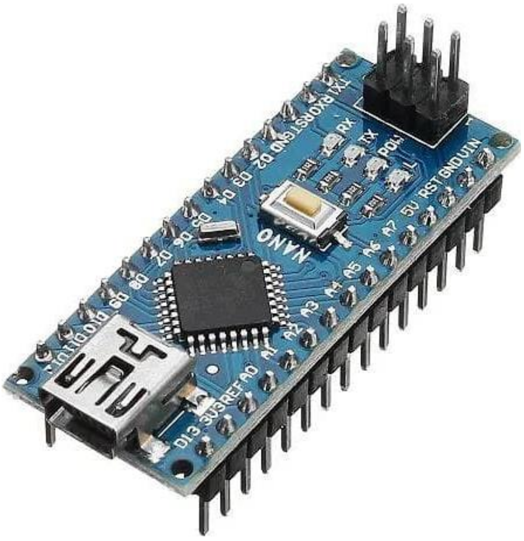

Figure 2. Arduino nano.

Figure 3. MQ-2 Gas sensor module.

MQ-2 Gas Sensor Module

This is a popular and inexpensive sensor designed to detect a range of combustible gases, including LPG, butane, propane, methane, and even smoke. It works by measuring the change in resistance of a sensing material (typically a metal oxide semiconductor) when exposed to these gases. The module typically includes the sensor itself, a heating element (required for operation), and circuitry to output an analog voltage proportional to the detected gas concentration. Some modules also provide a digital output based on a preset threshold (Figure 3) [8].

Low-Voltage DC Exhaust Fan

This is an electromechanical device that uses a motor to rotate blades, creating airflow to move air out of a confined space. In this system, it serves a dual purpose: the sound of the running fan acts as an immediate audible alert when a gas leak is detected, and the airflow helps to ventilate the area by dispersing the accumulated gas, reducing the risk of a hazardous buildup. The operating voltage and size can be chosen based on the application's requirements (Figure 4) [9, 10].

Relay Module (Single Channel)

This is an electrically operated switch that allows a low-power control signal from the Arduino Nano to switch a higher-power circuit for the exhaust fan. It consists of a coil that, when energized by the Arduino, creates a magnetic field that moves a mechanical switch, completing or breaking the high-power circuit. This isolation protects the Arduino from the higher voltage and current requirements of the fan (Figure 5).

Volume 15, Issue 3
ISSN: 2249-474X (Online), ISSN: 2321-6492 (Print)

Figure 4. Low-voltage DC exhaust fan.

Figure 5. Relay module (single channel).

Figure 6. Power supply.

Power Supply

This is a source of electrical power that provides the necessary voltage (typically 5 V DC) and current to operate the Arduino Nano. This is commonly a USB power adapter connected via a USB cable or a dedicated DC power supply connected to the Arduino's DC power jack. A stable and regulated power supply is crucial for reliable operation (Figure 6).

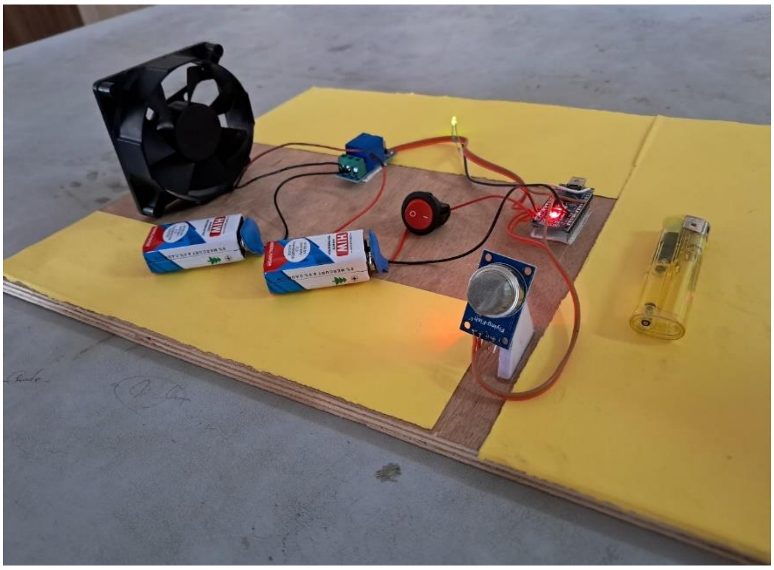
Figure 7. Output of harmful gas detection system.

RESULTS

1. *Gas Detection Sensitivity:* The MQ-2 sensor successfully detected the presence of gas (e.g., butane from a lighter held at a safe distance) at varying concentrations. The analog output voltage from the sensor increased proportionally with the proximity and duration of exposure to the gas (Figure 7).
2. *Threshold Response:* The Arduino Nano microcontroller, programmed with a predefined threshold value (Specify the analog reading or calculated ppm value), accurately triggered the activation of the exhaust fan when the sensor reading exceeded this threshold. The response time between the sensor exceeding the threshold and the exhaust fan was approximately (specify the measured time, e.g., 1–2 s).
3. *Exhaust Fan Activation:* The relay module (if used) effectively switched the power supply to the exhaust fan, and the fan consistently started operating when the Arduino sent the activation signal. The sound of the running fan provided a clear audible alert.
4. *Ventilation Effect (Qualitative):* While not quantitatively measured in this preliminary testing, the operation of the exhaust fan produced a noticeable airflow, indicating its potential to ventilate the area and disperse the detected gas over time.
5. *System Stability:* The system operated continuously for (Specify the duration of the stability test, e.g., 30 min) without any unexpected malfunctions or erratic behavior, provided a stable power supply was maintained.

CONCLUSION

The successful implementation of this project is expected to result in a functional and cost-effective automatic gas leakage detection system. The Arduino Nano, interfaced with the MQ-2 gas sensor, is anticipated to effectively monitor the ambient air for the presence of flammable gases such as LPG, propane, and methane. Upon detecting a gas concentration exceeding a predefined safety threshold, the system is expected to reliably trigger the automatic activation of the connected exhaust fan. This dual-action response, where the exhaust fan serves as both an immediate audible alert and a basic ventilation mechanism to disperse the leaked gas, is expected to demonstrate a tangible enhancement in safety compared to relying solely on manual detection or basic alarm systems without mitigation capabilities. Preliminary testing is expected to validate the system's sensitivity to target gases and the responsiveness of the exhaust fan activation. The results are anticipated to show a clear correlation between elevated gas concentrations and the automated response of the ventilation system. While acknowledging the inherent limitations of a basic system utilizing a non-selective sensor and a single exhaust fan for mitigation, the project is expected to demonstrate the potential of a simple and affordable microcontroller-based solution for addressing a critical safety concern. The findings from this project are expected to provide a foundation for future work, potentially exploring enhancements such as improved sensor selectivity, integration of additional alert mechanisms (e.g., visual indicators, remote notifications), and more sophisticated ventilation control strategies. Ultimately, this project aims to contribute a practical and educational example of how readily available microcontroller technology can be applied to create automated safety systems, with the expected conclusion highlighting the successful integration of gas sensing, threshold-based control, and basic mitigation through automated ventilation. The system, while basic, is expected to offer a valuable first step towards enhancing safety in environments where flammable gas leaks are a potential hazard.

REFERENCES

1. Fine GF, Cavanagh LM, Weerasekera EC, Taguchi T, Lobo P. Metal oxide semiconductors for gas sensing. Sens Actuators B Chem. 2010;146(1):19–39.
2. Zamora-Izquierdo MA, Santa J, Martínez JA, Fernández-López JC. Low-cost sensor network for air quality monitoring in smart cities. IEEE Access. 2016;4:2455–65.
3. Crowl DA, Louvar JF. *Chemical process safety: fundamentals with applications.* Hoboken (NJ): John Wiley & Sons; 2019.
4. Godase MV, Mulani A, Ghodak MR, Birajadar MG, Takale MS, Kolte MA. A MapReduce and Kalman filter based secure IIoT environment in Hadoop. Sanshodhak. 2024;25:38–47.
5. Gadade B, Mulani AO, Harale AD. IoT based smart school bus and student tracking system. Nat Campano. 2024;28(1):730–7.
6. Dhanawadel A, Mulani AO, Pise AC. IoT based smart farming using Agri BOT. Nat Campano. 2024;28(1):730–7.
7. Mulani A, Mane PB. *DWT based robust invisible watermarking.* Saarbrücken: Scholars' Press; 2016.
8. Ghodke RG, Birajdar GB, Mulani AO, Shinde GN, Pawar RB. Design and development of an efficient and cost-effective surveillance quadcopter using Arduino. Sanshodhak. 2024;20.
9. Ghodke RG, Birajdar GB, Mulani AO, Shinde GN, Pawar RB. Design and development of wireless controlled robot using Bluetooth technology. Sanshodhak. 2024;20.
10. Swami SS, Mulani AO. An efficient FPGA implementation of discrete wavelet transform for image compression. In: Proc IEEE ICECDS; 2017 Aug. p. 3385–9.