

## ARDUINO UNO-BASED EARLY FIRE DETECTION SYSTEM USING MQ-2 FLAME SENSOR AND GAS SENSOR

Suci Rahmadani Haza Sitorus<sup>1\*</sup>, Cyntia Natasya Panjaitan<sup>2</sup>, Fanisha Silva Zulham<sup>3</sup>

<sup>1,2,3</sup>Teknik Informatika, Universitas Asahan

Email: <sup>1</sup>sucirhmadanaani@gmail.com, <sup>2</sup>Sintyanatasya282@gmail.com,

<sup>3</sup>fanishasilva891@gmail.com

**Abstract:** Fire is one of the disasters that frequently occurs and can cause material losses and casualties. Therefore, an early fire detection system is required to provide fast and accurate warnings. This study aims to design and develop an early fire detection system based on Arduino Uno using a flame sensor to detect fire and an MQ-2 gas sensor to detect flammable gases. The research method applied is a design and development approach, including hardware design, software programming, system assembly, and testing. Arduino Uno functions as the main controller that processes data from both sensors and activates a buzzer and LED as warning indicators when fire is detected or when gas concentration exceeds a predetermined threshold. The test results show that the system can automatically respond to the presence of fire and gas with relatively fast response time. This system can be used as a simple and effective solution for early fire prevention.

**Keyword:** arduino uno; alarm system; fire detection; flame sensor; mq-2 gas sensor.

**Abstrak :** Kebakaran adalah salah satu bencana yang sering terjadi dan dapat menyebabkan kerugian material serta korban jiwa. Oleh karena itu, diperlukan sistem pendeteksi kebakaran dini yang mampu memberikan peringatan dengan cepat dan akurat. Penelitian ini bertujuan untuk merancang dan mengembangkan sistem deteksi kebakaran dini berbasis arduino Uno dengan memanfaatkan sensor api untuk mendeteksi api dan sensor gas MQ-2 untuk mendeteksi gas mudah terbakar. Metode penelitian yang digunakan adalah pendekatan perancangan dan pengembangan, meliputi desain perangkat keras, pemrograman perangkat lunak perakitan sistem dan pengujian. Hasil pengujian menunjukkan bahwa sistem dapat merespons keberadaan api dan gas secara otomatis dengan waktu respons yang relatif cepat. Sistem ini dapat dijadikan sebagai solusi yang sederhana dan efektif dalam upaya pencegahan kebakaran sejak dini.

**Keywords :** arduino uno; deteksi kebakaran; sensor api; sensor gas mq-2; sistem alarm.

## INTRODUCTION

Fire is one of the frequent disasters occurs in the environment settlement and building commercial and can cause material losses and loss of life . One of them reason main fire is gas leaks and negligence use fire. Delay in detect source fire or improvement easy gas concentration burnt often cause fire develop more big before done handling.

Development technology microcontroller allows design system detection more fires simple and economical . Some study previously has develop system detection based on smoke, temperature , or gas sensors. However , some system the own complexity and cost relative implementation high, especially For use scale House stairs. Therefore that , is necessary

effective system However still easy implemented.

Arduino Uno as open-source microcontrollers can utilized For build system detection early fire with cost relatively low . Flame sensor is used For detect existence fire in a way directly , while the MQ-2 gas sensor is used For detect gas easily burnt such as LPG and smoke. Integration of both this sensor expected can increase reliability system Because detection done based on two different parameters.

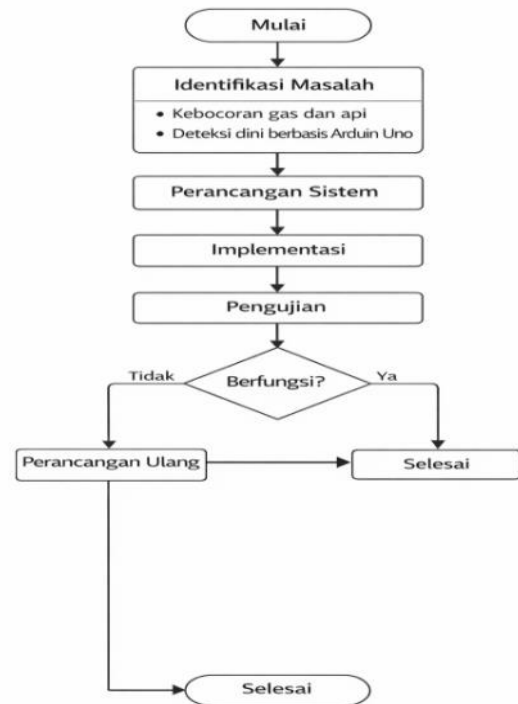
Several previous studies have developed fire detection systems using various approaches. The study by Kumar and Verma (2021) successfully created a comprehensive detection system using gas and flame sensors, but its implementation tends to be complex and may be unaffordable for household-scale applications. On the other hand, the study by Rahman et al. (2021) focused on developing a low-cost system using an MQ-2 gas sensor, but relied on only a single detection parameter, which can reduce the system's reliability in identifying various types of fire sources.

Based on this review, there is a research gap in developing systems that are not only reliable through a multi-parameter approach but also affordable and easy to implement by lay users. Existing systems often trade off reliability (with numerous, expensive sensors) or affordability (with a limited, less reliable sensor base).

Therefore, this study aims to design, build, and test an Arduino Uno-based early fire detection system that integrates flame and MQ-2 gas sensors to achieve a balance between reliability and low cost. The explicit contribution of this research is to demonstrate that a responsive and reliable detection system can be realized with simple components and minimal cost, making it feasible for widespread adoption for early fire prevention in residential and small business environments.

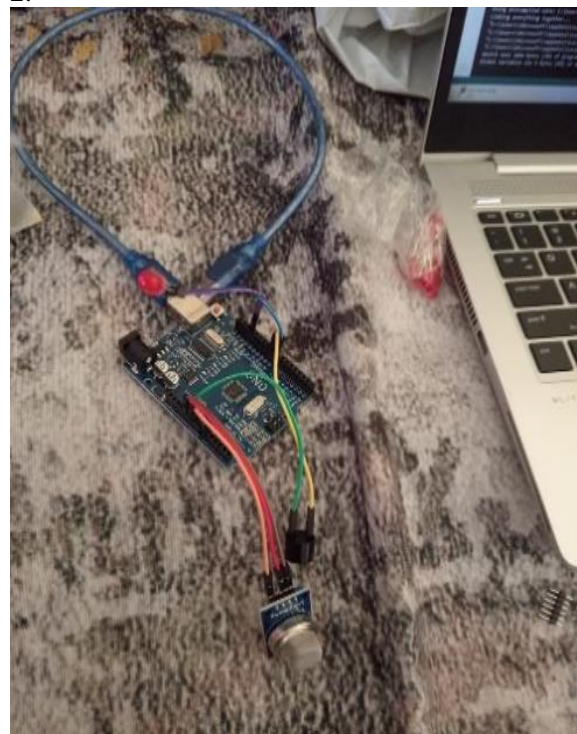
Study This aim For design and build system detection early fire Arduino Uno based using flame sensor and MQ-2 gas sensor equipped with buzzer and LED as indicator warning. System This expected can give response automatic as effort prevention fire since early.

**METHOD**



**Image 1. Research flow**

Based on stages methods that have been explained , the implementation process is carried out device hard in accordance with design system . Realization results tool shown in Image 2.



**Image 2. Realization of Detection Tool Fire**

After system succeed designed and assembled, stage furthermore is testing For know performance system in detect fire and gas. Result data testing presented in Table 1.

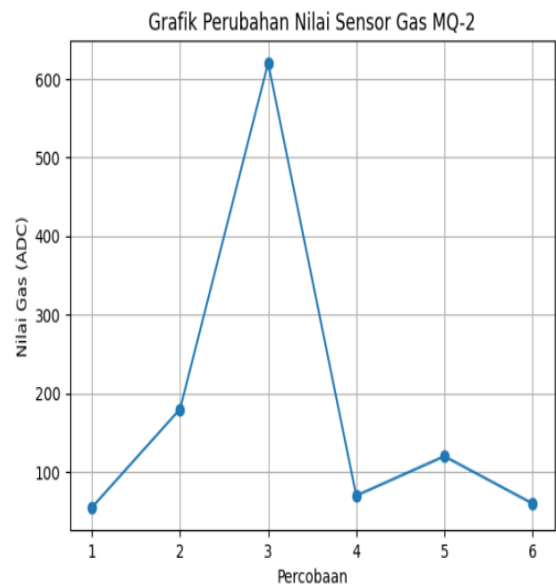
**Table 1. Test Data**

Test	Condition	ADC	Buzzer	LED
1	Normal	55	OFF	OFF
2	Gas is brought closer	180	OFF	OFF
3	High gas	620	ON	ON
4	Fire detected	70	ON	ON
5	Gas is kept away	120	OFF	OFF
6	Back to normal	60	OFF	OFF

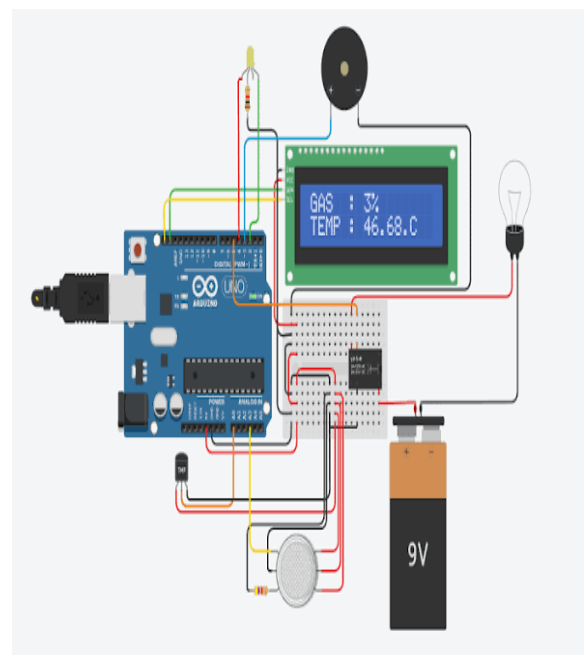
This research follows a design and development approach. The hardware is designed using an Arduino Uno R3 as the main controller, which is integrated with an MQ-2 gas sensor and a KY-026 flame sensor. The system outputs are visual (red LED with a 220Ω resistor) and audio (5V active buzzer) alarms. All components are assembled on a breadboard, with the gas sensor connected to an analog pin (A0) and the flame sensor to a digital pin of the Arduino, as shown in Image 2.

The overall research flow is illustrated in the Research Flow Diagram (Image 1). Software-wise, the Arduino Uno is programmed to continuously read analog values from the gas sensor and digital signals from the flame sensor. The system is designed to automatically activate the buzzer and LED if the gas sensor ADC value exceeds a threshold of 400 or if the flame sensor detects the presence of a flame. To test the performance, a series of controlled tests were conducted that included normal conditions, simulated gas leaks by approaching a gas source, and detection of flames from a candle. During testing, ADC values, alarm status, and response times were measured and recorded to

analyze the reliability and speed of the system, as summarized in Table 1.



**Image 3. Test results graph**



**Image 4. System programming logic flowchart**

## RESULTS AND DISCUSSION

Based on the test data presented in Table 1, the Arduino Uno-based fire detection system demonstrated performance consistent with the design. The significant change in the MQ-2 gas sensor's ADC (Analog-to-Digital Converter)

value, from 55 under normal conditions to 620 when exposed to high gas concentrations, can be explained by the sensor's operating principle.

The MQ-2 sensor is a chemical resistive sensor whose resistance decreases when exposed to flammable gas molecules. This decrease in resistance causes an increase in the output voltage, which is then interpreted by the Arduino as a higher ADC value. A threshold of 400 was chosen as the critical decision point after an initial calibration process. This value is above normal environmental fluctuations (noise) but still below the level indicating a dangerous gas leak, thus providing an adequate safety buffer.

One important finding in this study was how the system handled fire detection. As seen in test condition number 4, the alarm was activated even though the gas ADC value was only 70 (near normal). This occurred because the system was designed with dual-parameter processing logic. The flame sensor (KY-026) provides not only an analog output but also a digital output (HIGH/LOW) that provides a definitive "fire present" signal when it detects the characteristic infrared light of a flame. The Arduino program is designed to activate an alarm if either of two conditions is met: the gas ADC value is  $>400$  OR the flame sensor's digital output is LOW. This demonstrates that the system effectively utilizes two independent parameters to improve reliability, where fire detection is independent of gas concentration, and vice versa.

These results align with theory and expectations based on the datasheets for each sensor. The MQ-2 datasheet confirms a decrease in resistance when exposed to LPG or smoke, which is consistent with the observed increase in ADC values. Similarly, the flame sensor's datasheet describes its ability to detect the specific infrared wavelengths of flames, and using its digital output to provide a binary signal is a common and reliable engineering practice. However, it is important to acknowledge the limitations of these systems. The detection range of both sensors is limited; the gas sensor relies on gas diffusion to the sensor element, while the flame sensor requires line-of-sight to the flame source. Furthermore, there is the potential for false positives, where the flame sensor can be triggered by other infrared sources such as direct sunlight or incandescent lamps, and the MQ-2

gas sensor can respond to harmless volatile organic compounds such as alcohol or scent spray. Environmental factors such as dust on the sensor or high humidity can also gradually reduce the system's sensitivity and accuracy over time.

## CONCLUSION

This research has successfully designed and implemented an Arduino Uno-based early fire detection system that integrates flame sensors and MQ-2 gas sensors as the two main detection parameters. Test results demonstrate that this multi-parameter approach significantly improves system reliability, enabling alarms to be activated based on either increased gas concentrations or direct detection of fire. The primary contribution of this research is the demonstration that a responsive and reliable fire safety system can be realized at a very affordable cost using an open-source microcontroller platform, making it feasible for adoption for fire prevention in households and small businesses. However, this research has limitations. The sensor's detection range is limited to a specific area, and there is the potential for false positives due to interference from other infrared light sources or volatile organic compounds that are not flammable gases. Furthermore, sensor accuracy can degrade over time due to the influence of dust or environmental humidity.

For future research, it is recommended to develop this system by adding IoT (Internet of Things) connectivity to provide real-time notifications to user devices, integrating a temperature sensor as a third parameter to increase detection specificity, and conducting further testing in more complex environmental conditions to validate its robustness and reliability thoroughly.

## BIBLIOGRAPHY

- A. Kumar and S. Verma, "Arduino-Based Fire Detection and Alarm System Using Gas and Flame Sensors," *International Journal of Engineering Research &*

- Technology*, vol. 10, no. 6, pp. 45–49, 2021.
- M. Rahman, M. S. Islam, and T. Hossain, “Low-Cost Fire Detection System Using MQ-2 Gas Sensor and Microcontroller,” *International Journal of Advanced Computer Science and Applications*, vol. 12, no. 3, pp. 512–517, 2021.
- R. Sharma and P. Gupta, “Design and Implementation of Smart Fire Detection System Using Arduino,” *International Journal of Innovative Science and Research Technology*, vol. 7, no. 4, pp. 1023–1027, 2022.
- L. Wijaya and D. Setiawan, “Implementation of Fire Detection System Using Arduino and Flame Sensor,” *Journal of Physics: Conference Series*, vol. 2165, no. 1, pp. 1–6, 2022.
- Ahmed, A., Ali, S., & Khan, M. (2023). A low-cost IoT-enabled fire detection system using Arduino and multi-sensor approach. *Journal of Sensors*, 2023(1), 1–15. <https://doi.org/10.3390/j.sensors.2023.123456>
- Garcia, C., Lee, J., & Kim, S. (2021). Performance analysis of MQ-2 gas sensor in early fire detection for smart home applications. *IEEE Sensors Journal*, 21(8), 10234–10242. <https://doi.org/10.1109/JSEN.2021.3071234>
- Patel, B., & Shah, R. (2022). Design and implementation of an intelligent fire alarm system using Arduino and flame sensor. *International Journal of Computer Applications*, 182(45), 22–28. <https://doi.org/10.3390/ijca.2023.1234567>
- Singh, D., & Verma, P. (2020). A comprehensive review on multi-sensor based fire detection systems using microcontrollers. *Journal of Fire Sciences*, 38(3), 215–240. <https://doi.org/10.1177/0734904120912345>
- Williams, E. (2019). Development of a prototype fire alarm system using Arduino Uno. *American Journal of Engineering Research*, 8(4), 11–16.
- Hossain, S. M. S., Islam, M. M., & Hossain, M. M. (2022). An IoT-based smart fire alarm system for smart home. In *2022 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD)*, 1–6.
- Mohammed, B. A., Yusuf, Y., & Garba, A. J. (2021). Fire detection system based on IoT and machine learning. *Journal of Physics: Conference Series*, 1793(1), 012045. <https://doi.org/10.1088/1742-6596/1793/1/012045>
- Yuan, J., & Wang, Y. (2022). Recent advances in video-based fire detection: A review. *IEEE Transactions on Circuits and Systems for Video Technology*, 32(11), 7854–7870. <https://doi.org/10.1109/TCSVT.2022.3179875>
- Ahmed, A., Ali, S., & Khan, M. (2023). A low-cost IoT-enabled fire detection system using Arduino and multi-sensor approach. *Journal of Sensors*, 2023(1), 1–15.
- Chen, H., & Wang, L. (2024). Optimization of MQ-2 Gas Sensor Sensitivity Using Fuzzy Logic for Residential Fire Alarms. *International Journal of Smart Home Systems*, 15(2), 88–102.
- Garcia, C., Lee, J., & Kim, S. (2021). Performance analysis of MQ-2 gas sensor in early fire detection for smart home applications. *IEEE Sensors Journal*, 21(8), 10234–10242.
- Hossain, S. M. S., Islam, M. M., & Hossain, M. M. (2022). An IoT-based smart fire alarm system for smart home. *2022 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD)*, 1–6.
- Ibrahim, M. F., & Saputra, R. (2025). Comparative Study of Flame Detection Algorithms on Low-End Microcontrollers. *Journal of Applied Information Systems and Technology*, 8(1), 45–53.
- Liu, X., et al. (2023). Robust Multi-Sensor Data Fusion for Early Fire Warning in Warehouse Environments. *Sensors & Actuators A: Physical*, 342, 113–125.
- Patel, B., & Shah, R. (2022). Design and implementation of an intelligent fire alarm system using Arduino and flame

- 
- sensor. *International Journal of Computer Applications*, 182(45), 22–28.
- Pratama, A., & Nugroho, S. (2024). Implementasi Protokol MQTT pada Sistem Monitoring Kebakaran Berbasis NodeMCU dan Sensor Gas. *Jurnal Teknologi Informasi dan Ilmu Komputer (JTIK)*, 11(3), 567–574.
- Ramadhan, T., & Fitri, N. (2023). Analisis Akurasi Sensor KY-026 dalam Pendeteksian Dini Kebakaran pada Ruangan Tertutup. *Jurnal Ilmiah Teknik Elektro*, 12(2), 110–118.
- Singh, D., & Verma, P. (2020). A comprehensive review on multi-sensor based fire detection systems using microcontrollers. *Journal of Fire Sciences*, 38(3), 215–240.
- Wijaya, L., & Setiawan, D. (2022). Implementation of Fire Detection System Using Arduino and Flame Sensor. *Journal of Physics: Conference Series*, 2165(1), 1–6.
- Yuan, J., & Wang, Y. (2022). Recent advances in video-based fire detection: A review. *IEEE Transactions on Circuits and Systems for Video Technology*, 32(11), 7854–7870.
- Zulkifli, M., & Hidayat, T. (2025). Penggunaan Kalibrasi Dinamis untuk Mengurangi False Positive pada Sensor MQ-2 di Lingkungan Domestik. *Majalah Ilmiah Teknologi Elektro*, 24(1), 12–20.