An IoT-Based Intelligent Gas Leakage Detection and Automatic Pipeline Shut-Off System for Residential Societies

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***Abstract*—In residential societies, the growing popularity of centralized natural gas pipeline networks has created major concerns regarding their safety from leaking gas that could potentially cause fire, explosion and loss of life. This paper presents an IoT-enabled automated gas leak detection and automatic shut-down of pipelines to prevent gas exposure in home environments. This includes the use of gas detection sensors, as well as the development of an electronic microcontroller to help provide both real-time monitoring of gas leaks and immediate response to any detected leaks. The system will initiate several safety measures once the detection of a gas leak exceeds the specified limit. The initial action will be to activate an alarm which draws attention to the leak, in addition to sending all residents/authorities any necessary alerts through IoT platforms. The final action is to shut down the supply of gas via the use of a solenoid valve. The system can also help locate any leaks in a residential network for quick response times and to improve maintenance habits. The use of embedded controllers with automatic decision-making provides more reliability to the system and reduces reliance on human supervision. In addition, this solution will be affordable and easily expandable, as well as being appropriate for use in smart cities.**

***Index Terms*—Internet of Things (IOT), Gas Leakage Detection, NodeMCU, Real-time Alerts, Sensor Technology**

I. INTRODUCTION

considering the trend that is currently prevalent where the supply of natural gas takes place through the pipeline system within the area, it is very likely that there could be many risks of the leaking of gas that could result in fire outbreaks, explosions, and even fatalities. Thus, it becomes important that the process is controlled and this can only be done with the help of a real-time approach. In this way, it will become possible to create an IoT application whereby it will be possible to monitor and shut down the process by using the solenoid valves without the intervention of any human operator. With the help of cheap and scalable components such as gas sensors and NodeMCU microcontroller, along with shutting down of the process itself, the risk of leakage can be avoided.

II. LITERATURE REVIEW

1) On the basis of research conducted by Choche et al., (2021), the following recommendation can be made regarding the usage of gas leak detector system based on IoT technology which consists of Arduino Uno microcontroller and MQ gas sensors in order to monitor the level of gases and provide users with alerts through IoT technology when there is leakage in the gases. However, this system does not have an automatic shutdown system for the leakage.[2]
2) Sujarwo et al. (2021) designed an intelligent LPG leakage detector that incorporated NodeMCU ESP8266, MQ-6 Gas Sensor, and Blynk IoT platform. With this technology, it was now possible to detect the levels of LPG concentration remotely via mobile phones. Though this technology facilitated effective monitoring, its scope was limited to detection and alerts.[3]
3) Leakage detection system for LPG using IoT has been designed by Jumaa et al. (2022) utilizing the Blynk model. In this case, the Blynk model was chosen to continuously monitor the LPG level and provide an immediate alert to the user about any leakages.
   Cloud computing played a role here in reducing emergency response time. [4]

4) This project has been developed by Adrama et al. (2022). The LPG leakage detector and controller system uses NodeMCU ESP8266, MQ-2 gas sensor, and solenoid valve. Once any kind of danger arises in terms of gas concentration, the supply of gas stops instantly and notification is sent to the user's mobile device.[5]
5) The LP gas leakage detection system using IoT technology was invented by Prananda et al. (2023) using MQ-2 gas sensor and NodeMCU ESP8266 module. The system was able to monitor the process remotely and automatically switch off the gas regulator when any dangerous gas was detected.[6]
6) An IoT-based monitoring system for monitoring gas leakages and levels using MQ-2 sensor and NodeMCU was developed by Sangale et al. (2024). This system helped to monitor the real-time gas leakages and levels and also notify the users using their mobiles through the cloud connectivity service. Real-time monitoring became significant in this research study.[7]
7) In addition, there is an extremely detailed analysis that has been carried out in (Proc. Computer. Sci., Procedia Computer Science (2024)) on a gas leakage detection system that employs the use of the MQ-2 sensor and NodeMCU to monitor the gas level and alert the user in case of any leakage. It is extremely important to understand that the use of IoT in detecting gas leakage could help in saving lives.[8]

III. RESEARCH GAP

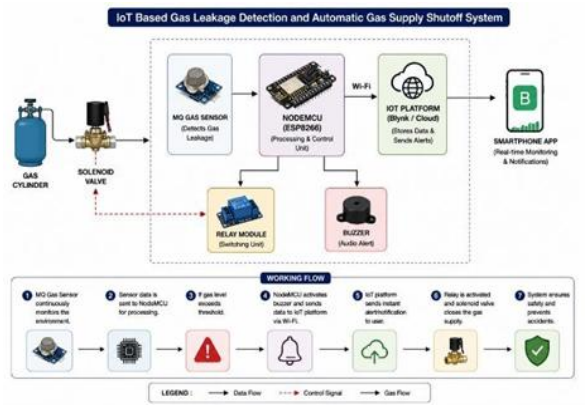
From the above literature review, it is clear that there are many gadgets available in the market for gas leakage detection and mobile alerts. In fact, there are also gadgets with the automatic shutdown facility, but they lack the combination of all three – the use of IoT for constant monitoring, automatic shutdown of the gas flow with the help of the solenoid valve, and mobile alert system all in one cost effective gadget. Hence, the main objective of this research is to develop an IoT based cost effective gadget for gas leakage detection with the help of NodeMCU, MQ series gas sensor, and solenoid valve.

IV. PROPOSED SYSTEM

A. System Overview

For the design that has been proposed, there will be a system for detecting any gas leakage, as well as an automatic system for cutting off the gas, using the concept of IoT (Internet of Things). Any detection of gas leakage and automatic cutting off of gas will be done using MQ gas sensors, working on the concept of IoT (Internet of Things). All the data that has been collected using the gas sensors will be processed by means of a NodeMCU (ESP8266) microcontroller. If the concentration of the gas crosses the defined threshold value, then NodeMCU implements a number of precautions. These include making use of the buzzer for informing the user through sounds, and at the same time sending a message to the user's mobile phone through the Internet of Things. Also, the relay is switched on to cut off the gas supply coming out from the solenoid valve. Thus, there is no danger of any fire or explosion. The solution presented above incorporates all those characteristics mentioned before, including gas sensing, wireless communication, real-time monitoring, and automation. The implementation of NodeMCU microcontroller based on ESP8266 allows the Wi-Fi communication capabilities of the system to be used without utilizing any communication protocol, which will allow the solution to be applied not only at home but also at the industrial level to ensure security.

V. BLOCK DIAGRAM



VI. COMPONENTS USED

A. Hardware Components

1) NodeMCU ESP8266:

The development board which has been developed with the help of ESP8266 Wi-Fi SoC is known as NodeMCU ESP8266 Development Board. The NodeMCU ESP8266 Development Board consists of

32-bit microcontroller and helps to achieve the connectivity through Wi-Fi. In simpler words, it can be said that this development board is most suitable for developing wireless communication and IoT technology. *[9]*

2) MQ-2 Gas Sensor (or MQ-5/MQ-6 depending on gas type):
Gas sensors based on the principle of working of semiconductors technology for detecting the presence of flammable gases and smoke is MQ-2 Gas Sensor. The sensing material used in this type of gas sensor is SnO2. The conductivity of the SnO2 depends on the amount of flammable gases available. If the air is clear, then the conductivity of the MQ-2 gas sensor will be very low. However, with the rise in the amount of flammable gases, the conductivity of the sensor increases.[10]

3) Solenoid Valve (12V DC, Normally Closed):
A 12V DC NC Solenoid Valve is an instrument used for controlling the automatic flow of fluids or gases. Various parts of a solenoid valve consist of electromagnetic coil, plunger, spring, and body of the valve. With respect to the NC type valve structure, the valve stays in closed position and stops the flow of gas or liquid through it. However, in case of 12V DC supply for electromagnetic coil, there will be the creation of magnetic field; thus, by the help of spring, the plunger moves upwards.[11]

B. Software Components
1) Arduino IDE:
Arduino IDE is an application which is used as an Integrated Development Environment, and this software is free of cost and provides help to the user in developing codes that can run on the Arduino platform as well as on microcontrollers like NodeMCU ESP8266. This is a highly user-friendly application, and thus beginners can easily learn how to program using it. The programs developed through the Arduino IDE are known as sketches and are developed using C and C++ language.[12]

2) Blynk IoT (or ThingSpeak)
A platform called Blynk IoT provides the opportunity for the users to manage, monitor, and control their IoT devices via web/mobile applications. It is easy to build customized dashboards on the Blynk IoT platform thanks to widgets such as buttons, gauges, graphs, LEDs and notifications without writing lots of codes in the mobile app. The Blynk IoT platform supports popular microcontrollers such as NodeMCU ESP8266, ESP32, and Arduino. Blynk IoT employs various methods of communication including Wi-Fi, Ethernet and cellular communication networks. Blynk Cloud IoT serves for the storage of IoT device data and its connectivity to the internet.[13]

3) ESP8266 Board Package:
The Esp8266 Board Package is one of the most significant packages that make it possible for the user to upload and write the code using Arduino IDE on the ESP8266 board including NodeMCU ESP8266 and WeMos D1 mini. It is known that the ESP8266 board is not supported by the Arduino IDE; therefore, it becomes necessary to use the Esp8266 Board Package from the Boards Manager.[14]

4) Blynk Library / ESP8266WiFi Library:
The two important libraries that should definitely be included when you are implementing your IoT project through the NodeMCU ESP8266 board are the ESP8266WiFi library and the Blynk library.
While the function of the ESP8266WiFi library is to create a connection between the ESP8266 board and a wireless network and also control its Wi-Fi connectivity, the function of the Blynk library gains importance when creating a connection between the NodeMCU ESP8266 board and the Blynk cloud server.[15]

VII. WORKING PRINCIPLE

In the proposed IoT-based gas leakage detection system, there is continuous monitoring of the surroundings by means of the MQ-2 gas sensor. The gas sensor senses the presence of the gas in the surrounding and sends the readings to the NodeMCU ESP8266 microcontroller which then compares the readings with a certain threshold value.

Whenever the gas level crosses the threshold limit, then the NodeMCU triggers the buzzer alarm, immediately alerts the user through the Blynk IoT platform and actuates the relay to control the operation of the NC (Normally Closed) solenoid valve at 12 V DC.

VIII. RESULTS AND DISCUSSION

Gas Leak Detection System using IoT Technology is implemented by NodeMCU ESP8266, MQ-2 Gas Sensor, Blynk IoT, relay, and 12V DC Normally Closed Solenoid Valve. The Gas Leak Detection System based on the IoT can detect the amount of the gas concentration and act automatically when gas concentration level surpasses the threshold value. The gas leak is sensed by the MQ-2 gas sensor and the NodeMCU sounds buzzer along with message being sent via Blynk IoT and relay automatically closes the solenoid valve.

From the findings of the experiment, it is evident that the Gas Leak Detection System based on the IoT is capable of detecting the gas leak, monitoring it remotely, and controlling its flow.

IX. FUTURE SCOPE

However, in addition to this IoT-based system for gas leakage detection, there are certain sensors that can be used in detecting such gases as well. Artificial intelligence and machine learning capabilities can be utilized in order to predict the probability of gas leakage.
Moreover, the technology of GPS can also be used in locating the source of gas leakage in case of residential or industrial areas. Lastly, using GSM or cloud service, the firefighters can be informed about the probability of gas leakage.

X. CONCLUSION

The proposed IoT-based gas leak detector and gas shut-off mechanism provides an effective solution to the problem of natural gas safety in residential and small business settings.

Firstly, it should be acknowledged that the system would have an opportunity to use such components as an MQ-2 gas sensor, NodeMCU ESP8266 microcontroller, Blynk IoT application, relay module, and a 12V DC Normally Closed solenoid valve for gas leak detection and shut-off of the gas flow. It means that the suggested system is economically justified.

REFERENCES

[1] Farooq, M. S., R. Javid, S. Riaz, and Z. Atal, “IoT based smart greenhouse framework and control strategies for sustainable agriculture,” *IEEE Access*, vol. 10, pp. 99394–99420, Sep. 2022.

[2] M. Choche, A. Yadav, M. Shelke, and S. Tyagi, “Internet of Things based hazardous gas leakage detection system using Arduino UNO,” in Proc. Int. Conf. Innovative Computing & Communication (ICICC), 2021.

[3] N. R. F. Sujarwo, N. Kholis, L. Anifah, and F. Baskoro, “Design build of IoT based smart liquefied petroleum gas leakage detector with NodeMCU ESP8266 module,” in Proc. Int. Joint Conf. Science and Engineering (IJCSE), 2021.

[4] N. K. Jumaa, Y. M. Abdulkhaleq, M. A. Nadhim, and T. A. Abbas, “IoT based gas leakage detection and alarming system using Blynk platforms,” Iraqi Journal for Electrical and Electronic Engineering, vol. 18, no. 1, 2022.

[5] I. N. G. Adrama, G. Ramadhan, and I. W. Sukadana, “Design of monitoring and control system for LPG gas leakage using NodeMCU ESP8266,” Jurnal Ilmiah Telsinas, vol. 5, no. 1, 2022.

[6] M. I. Prananda, S. Syahputra, and M. A. Syari, “Design of an LPG leak detection system using IoT based MQ-2 sensor,” Journal of Artificial Intelligence and Engineering Applications, vol. 3, no. 1, 2023.

[7] V. S. Mayuri et al., “IoT based LPG gas leakage and level detection to avoid accidents,” International Journal of Research in Engineering, Science and Management, vol. 7, no. 2, 2024.

[8] “Enhancing gas leak detection with IoT technology: An innovative approach,” Procedia Computer Science, vol. 235, pp. 961–969, 2024.

[9] Espressif Systems, ESP8266EX Datasheet. Shanghai, China: Espressif Systems. [Online]. Available: Espressif Systems

[10] Hanwei Electronics Co., Ltd., MQ-2 Gas Sensor Technical Data (Datasheet). [Online]. Available: Hanwei Electronics

[11] Thomas, “Normally closed solenoid valves: Installation, operation, and applications,” 2025. [Online]. Available: Thomasnet

[12] Arduino, Using the Arduino Software (IDE).

[Online]. Available: Arduino Documentation
[13] Blynk Inc., Blynk Documentation. [Online]. Available: Blynk Documentation
[14] ESP8266 Community, Installing ESP8266 Board in Arduino IDE. [Online]. Available: ESP8266 Arduino Core Documentation
[15] Blynk Inc., Blynk Library *Documentation*. [Online]. Available: Blynk Documentation