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IoT Based Gas Leakage Detection and Ventilation for Home Using Solar

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Abstract

This project involves developing an IoT-based Gas Leakage Detection And Ventilation utilizing the ESP32 microcontroller with Manual Control & Monitoring System capabilities. It emphasizesthe creation of an intelligent exhaust fan setup utilizing environmental sensors like theMQ-2 Gas/Smoke Sensor and the DHT11 Humidity Temperature Sensor, to monitor factors such as gas levels, temperature, and humidity. Data collected from these sensors is transmitted to the Blynk Dashboard for real-time monitoring. A significant aspect of the project is the automation of the exhaust fan, which is connected to a 7V DC power supply via a relay. The fan's operation is regulated based on the gas levels detected by the MQ-2 sensor. In the event of high gas levels, the system automatically activates the fan to ventilate the area, thereby enhancing safety and improving air quality. Furthermore, the system offers manual control of the fan through the Blynk Dashboard. This feature allows users to override the automated settings as needed, providing personalized control tailored to individual preferences or requirements. This IoT-based solution integrates smart monitoring and control technology for an exhaust fan, demonstrating the practical application of IoT in enhancing home and environmental safety.

1. Introduction

The unintended discharge of gases from a pipeline, storage tank, or other containment system such as natural gas, propane, or other dangerous gases is referred to as gas leakage [1]. Gas leaks can happen for several causes, such as broken pipes, faulty installation, or human mistakes. Disasters like hurricanes, floods, and earthquakes can also cause gas leaks. Gas leaks can cause both financial and personal harm, thus it's critical to have trustworthy methods for sensor-based leak localization and detection [2]. There are serious safety risks related to these leaks, such as the possibility of fire, explosions, and health problems.

Natural gas, a fossil fuel mostly made of methane, is the gas most frequently utilised in a kitchen. It operates several kitchen equipment including stoves, ovens, and grills in addition to being used for cooking and heating. Utility pipes are used to supply natural gas to residences and other structures. It is renowned for being easy to use, reasonably priced, and a clean-burning fuel that emits less greenhouse gases and causes less pollution than other fossil fuels like coal and oil. Although natural gas has no smell and is colorless, mercaptan, an odorant, is added to give it a distinct fragrance so that leaks may be easily found. In addition, it serves as a raw material for the synthesis of chemicals and fertilisers as well as a motor fuel. Apart from that, propane is frequently used in kitchens as a fuel, particularly in places where natural gas infrastructure is not easily accessible [1]. Among the gases found in the Bunsen burner that are frequently seen in school labs is propane. Propane is a highly flammable gas, despite being commonly used and thought to be safe when handled correctly.

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 276-287

Moreover, a ventilation system replaces or modifies the air in any area to regulate temperature and get rid of things like moisture, smoke, dust, foul oduors, microbes, and more [1]. A ventilation system is used when there is a gas leak to evacuate the leaking gases swiftly and efficiently from the region, reducing the possibility of an ignition or injury to those in the vicinity.

2. Literature Review

2.1 A smart gas leakage monitoring system for use in hospitals

In 2020, Nadia Mahmood Hussien, Yasmin Makki Mohialden, Nada Thanoon Ahmed, Mostafa Abdulghafoor Mohammed, and Tole Sutikno proposed a smart gas leakage monitoring system for hospitals. The system uses Arduino to detect gas leaks and sends notifications to users' mobile devices via the GSM network. The system uses two types of MQ sensors: MQ-6 for identifying LPG, butane, and propane, and MQ-2 for hydrogen, propane, and butane. When a leak occurs, the gas sensor sends a signal to the microcontroller, which processes the signal and sends notifications to external devices like an LCD, buzzer, and a GSM module. The alarm sends notifications until an accepting reply message is received. The gas sensors continuously scan for gas and detect leaks based on a predefined threshold. [6]. The system works independently of human entry and works dependably when the human or the responsible operator presses the push button switch when any leak occurs.

2.2 Automatic Temperature Control System Based on PIC Controller for Smart Ventilation Fan

In 2017, N. N. S. N. Dzulkefli et al. proposed an Automatic Temperature Control System for a Smart Ventilation Fan using a PIC Controller. The system integrates a microcontroller and LM35 temperature sensor to regulate fan speed based on user-defined temperature settings. The PIC16F887 microcontroller manages both the fan and a buzzer, activating the fan when room temperature exceeds the user-set threshold, and triggering the buzzer for overheating alerts. This setup ensures efficient climate control, offering a cost-effective alternative to energy-intensive air conditioning [9]. By using a microcontroller and temperature sensor to monitor and adjust the fan speed based on user-set temperature values, the system can help maintain a comfortable environment for residents while also being more economical compared to air conditioners that use a lot of electricity. The circuit is designed to be easy to use and can be applied in large spaces or during hot weather to improve cooling efficiency.

2.3 LPG Gas Leakage and Alert System

In 2017, E. Jebamalar Leavline et al. proposed an LPG Gas Leakage Detection and Alert System aimed at enhancing safety by detecting LPG gas leaks promptly. The system employs an MQ-6 gas sensor known for its high sensitivity and rapid response to detect LPG gas leaks effectively. It is designed to operate on battery power for portability but can also function with AC power using a bridge rectifier and IC7805 regulator for a stable +5V supply. The primary goal is to prevent fire accidents and injuries caused by the highly inflammable nature of LPG gas, alerting individuals onboard upon detection of gas leakage [8]. When the sensor detects LPG gas leakage, it triggers an alarm to alert people onboard. The system is designed to be simple, reliable, and effective in preventing fire accidents caused by LPG gas leakage. This project also highlights the importance of developing a gas leakage alert system to prevent fire accidents caused.

2.4 Design and Implementation of a Smart home Gas Detection Based on Mobile Network System

Ammar F. Abbas, and Mahmood Z. Abdullah proposed Design and Implementation of a Smart home Gas Detection Based on Mobile Network System published in 2021. This project is a low-cost system that uses a gas sensor and mobile network to detect gas leaks in smart homes. Depending on the speed of the mobile phone network, the system may be modified to function with various types of gas installations and appliances. It also delivers a clear message to the user or the emergency department in the city. The system for gas leak detection and alerting works by using a gas sensor to measure the value of gas in the atmosphere. After initialization, the MQ-6 gasses sensor reads the ratio of gases in the air and sends the signal to the ESP32 microcontroller. If there is a gas leak, the ESP32 will send a signal to the SIM900 module that already has a specific message to send to the user to alarm them about the gas leak in the area [12]. The system sends an alarm message to the home user after detecting gas in the air. Additionally, the system is interesting for being reasonably priced and enabling the user to keep an eye on the gas leak within their home from the outside.

3. Methodology

3.1 System Block Diagram

The development of gas leakage detection and ventilation systems for homes based on IoT will be discussed in this chapter. The block diagram and flow chart of the project will be provided to explain more details about the entire project.

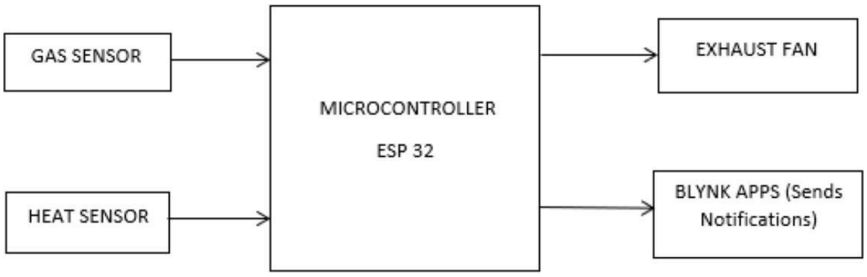


Figure 1: Project's block diagram

Figure 3.1 shows an overall block diagram of this project. The project utilizes an MQ-2 gas sensor and a DHT 11 temperature/humidity sensor for input, controlled by a Node MCU ESP 32 microcontrollers. Outputs include an exhaust fan and notifications through the Blynk app. The system detects gas leaks and high temperatures, prompting alerts and allowing users to activate the fan remotely for safety and comfort.

3.2 Hardware Development

At this point, the system's required hardware components are determined. This step includes a list of components, their functions, a schematic picture of the hardware, and pin connections. A schematic design of the hardware system is displayed in Figure 2. The graphic prominently displays the primary components that are used. Table 1 the pin connections between the relay module, MQ-2, ESP32, and DHT- 11, while Table 2 lists the components along with their specifications and functions.

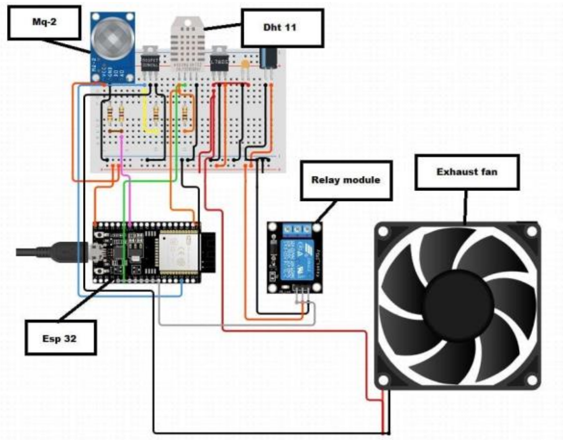


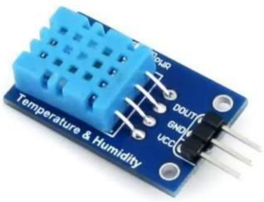
Figure 2: Schematic diagram of the project

Two exhaust fans are connected as the output to the GND at the ESP32 via theCOM at the relay module. The MQ-2, DHT 11, and relay module ports that were connected to the ESP32

ESP 32	MQ-2	DHT 11	Relay Module
V5	VCC	VCC	VCC
G26	-	-	IN
G23	-	-	
G22	-	AO	-
G34	AO	-	-
GND	GND	GND	GND

Table 1: Pin Connection Between ESP 32, MQ-2, DHT 11, and Relay Module

List of components

Components	Function	Specification
Node MCU ESP 32 	Act as a microcontroller and generate command tooutput.	a) Built-in with WiFi andBluetooth. b) Built-in flash memory forprogram storage.
MQ-2 Gas Sensor 	Act as the input to detectgas leakage.	a) Semiconductor sensingtechnology. b) Can detect a variety of gas including Methane (CH4),Propane(C3H8), Butane(C4H10), c) Detection range is 300-10 000 ppm
DHT 11 Temperature and HumiditySensors 	Act as the input which is temperature sensing.	a) The DHT11 sensor is compact and has a small size, making it suitable for use in space-constrained environments. b) Temperature range is 0°C- 50°C
DC 5V Fan 	Act as the output which is exhaust fan helping to improve air circulation in helping heat and gas emissions.	a) The speed of the fan is 6500rpm.

		b) Compact size making it suitable for use in small electronics projects. c) Designed to operate efficiently at low voltage of 5V
Relay Module 	Switch high voltage devices using a lowerpower control.	a) Compatible with any b) Digital output controllable c) Maximum switching voltage 250 VAC/ 30 VDC

Table 2: List of components with The Functions and Specifications

3.3 Software Development

This section describes the appropriate software needed for the monitoring system in this project. The system flowchart created for this project is displayed in Figure 3. The Arduino IDE editor was utilized to write code for the ESP32 microcontroller and to integrate system input and output features for usage with web- based applications. A collection of programs employing the C++ programming language was constructed.

Blynk was selected for this project because it offers real-time IoT (Internet of Things) monitoring capabilities. With its array of widgets that users may add to the interface of mobile apps, Blynk is a platform that lets users design unique mobile apps for remote control and monitoring of multiple devices.

The Blynk app is set up in this project to monitor temperature and gas levels in real time. The user will receive alarm notifications via email and the app. A programmable switch to activate exhaust fans is provided for high temperature monitoring to fully utilize Blynk's capabilities.

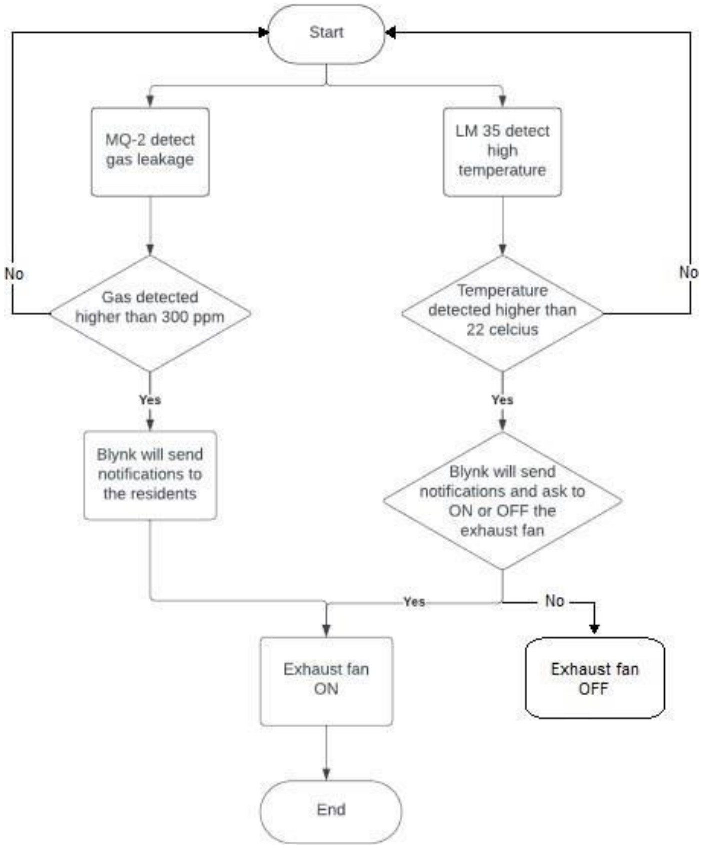


Figure 3: Project Flowchart

Blynk's App

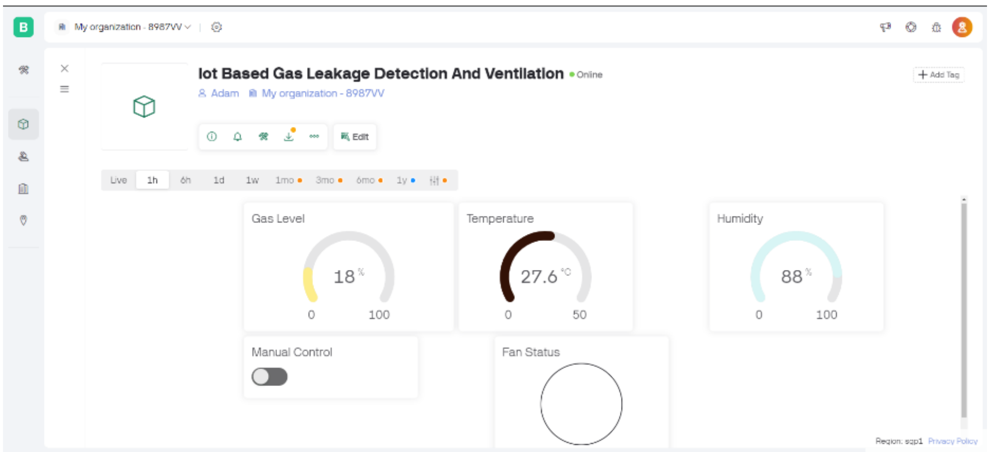


Figure 4: Project Design in Blynk's App

Integrating Blynk apps into an IoT-based system for gas leakage detection and ventilation enhances home safety by providing real-time notifications and remote- control capabilities. This allows for swift responses to potential risks and user -friendly monitoring and control. Including gauges displaying temperature values in Celsius and gas levels in parts per million (ppm) offers users clear and understandable information about current environmental conditions, facilitating prompt analysis and action if necessary. Moreover, incorporating a switch button for controlling the exhaust fan adds convenience and versatility for users. In the event of high temperatures, users can manually activate or deactivate the exhaust fan, granting them greater control over their home environment. Additionally, automated activation of the exhaust fan in response to a gas leak enhances safety measures by swiftly venting harmful gases from the premises. By integrating gas leakage detection, temperature monitoring, and ventilation control through Blynk apps, this initiative provides users with a comprehensive solution for safeguarding their homes and loved ones from potential hazards.

3.4 Project Testing

The purpose of this test is to ensure that the software and hardware are operating properly. The two components of this project's testing are the DHT 11 temperature and humidity sensor and the MQ-2 gas sensor. The MQ-2 gas sensor detects the presence of flammable and dangerous gases. Aerosol spray cans (used for insect repellent and deodorant) and lighters are the test subjects for hazardous gas. Additionally, lighter is utilized as a test subject for DHT 11's high temperature testing.

3.5 PPM

For gas concentration, volume fraction or mole fraction units are commonly employed. Part per million, or ppm, is the value fraction that is most frequently employed. Parts per million (ppm) is a unit of measurement that is used to represent the concentration of a particular gas in a mixture. Equation (1) is the calculation usedin the field of gas concentration measurement.

$$ppm = \frac{mass\ of\ solution\ gas\ (g)}{mass\ of\ gas\ solution\ (g)} x\ 10^6$$

The formula, multiplied by 10^6 for the ppm unit, indicates the ratio of the volume of gas to be measured to the total volume of the mixture. This measurement technique is especially relevant when using gas sensors such as the MQ-2, which provide output signals according to gas concentrations.

4. Development of Prototype

A gas value taken and the notifications from Blynk and e-mail will be presented as a result. An explanation will be given for each result taken.

4.1 Prototype Design

Figure 4.2 shows the model house installed with gas leakage detection and ventilation system. The exhaust fan and control box are shown in the figure below.

Figure 4: House's Replica Installed with Gas leakage Detection and Ventilation System

4.2 Testing Result

Subject	Value (ppm)
Lighter	1448
Deodorant spray	1245
Mosquito spray	1327

Table 2: Gas Reading Value Taken from The Test

a) Lighter

Butane gas is usually found in lighters. Because it burns cleanly, butane is a highly flammable hydrocarbon gas that is frequently used in portable lighters. It is an odourless, colourless gas that vaporizes readily at room temperature, making it a good choice for lighting. Because it creates a steady flame and is convenient to store in pressurized containers butane is frequently used in lighters.

b) Deodorant Spray

Compressed gases such as butane, isobutane, or propane are commonly used as propellants in deodorant sprays. These gases assist in releasing the deodorant product from the container, just like mosquito sprays practice. Hydrocarbon gases that are easily compressed into a liquid condition for storage include propane, butane, and isobutane. They were picked because they can build up pressure inside the container and, when the valve is opened, discharge the substance as a fine mist.

c) Mosquito Spray

Propane or butane are common propellant gases found in mosquito repellents. The active substances (such as insecticides or repellents) are propelled out of the canister by means of these gases. Hydrocarbon gases such as propane and butane are frequently utilized as propellants because of their capacity to generate pressure inside the canister, which facilitates the efficient dispersion of spray.

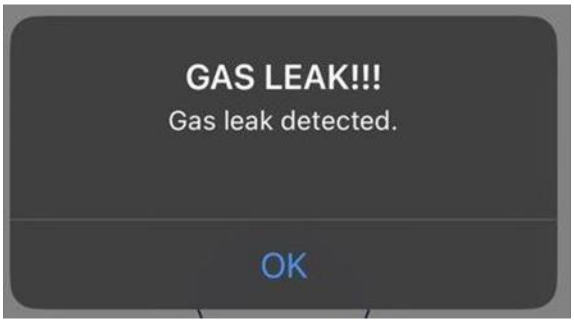


Figure 5: Notification's Alert When Gas Leakage Detected.

Figure 6: Notification Alert When High Temperature Detected.

Figure 7: Notification Alert from Blynk Apps and E-Mail.

Table 2 shows gas leakage values obtained from testing with three subjects. Figure 5 illustrates the notification alert triggered by gas leakage detection, coinciding with the operation of the exhaust fan. Figures 6 and 7 depict notifications sent via Blynk and email for high temperature detection, with Blynk prompting users to activate the exhaust fan if temperatures exceed 30°C.

5. Conclusion

5.1 Conclusion

The Gas Leakage Detection and Ventilation System for Kitchens, built on IoT technology, has been successfully developed and tested, representing an innovative approach to enhancing home safety. By integrating the MQ-2 gas sensor, DHT11 temperature and humidity sensor, Node MCU ESP32 microcontroller, relay module, and Blynk app, the system enables real-time monitoring and immediate user alerts in case of a gas leak or high temperature. Acting as a central hub, the Blynk app not only notifies users of emergencies but also provides control over the ventilation system. This integration of technologies addresses crucial safety concerns, offering homeowners a comprehensive solution that combines rapid hazard response with user-friendly control for increased comfort and safety. Considerations for calibration and the potential for future sensor expansion demonstrate the project's commitment to ongoing improvement in ensuring the reliability and effectiveness of home safety systems.

5.2 Limitation

While an Internet of Things-based gas leak detection and ventilation system offers a comprehensive safety solution for homes, it does have its limitations. One major drawback is its reliance on Wi-Fi connectivity for remote control and monitoring via the Blynk app. In areas with poor or inconsistent Wi-Fi service, the effectiveness of remote control and real-time notifications may be compromised. Additionally, the system's dependence on electricity for powering the ventilation system, microcontroller, and sensors could pose challenges during blackouts, rendering the device inoperable when most needed.

Moreover, the system's ability to identify hazards is limited as it relies on sensors like the MQ-2 and DHT 11, which may not detect all gases or environmental conditions. Despite detecting gas leaks and activating ventilation automatically, the system may not address all possible sources of gas leaks or effectively mitigate hazards in every scenario. Furthermore, proper installation, calibration, and maintenance are crucial for optimal system functionality, necessitating skilled technicians and regular inspections to ensure peak performance. Addressing these issues with backup power supplies, alternative communication channels, and enhanced sensors could enhance the system's reliability and usability across various residential settings.

5.3 Recommendation

Several recommendations can enhance the effectiveness and user- friendliness of the Internet of Things-based gas leak detection and ventilation system in residential buildings. Firstly, ensuring uninterrupted monitoring and response capabilities during power outages can be achieved by incorporating battery backup or alternative power sources such as solar panels. Additionally, utilizing alternative communication channels like GSM or Bluetooth can enhance connectivity resilience, ensuring reliable control and notifications even in areas with unreliable Wi-Fi coverage. To enhance hazard detection and provide comprehensive safety coverage, expanding the sensor array to include additional gas sensors capable of detecting gases beyond flammable ones, such as carbon monoxide, is advisable.

Furthermore, incorporating data analytics or machine learning techniques could enable the system to adapt and improve its sensitivity to household consumption patterns, enhancing gas leak detection and ventilation control over time. Simplifying setup and operation can be achieved by offering homeowners clear instructions for installation, calibration, and maintenance, coupled with user-friendly interfaces, ensuring they can effectively maintain and operate the system. Moreover, providing remote assistance and troubleshooting facilitates swift resolution of technical issues, ensuring system reliability and customer satisfaction. Implementing these recommendations can elevate the functionality, reliability, and user acceptance of the Internet of Things-based gas leak.

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