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IoT-Enabled Remote Air Pollution Monitoring and Real-Time Hazard Notifications

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ABSTRACT

This project presents an IoT-based real-time indoor air quality monitoring and alert system using the ESP8266 microcontroller. The system continuously monitors indoor environments to detect harmful gases and ensure human safety. It integrates MQ-135, MQ-7, and MQ-5 gas sensors to measure air pollution, carbon monoxide, and flammable gas leakage, respectively. These sensors collect real-time environmental data related to air quality. The sensed data is processed and transmitted wirelessly to an IoT cloud platform. This allows real-time visualization and remote monitoring of air quality parameters. An LCD display is used to show live sensor readings locally. A buzzer alert system provides instant warnings when gas concentrations exceed safe limits. The system enables early detection of hazardous gas leaks. Overall, it offers a cost-effective, energy-efficient, and reliable indoor air monitoring solution.

INTRODUCTION

Air pollution and the presence of hazardous gases in indoor environments have become a serious concern due to their negative impact on human health and safety. Rapid industrialization and urbanization have significantly degraded indoor air quality, leading to respiratory illnesses and other health issues. Harmful gases such as carbon monoxide, toxic pollutants, and flammable gases often go unnoticed until they reach dangerous levels. Existing air monitoring systems are either costly or lack real-time alert capabilities. Hence, there is a growing need for an affordable and intelligent indoor air monitoring solution. The Internet of Things (IoT) enables real-time data collection, remote monitoring, and instant alerts through connected sensors and cloud platforms. IoT-based systems are highly effective for safety-critical applications. Indoor spaces like homes, offices, laboratories, and industries are especially vulnerable to gas leaks and poor air quality.

Carbon monoxide is particularly dangerous because it is colorless and odorless. This project proposes an IoT-enabled real-time indoor air monitoring and alert system using ESP8266 to enhance safety and indoor environmental quality.

LITERATURE SURVEY

The literature review emphasizes the significance of IoT-based systems for indoor air quality and gas monitoring. Most studies focus on detecting harmful gases such as carbon monoxide, flammable gases, and air pollutants. IoT technology enables real-time data collection, cloud storage, and remote monitoring. Microcontrollers like ESP8266 are commonly used due to their low cost and wireless capability. Real-time alert mechanisms improve user safety during hazardous conditions. Cloud platforms support data visualization and long-term analysis. Many systems are designed for homes, offices, and industrial environments. Energy efficiency and scalability are highlighted as key advantages. Experimental results show reliable and accurate gas detection. Overall, the studies confirm IoT as an effective solution for smart indoor air quality management.

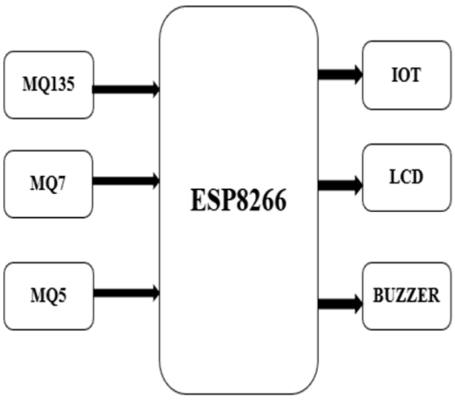
EXISTING SYSTEM

In the existing system, indoor air quality monitoring is mainly performed using conventional standalone devices and manual methods. Traditional gas detectors are designed to sense only specific gases such as carbon monoxide or LPG. These systems provide alerts only when gas levels exceed preset thresholds. Most existing devices operate independently without continuous monitoring or data storage capabilities. Alerts are usually limited to local indicators like LEDs or buzzers. Remote monitoring and real-time access to air quality data are not supported. Conventional systems lack cloud integration and data visualization features. Many systems monitor only a single gas, resulting in incomplete air quality assessment. Manual inspection increases the risk of delayed detection of hazardous gases. Overall, existing systems are often bulky, expensive, and difficult to scale.

PROPOSED SYSTEM

The proposed system is built around the ESP8266 microcontroller, which serves as the main processing and communication unit. It is chosen for its low power consumption, built-in Wi-Fi, and IoT compatibility. The system integrates MQ-135, MQ-7, and MQ-5 gas sensors for comprehensive air quality monitoring. MQ-135 detects general air pollutants, while MQ-7 monitors carbon monoxide levels. MQ-5 is used to sense flammable gases such as LPG and methane. These sensors continuously monitor the surrounding air and generate analog signals. The ESP8266 processes the sensor data in real time using predefined safety thresholds. Sensor readings are transmitted to an IoT cloud platform via Wi-Fi. Real-time data visualization and logging are supported through web or mobile applications. A buzzer alert is activated when gas levels exceed safe limits, ensuring immediate user awareness.

BLOCK DIAGRAM



HARDWARE REQUIREMENT

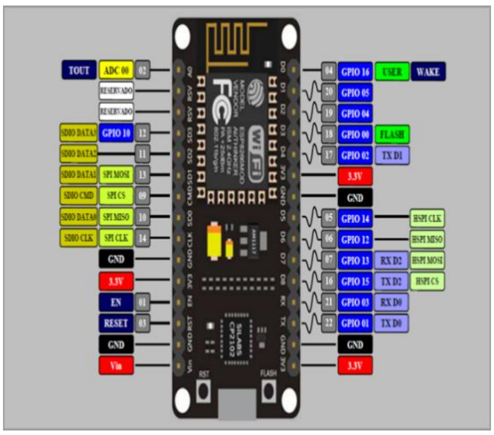


Fig:1 ESP8266

The ESP8266 is a low-cost, low-power Wi-Fi microcontroller widely used in IoT applications. It integrates a full TCP/IP stack, enabling direct internet connectivity without external modules. The controller supports 32-bit processing and operates at a clock speed of up to 80 MHz. ESP8266 can be programmed using Arduino IDE, NodeMCU, or MicroPython. It features multiple GPIO pins for interfacing sensors and peripherals. The module supports UART, SPI, and I²C communication protocols. Its compact size makes it suitable for embedded and portable applications. ESP8266 is commonly used for smart home and monitoring systems. It offers reliable wireless communication with minimal power consumption. Overall, the ESP8266 is an efficient and versatile platform for IoT development.

Fig:2 MQ-5

The MQ-5 gas sensor is used to detect flammable gases such as LPG, methane, and natural gas. It operates using a tin dioxide (SnO_2) sensing element whose resistance changes in the presence of combustible gases. The sensor provides analog output proportional to gas concentration levels. An internal heating element is required for proper operation and accurate sensing. MQ-5 is widely used in gas leakage detection and safety systems.

Fig:3 MQ-7

The MQ-7 is a widely used carbon monoxide (CO) gas sensor designed for air quality monitoring applications. It can detect CO concentrations ranging from 20 to 2000 ppm, making it suitable for both safety and environmental systems. The sensor employs tin dioxide (SnO_2) as its sensitive material, which changes conductivity in the presence of CO gas. It offers both analog and digital outputs, allowing easy integration with microcontrollers such as Arduino. The MQ-7 requires a 5V power supply and operates using a specific heating cycle that includes a high-temperature cleaning phase and a low-temperature sensing phase to ensure accurate detection. It is commonly used in CO leak detectors, indoor air quality systems, and smart home devices. The sensor is compact, cost-effective, and well-suited for real-time gas monitoring. For reliable performance, proper calibration and a warm-up period are essential. Its versatility and user-friendliness make it a popular choice in embedded and IoT-based air quality solutions.

Fig:4 MQ-135

The MQ-135 is a versatile air quality sensor capable of detecting a wide range of harmful gases such as ammonia, nitrogen oxides, alcohol, benzene, smoke, and carbon dioxide. It operates on a 5V power supply and offers both analog and digital outputs, making it easy to interface with microcontrollers like Arduino. The sensor uses a tin dioxide (SnO_2) sensing layer, which varies its resistance based on the concentration of gases in the air. It is widely used in environmental monitoring systems for homes, offices, and industrial settings. Due to its broad sensitivity, the MQ-135 is ideal for detecting indoor air pollutants. Accurate readings require proper calibration, often using clean air as a baseline. The module includes a built-in potentiometer to adjust the digital output sensitivity threshold. Its compact size, affordability, and user-friendly design make it a popular choice for real-time air quality applications. A preheating phase is necessary to ensure stable and accurate performance. Overall, the MQ-135 is a reliable and effective solution for monitoring air pollution.

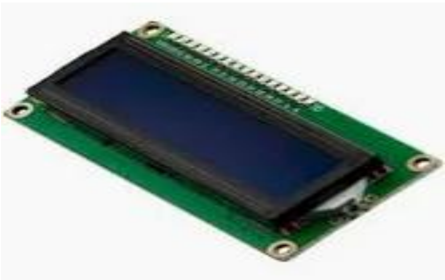
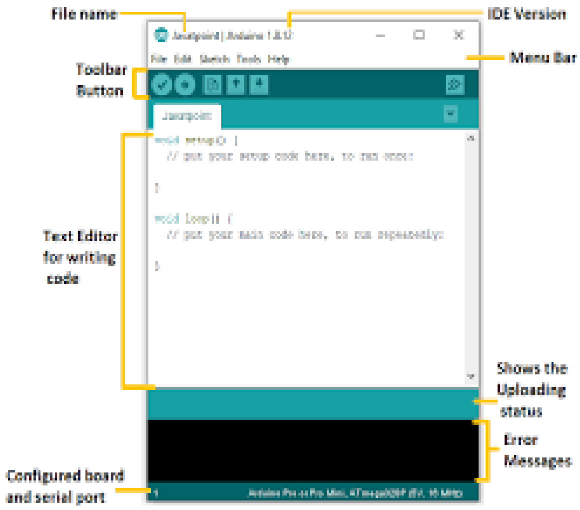


Fig:5 LCD DISPLAY

An LCD (Liquid Crystal Display) is a widely used flat-panel display technology designed to show characters, numbers, or simple graphics. It works by controlling the passage of light through liquid crystals using electric signals. In embedded systems, popular LCD types include the 16x2 and 20x4 modules, which can display 16 or 20 characters per line across 2 or 4 lines, respectively. These modules are commonly interfaced with microcontrollers like Arduino, using either parallel or I2C communication protocols. Each character on the display is formed using a dot matrix arrangement of pixels. LCDs typically operate at 5V and include features like a backlight and contrast adjustment for clear visibility in different lighting conditions. They are frequently used in digital clocks, meters, control panels, and other embedded interfaces.

SOFTWARE REQUIREMENT

Arduino Software (IDE)



The Arduino IDE (Integrated Development Environment) is a simple yet powerful platform used to program Arduino boards. It supports C and C++ programming languages with an easy-to-understand syntax tailored for microcontroller applications. The IDE provides a clean and intuitive interface where users can write, compile, and upload code directly to Arduino hardware. It includes a rich set of built-in libraries, making it easy to perform common tasks such as reading sensors, controlling LEDs, or operating motors. The integrated Serial Monitor allows real-time communication and debugging between the Arduino and the computer. Compatible with Windows, macOS, and Linux, the IDE is accessible across multiple platforms.

Users can extend its functionality using the built-in Library Manager, which offers access to numerous community-developed libraries. As an open-source tool, the Arduino IDE can be customized to fit specific development needs.

CONCLUSION

This project successfully demonstrates an IoT-enabled real-time indoor air monitoring and alert system using the ESP8266 microcontroller. The integration of multiple gas sensors allows effective detection of air pollution, carbon monoxide, and flammable gas leaks. Sensor data is continuously monitored and transmitted to a cloud platform for real-time access. A local LCD display provides instant visibility of air quality parameters. The buzzer alert mechanism ensures immediate warning during hazardous conditions. The system enhances user awareness and safety through timely alerts. It is designed to be cost-effective and reliable. Overall, the solution offers an efficient approach to improving indoor air quality and human safety.

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