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DEVELOPMENT OF A SMART FIRE SAFETY SYSTEM WITH AUTOMATIC SUPPRESSION AND EMERGENCY COMMUNICATION

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ABSTRACT

This paper presents the development of an automated gas leakage and fire detection system designed to quickly identify hazards, alert individuals, and mitigate damage without human intervention. Utilizing an ESP8266 Node MCU microcontroller, an MQ-2 gas sensor, and IoT cloud computing via Adafruit IO, the system provides real-time monitoring and automated emergency responses. Upon detecting gas concentrations exceeding a specified threshold, the system triggers local actuators (a buzzer and an exhaust motor) and sends auto-generated email alerts to designated authorities or users.

Keywords: Smart Fire Safety System, IoT, Fire Detection, Gas sensor, Temperature Monitoring

1. INTRODUCTION

Automation involves the use of control systems, such as sensors, to manage machinery and processes, thereby reducing the need for human intervention. In the context of fire safety and hazardous environments, automation can substantially increase safety by replacing humans in dangerous tasks and ensuring 24/7 protection. The primary objective of this research is to develop an automated leakage detection system that detects fires quickly, alerts people, and extinguishes the hazard before it causes significant damage. The system is designed to activate automated actuators, such as an exhaust motor and a buzzer, and to convey auto-generated alert messages through email to the local fire safety department.

2. HARDWARE AND COMPONENTS

The system's architecture relies on several interconnected electronic components:

- **Microcontroller:** The ESP8266 Node MCU is a low-cost, low-power Wi-Fi System on a Chip (SoC) that brings IoT capabilities to the project, allowing the module to transmit and receive information over a Wi-Fi network.
- **Gas Sensor:** An MQ-2 Metal Oxide Semiconductor (MOS) gas sensor is used to detect combustible gases like Methane, Butane, LPG, Propane, Hydrogen, and smoke. It has a high sensitivity detection range of 300 to 10,000 ppm.
- **Actuators and Switching:** A 5V passive buzzer is implemented to provide an audible alarm. To drive high-power AC applications (like the exhaust motor) using the low-power signals from the ESP8266, an electro-mechanical relay is used as an AC switch. A BC547 NPN bipolar junction transistor is used for current amplification and fast switching to operate the actuators.
- **Safety and Indication:** A protection diode is connected to the relay to shield the ESP8266 from reverse current originating from the AC supply side. Light Emitting Diodes (LEDs) are used as indicators: Red for power supply, Green for exhaust status, and Blue for alarms.

3. SYSTEM DESIGN AND METHODOLOGY&PRINTED CIRCUIT BOARD (PCB) DESIGN

The hardware was assembled on a custom Printed Circuit Board (PCB) to ensure highly

efficient, low-maintenance, and clean connections. The PCB schematic was created using EAGLE software, which allows for precise virtual component placement. The circuit pattern was printed onto high-quality paper using a laser printer and transferred to an oxide-free copper board via the application of heat. After masking, the board was etched by dipping it into an aqueous solution of Ferric Chloride (*FeCl*3) to dissolve the exposed copper and isolate the tracks. Finally, the components were assembled and secured using a soldering iron and tin solder.

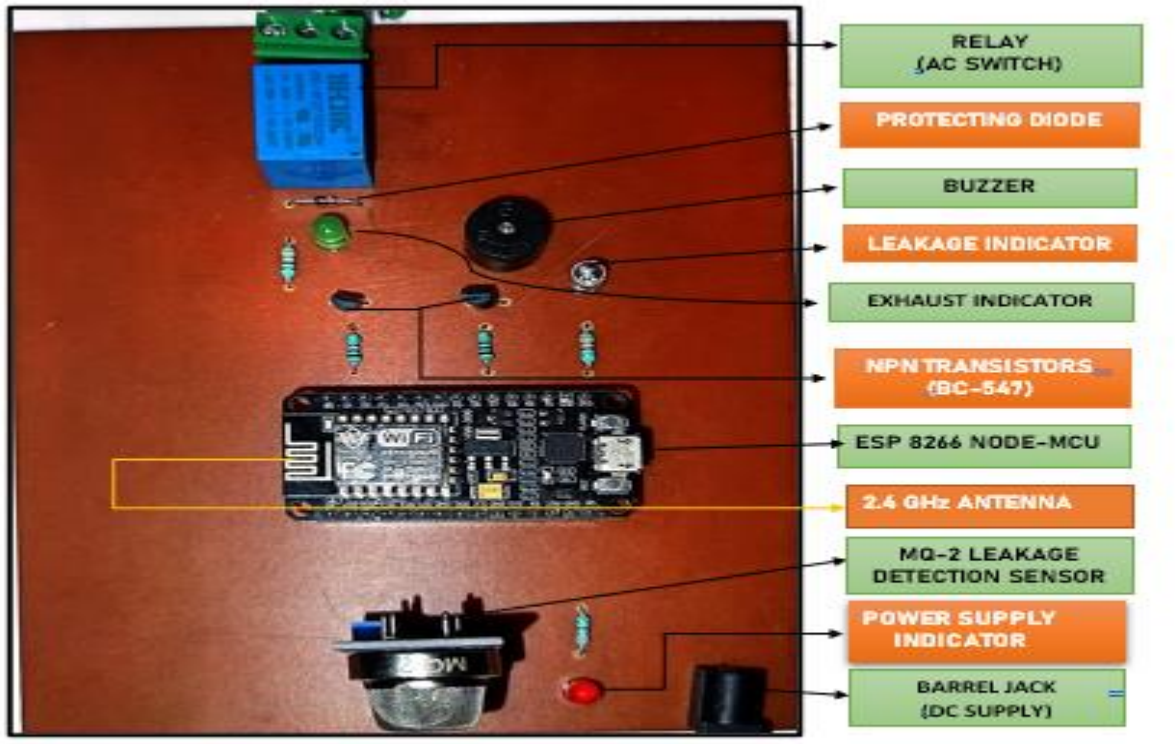

Figure 32:

PCB board after being assembled & soldered completely.

3.2 IoT Implementation and Operating Logic

The ESP8266 module was programmed using the open-source Arduino IDE software. To enable cloud communication, the Adafruit IO platform was integrated into the system by installing the Adafruit MQTT library.

The operating logic continuously reads analog input from the MQ-2 sensor. If the detected gas level exceeds 175 ppm, the microcontroller simultaneously executes three actions:

1. It switches the buzzer ON.
2. It switches the exhaust motor ON via the relay.

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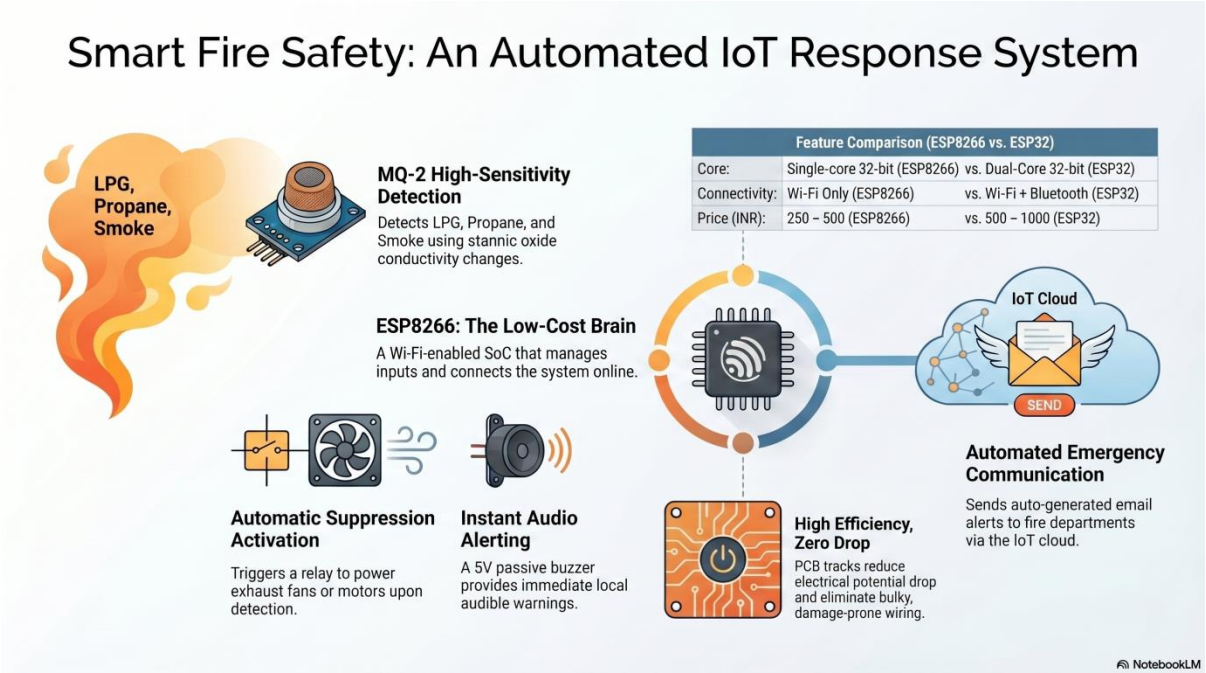
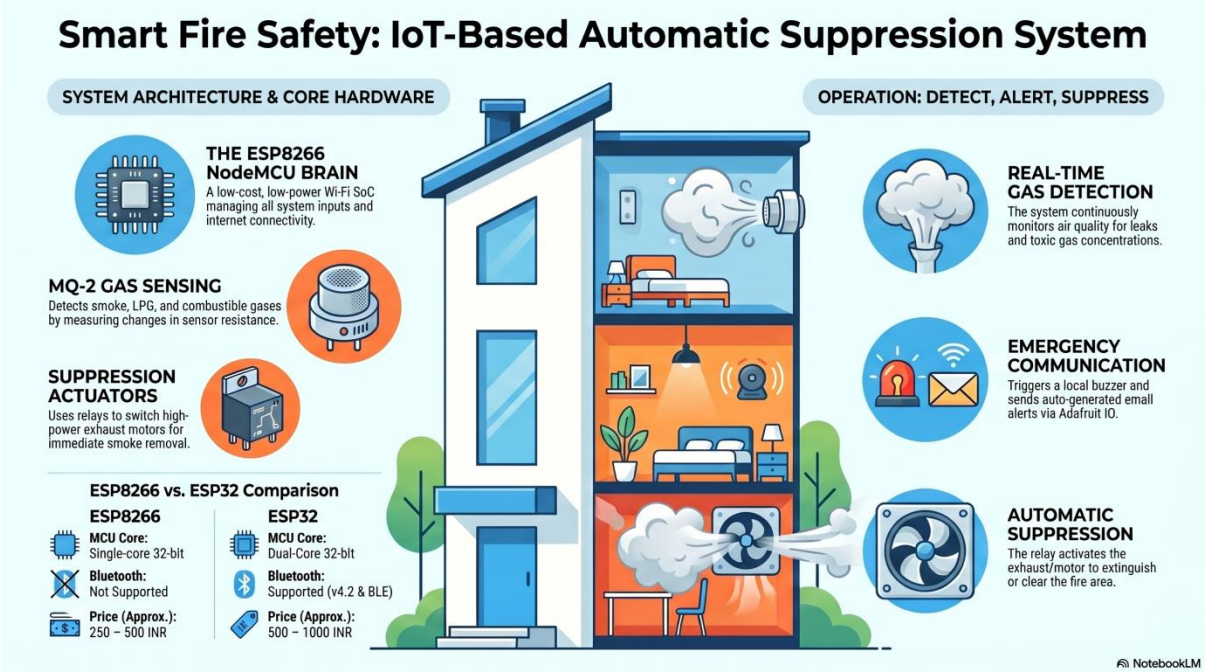
3. It publishes a signal to the Adafruit IO cloud, triggering a reactive action that immediately emails a pre-configured alert message ("!!!Attention!!! Fire detected at your home... leakage value is greater than 175 ppm").



4. RESULTS AND APPLICATIONS

The system was tested in a residential kitchen environment. When gas leakage occurred and surpassed the 175 ppm threshold, the sensor successfully detected it, the system relayed an email alert to the user, triggered the audio alarm, and activated the protection circuitry (motor/exhaust). Due to its successful deployment, this system can be widely applied in:

- Portable gas detectors for underground coal miners.
- Industrial settings that are highly prone to gas leaks or smoke exposure, such as plastic producing industries.
- Household kitchens near gas outlets to provide early detection.



5. FUTURE SCOPE

Future enhancements to this system could include:

- Integrating a water pipeline facility that can be automatically accessed in the event of a fire.
- Adding Bluetooth or GSM modules to alert users who are within physical proximity but do not have active internet connections.
- Incorporating a pressure sensor inside the cylinder pipe to detect internal pressure drops, providing an additional layer of leak detection before the gas fully escapes.

6. CONCLUSION

This research successfully addresses the risks associated with household and industrial LPG leakage by developing a smart, automated safety system. By automatically switching on actuators like exhaust fans and alarms, the system mitigates the danger instantly. Furthermore, utilizing the ESP8266 and Adafruit IO allows the sensor data to be transmitted wirelessly over the internet to portable devices such as smartphones and laptops. If implemented widely according to safety guidelines, this system has the potential to drastically reduce fatal accidents, save lives, and protect critical infrastructure.

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