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Minimizing Cigarette Smoke Exposure Based on IoT Using Automatic Filtration and MQ-2 Sensor

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ABSTRACT

This study designs and implements an Internet of Things (IoT)-based system to minimize cigarette smoke exposure in enclosed spaces. The system uses an MQ-2 sensor integrated with an ESP32 microcontroller, along with automatic fan-based filtration and a HEPA + activated carbon filter. The method used is research and development (R&D) through the design, implementation, testing, and analysis stages. The results show that the MQ-2 sensor is able to detect cigarette smoke concentrations in real time and transmit data to the Thinger.io platform. An LED traffic light indicator system is used to show air quality status, while an automatic relay controls the fan to speed up the filtration process. The trial showed that the system was able to reduce cigarette smoke levels by more than 70% and provide warning notifications to users. Thus, this system has the potential to increase awareness of active smokers and protect passive smokers in the household environment.

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1. INTRODUCTION

Exposure to cigarette smoke within households has been recognized as one of the major risk factors affecting human health, particularly among children and the elderly. According to the World Health Organization, prolonged exposure to secondhand smoke can lead to respiratory illnesses such as asthma, bronchitis, and pneumonia, as well as delayed lung development in children [1]. The problem becomes more severe in enclosed spaces where limited air circulation causes harmful particles and toxins to accumulate [2]. This condition highlights the urgent need for an automatic, technology-based intervention capable of detecting and reducing smoke exposure in real-time to maintain healthy indoor air.

The Internet of Things (IoT) has emerged as a promising solution for creating real-time environmental monitoring systems. IoT technology enables interconnected devices to communicate and respond automatically through wireless networks [3]. In air quality management, IoT allows the integration of sensors that can detect the presence of pollutants such as cigarette smoke and trigger automated filtration mechanisms [4]. Through cloud connectivity, such systems can transmit sensor data for analysis and control air-cleaning devices without manual operation.

A crucial component of such systems is the MQ-2 gas sensor, which is widely used for detecting combustible gases including cigarette smoke, LPG, methane, and hydrogen [5]. The MQ-2 sensor operates based on changes in electrical resistance when its sensitive layer, typically SnO_2, interacts with target gases. It offers high sensitivity, low cost, and easy integration with microcontrollers such as the ESP32 or Arduino, making it ideal for IoT-based applications [6]. The sensor's analog output can be converted into digital data, enabling accurate measurement of gas concentration in parts per million (ppm).

Automatic air filtration systems are designed to purify indoor air without manual intervention. They usually consist of a fan, a High Efficiency Particulate Air (HEPA) or activated carbon filter, and a control unit managed by an IoT-based microcontroller. When the system detects pollutants, the fan activates to draw contaminated air through the filter, which traps harmful particles and chemical vapors [7]. According to the U.S. Environmental Protection Agency, HEPA filters can remove up to 99.97% of airborne particles as small as 0.3 microns, making them highly effective for continuous air purification [8].

The integration of the MQ-2 sensor with an IoT-based air filtration system provides an innovative and practical solution to minimize cigarette smoke exposure. When the sensor detects increased levels of smoke, it automatically activates a fan or filter system such as HEPA or activated carbon filtration to reduce the concentration of pollutants [9]. Experimental studies show that combining gas detection with IoT-based filtration can reduce smoke particle exposure by up to 70% compared to manual air purifiers [10]. Additionally, these systems can notify users via smartphone alerts or indicator lights to improve real-time awareness of indoor air conditions.

IoT integration also allows for the inclusion of advanced smart features, such as mobile notifications, long-term air quality analysis, and connectivity with smart home assistants like Alexa or Google Home [11]. Data collected from sensors can be stored in the cloud and analyzed to detect trends, predict pollution levels, and optimize filter operation times [12]. These enhancements not only improve energy efficiency but also raise awareness among users about the importance of maintaining clean air indoors.

However, despite its benefits, the implementation of IoT-based air filtration systems remains limited due to several factors, including hardware cost, unstable internet connectivity, and data security issues [13]. Many existing air purifiers still operate manually, without sensor-based automation. Research indicates that by integrating IoT and automatic control, system responsiveness and operational efficiency can be improved significantly, resulting in better air quality and lower maintenance costs [14].

In conclusion, IoT technology not only functions as a monitoring tool but also serves as an automatic protection system that safeguards family members—especially children and the elderly—from harmful cigarette smoke. Through real-time sensing, autonomous control, and cloud-based analytics, IoT-based systems provide an innovative, efficient, and sustainable solution for improving indoor air quality in residential environments [15].

2. METHOD

This research uses a research and development method. Researchers develop tools through research and testing, including prototype design, testing, and evaluation to ensure that the product or process meets the researcher's desired standards

2.1. Research Tools

To assist and support research on good system design, various system design tools are required. Table 1 shows some of the instruments used in this research.

Table 1. Research Tools

NO.	Tool	Description
1.	*Thinger*	1 Programming Applications
2.	*Microsoft Office* 2021	1 Report Creation
3.	*Fritzing*	1 Design Application
4.	*Arduiono Programmer*	1 Programming Applications

2.2 RESEARCH MATERIALS

To support this research, materials were used during the system design process. Some of the materials used in this research are described in Table 2.

Table 2. Research Materials

No.	Device	Description
1.	ESP 32	1 *Controller*
2.	ESP 32 *Expansion Shield*	1 *Controller*
3.	SensorMQ-2	1 Smoke Detector
4.	Filter *HEPA* + Karbon Aktif	2 Air filtration system

5.	Adaptor 12v 3A	1 Unit
6.	*Fan DC* 5v 0.2A	1 Unit
7.	*Relay 2 Channel*	1 Unit
8.	Traffic Light LED	1 Unit
9.	Kabel Serabut	3 Meters
10.	Kabel Fleksibel	50 Unit
11.	Kotak besi	1 Unit

2.3. RESEARCH FLOW

Figure 1 shows the research flow which explains the steps taken in this research to achieve success.

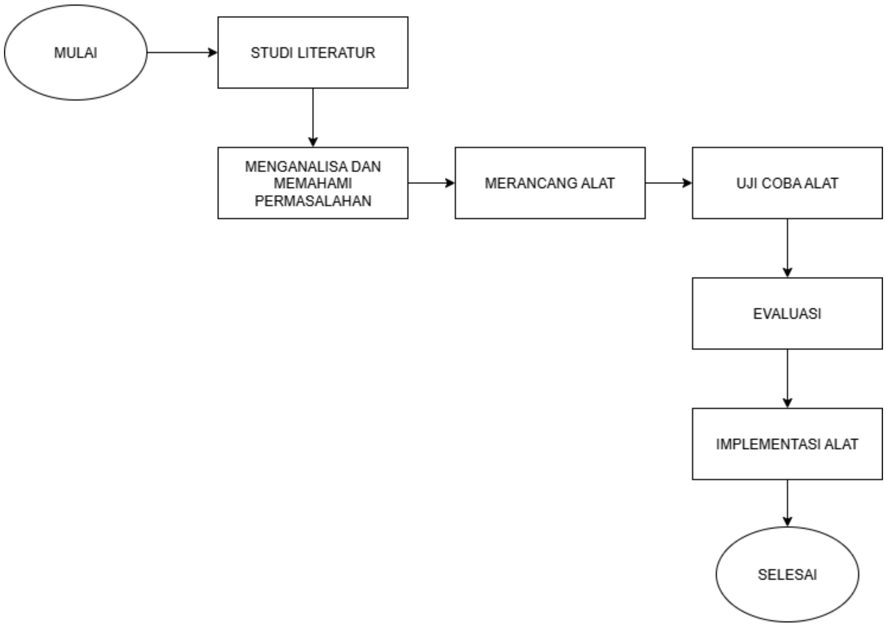

Figure 1. Research Flow

2.4. SYSTEM DESIGN

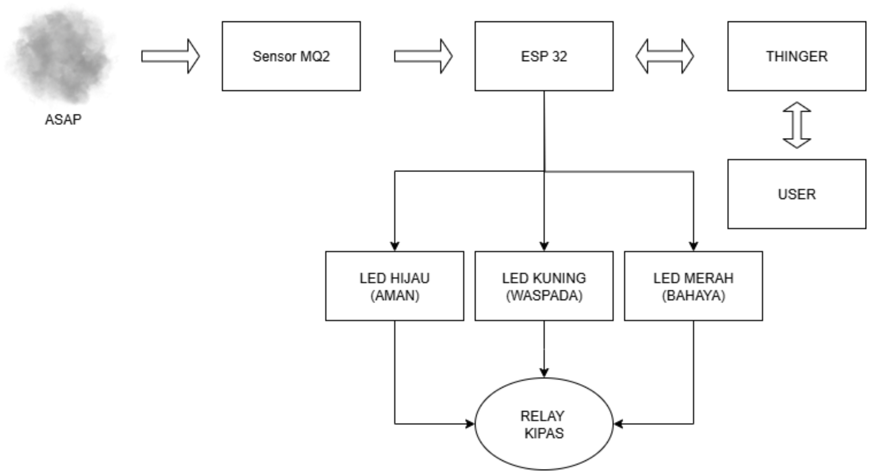

Figure 2. System Design

The block diagram of an ESP32-based gas detection system illustrates the relationships between the main components, from the MQ-2 sensor as input to Thinger.io as a cloud-based monitoring platform. This system works in an integrated manner to detect, process, and display air quality conditions in real time.

1. Sensor MQ-2
   This sensor detects the concentration of flammable gases and smoke in the air (such as LPG, methane, and alcohol). The detection results are sent as analog signals to the ESP32 for decision-making.
2. ESP32
   Acts as a data processing center with the following main functions:
   a. Reading analog values from the MQ-2 sensor.
   b. Determining air status (Safe, Alert, Danger) based on threshold values.
   c. Controlling indicator LEDs and fan relays based on detected conditions.
   d. Sending data to the Thinger.io platform via WiFi.

3. Thinger.io (Platform Cloud Monitoring)
   This platform displays real-time gas levels and air quality data via a web dashboard or app. Users can monitor environmental conditions, view historical data, and analyze trends without having to be on-site.

4. LED Indicator
Visually indicates the air status:
   a. Green (Safe): value ≤ 1000
   b. Yellow (Alert): 1001–1800
   c. Red (Danger): >1800

5. Relay and Ventilation Fan
   The relay controls the fan to speed up air circulation. When an alert or danger condition is detected, the relay activates the fan to quickly remove hazardous gases.

After preparing the block diagram design and explaining the use of each component, the next step is to design the program flow, which will be created as shown in Figure 3.

2.5 PROGRAM FLOW

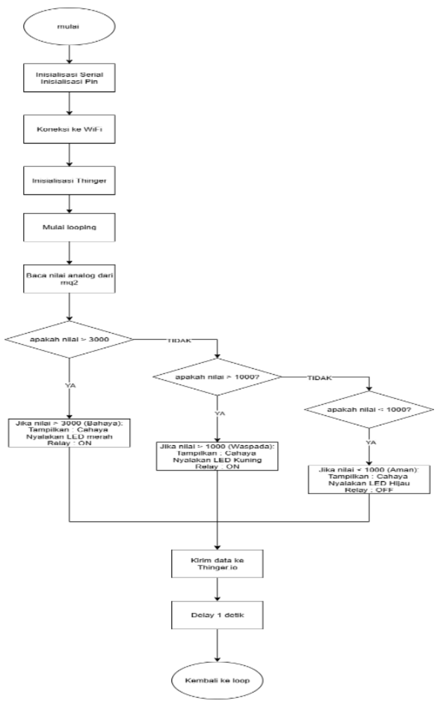

Figure 3. Program Flow

The program begins when the ESP32 receives power and performs initial initialization, including activating serial communication for debugging and assigning input-output pins to sensors, LEDs, and relays. The ESP32 then connects to the Wi-Fi network and connects to the Thinger.io platform using device authentication to monitor data in real time.

The system then enters a main loop that runs continuously as long as the device is active. In this loop, the MQ-2 sensor reads gas levels in the air via the analog pins and uses the results to determine the environmental status:

a. Safe if the value is ≤ 1000 (green LED on, relay off)
b. Alert if the value is 1001–1800 (yellow LED on, relay on)
c. Danger if the value is > 3000 (red LED on, relay on to turn on the fan)

After determining the status, the system sends gas level and environmental status data to the Thinger.io platform for display on the monitoring dashboard. This process includes a 1-second delay between the next sensor reading to maintain data stability and network efficiency. The entire cycle then repeats automatically to ensure continuous, real-time gas monitoring.

2.6 HARDWARE DESIGN

This research can be successful, when every electronic component used is interconnected.

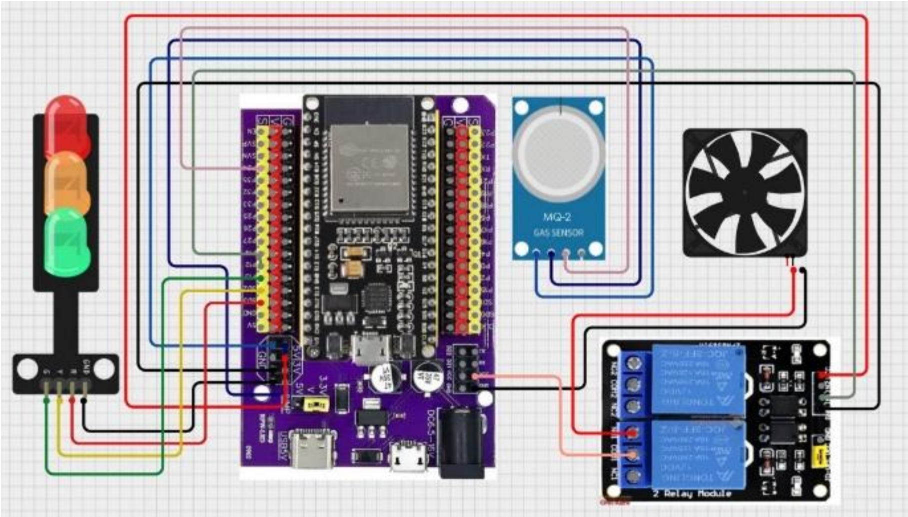

Figure 4. Hardware Design

This system uses an ESP32 as the main microcontroller, reading data from the MQ-2 gas sensor and controlling various output devices. The MQ-2 sensor is connected to GPIO pin 34 to read gas levels using the analogRead() function. Based on the detected gas levels, the system determines three main conditions: Safe (≤1000) with a green LED (GPIO 14), Alert (1001–1800) with a yellow LED (GPIO 12), and Danger (>1800) with a red LED (GPIO 13). This activates a relay on GPIO 26, which controls an alarm or ventilation fan.

Through a WiFi connection, the ESP32 sends real-time gas level and environmental status data to the Thinger.io platform, enabling users to monitor remotely via an IoT dashboard. In addition to digital monitoring, the system is also equipped with a HEPA filter and activated carbon to filter harmful particles and help sterilize the air around the sensor, increasing the system's effectiveness in maintaining indoor air quality.

3. RESULTS AND DISCUSSION

3.1 Results

This research resulted in an IoT-based cigarette smoke detector device designed and implemented to detect and integrate ambient air quality.The system hardware consists of an ESP32 Expansion Board as the main base, connecting various components such as the MQ-2 sensor, LED indicators, and a 2-channel relay to form an IoT-based cigarette smoke controller. The MQ-2 sensor was tested in two different positions—before and after the air filtration process—to compare the quality of air exposed to cigarette smoke. The difference in readings from both sensors is displayed in real time on the Thinger.io platform, allowing users to directly compare the effectiveness of the filtration process and air quality conditions. The test results between the MQ-2 sensor and cigarette smoke exposure before and after filtration can be seen in Table 3.

Table 3. MQ-2 Sensor Test Results before and after filtration

No.	Experiment using a cigarette	Results of Smoke Levels		Difference in air quality values between the MQ-2 sensor before and after filtration
		Mq-2 (Before)	Mq-2 (After)	
1.	Cigarette 1	2104	474	1630
2.	Cigarette 2	2278	581	1697
3.	Cigarette 3	2302	623	1679
4.	Cigarette 4	2496	680	1816
5.	Cigarette 5	2521	711	1810

Traffic light test results, which can display smoke levels on the thinger.io dashboard. The traffic light value requirements can be seen in Table 4.

Table 4. Traffic light test results on Thinger.io

No.	Status of Smoke Concentration	Smoke Condition	Expected Results	Testing Outcomes
1	<1000	Safe (Green)	The ESP32 will send a Traffic Light command to turn on the Green LED	The Green LED will turn on
2	1000-3000	Caution (Yellow)	The ESP32 will send a Traffic Light command to turn on the Yellow LED	The Yellow LED will turn on
3	>3000	Danger (Red)	The ESP32 will send a Traffic	The Red LED will turn on

			Light command to turn on the Red LED	

Test results from the automatic mode implemented with the MQ-2 sensor are used to read smoke levels in a room in real time. The values obtained from the MQ-2 sensor are used to determine the smoke level status. They are then processed by the microcontroller (ESP32), which then commands the traffic light to display an LED according to the smoke level status. They also control a relay to activate or deactivate the fan.

Table 5. MQ-2 Sensor and ESP32 Auto Mode Test Results

No.	MQ-2 Sensor	ESP 32		
	Smoke Concentration	Smoke Condition	*Traffic Light*	*Relay*
1.	None	Safe	Green	Off
2.	Moderate	Caution	Yellow	On
3.	High	Danger	Red	On

3.1.1. Software Research Results

On the dashboard on the thinger.io platform, the smoke level display and the smoke status will be displayed if it is functioning properly.

Figure 5. View on thinger.io dashboard

3.2. DISCUSSION

Results of system data testing and overall system performance testing. The tests conducted in this study demonstrate the device's function and performance. As shown in Figure 4.2, the system is connected to the internet via a WiFi network. The system uses the thinger application to process the data.

Overall, the test results indicate that the developed system performs very well in determining cigarette smoke levels in a room, although there are differences in measurements between the tests. This indicates that the system can be a useful tool in minimizing cigarette smoke exposure with sufficient accuracy.

4. CONCLUSION

Based on the results of the research that has been conducted, it was concluded that the Internet of Things (IoT) based cigarette smoke detection system using the MQ-2 sensor was successfully developed and functions well in detecting the presence of cigarette smoke in closed household spaces. The integration between the MQ-2 sensor and the automatic air filtration system is able to minimize smoke exposure effectively, so that the surrounding air becomes cleaner. In addition, this system also provides warnings or notifications to active smokers as a form of education and increasing awareness of the dangers of cigarette smoke for family members. Based on testing in a closed room, the system is proven to work according to the plan and established limits, although it has not yet performed a more specific gas classification.).

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