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Development design of an IoT-based smart home monitoring system with security features

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ABSTRACT

A smart home is a system that has been programmed and can work automatically by utilizing internet of things (IoT) technology, this system can control various electronic devices in the home. This paper presents a design for developing an IoT-based smart home monitoring system with the addition of security features. This research aims to design and develop a smart home monitoring system that uses the IoT which operates via the web and improves the security aspects of the system. This research includes the development of hardware and software that enables efficient and safe monitoring and control of various aspects of the home via smartphone or computer-based devices using resources from solar power plants. This system relies on the use of a Raspberry Pi as a microcontroller and several sensors. In this context has important value in maintaining user security, and privacy and supports the growing development of the smart home technology industry.

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1. INTRODUCTION

A smart home is a system that has been programmed and can work automatically by utilizing internet of things (IoT) technology. This system can control various electronic devices at home such as lights, AC, and TV [1], [2]. One of the important features of a smart home is the security feature, this feature can be used to monitor the condition of the house remotely and provide warnings if something undesirable happens such as theft or fire [3]. This technology was created to increase energy efficiency, increase the level of security, provide comfort, and several other benefits [4]. With the increasing availability of smart devices and widespread internet connectivity, the need for intelligent monitoring systems in the home has become increasingly urgent [5], [6].

Developing IoT smart home monitoring systems with security features has become an international concern. Several papers addressing this issue propose IoT-based intelligent security alert systems for homes which include features such as intruder detection, fire, smoke detection, and continuous monitoring [7]. Along with the evolution of technology, one of the security features of fire alarm systems has also experienced a significant increase in capabilities in recent years [8], [9]. Fire accidents are infrequent but if, they do occur the impact will be very large. Therefore, this system is expected to be able to save from the dangers of fire and other features [10]. This paper highlights the importance of addressing security issues in IoT smart home monitoring systems.

Reading IoT smart home monitoring systems with additional security features is important in Indonesia, these systems utilize technology to increase security and prevent theft and delivery [11].

The application of IoT in Indonesia has grown rapidly making it the second largest country in terms of IoT application in Southeast Asia [12]. Smart home systems using IoT platforms have been designed to improve security, safety, automate the home, provide remote monitoring and control [13]. The use of cloud-based IoT in monitoring and controlling electrical resources at home can result in energy savings and cost reductions [14]. In addition, home monitoring systems based on object sensors and cloud computing can help maintain residential security, reduce the risk of theft and trespass [15]. The use of IoT technology allows the implementation of advanced security systems that can be applied to homes, buildings, and environments [16].

Technological developments have gradually experienced significant changes in the utilization of various aspects of information especially thanks to advances in hardware and software [17], [18]. One example of the application of this technology is the ability to detect earthquakes at home. By utilizing the integration of the IoT in the smart home concept, this connected security system can detect earthquakes quickly and take preventive action [19]. Network-connected sensors allow homes to send alerts and automatically take safety measures such as closing doors and windows, providing additional protection to residents against potential earthquake risks [20]. With increasing awareness of the importance of earthquake preparedness, IoT-based security innovations in smart homes provide proactive measures to protect occupants and their assets [21].

Research related to an IoT-based smart home monitoring system with the addition of security features has been successfully designed with the title an advanced IoT-based security alert system for smart homes. The result of this research is that this low-cost home security system utilizes a small pyroelectric infrared (PIR) module and a Raspberry Pi to minimize delays during the email alert process. This paper also confirms the superior flexibility of the Raspberry Pi and the possibility of its wide use [22]. Another research was successfully designed with the title design and fulfillment of IoT-powered smart home (SH) materials using the blynk application. The final result of this research is an affordable, safe, and energy-efficient WiFi-based smart home system, which allows household appliances to be monitored by homeowners in local and remote locations via mobile phone/PC. Raspberry Pi 3 model B+ and Arduino Mega 2560 are used to configure the server automation framework. The proposed automation system can monitor and control home conditions via the Blynk application for Android or iOS [23].

Based on the analysis of the solutions that have been provided, to overcome these problems it is necessary to develop an IoT-based smart home monitoring system with additional security features involving the integration of various sensors and technology. One approach is to use radio frequency identification (RFID) sensors, gas detectors, and websites for wireless remote home security, another approach is to use Raspberry Pi, power transfer circuits, and various sensors such as gas, fire, and infrared receiver’s passive (PIR sensor), vibration sensor, fire sensor (KY-026), and DHT11 sensor. Additionally, attribute-based access control can be applied to strengthen the security of smart home IoT systems, enabling better access control and taking environmental conditions into account. Additionally, end-to-end systems can be developed to monitor, analyze and visualize the network traffic behavior of heterogeneous IoT devices in smart homes using programmable home routers, cloud-based analytics and smartphone applications [24]. This system is expected to provide better security to the home thereby preventing theft or fire, the ability to detect earthquakes, and maintain user privacy as well as supporting the growing growth of the smart home technology industry.

2. METHOD

In the context of this research, to create a development design for an IoT-based smart home monitoring system with the addition of security features, first design the hardware and software. By providing information with added security to the features of the planned equipment, it is hoped that it can provide better security for the home, thereby preventing theft or fire and the ability to detect earthquakes [25]. To design the hardware and software design for developing an IoT-based smart home monitoring system with the addition of security features, the methodology involved is discussed as follows:

2.1. Blok diagram

The following is the design block for developing an IoT-based smart home monitoring system with the addition of security features in Figure 1. The system design block diagram in Figure 1 consists of input, process, and output. In the input section, some sensors will read data as input for the microcontroller. The sensors used in this tool are the gas sensor, KY-026 sensor, DHT11 sensor, and PIR sensor. Next, the data read will be processed by the Raspberry Pi 3 microcontroller. The results of this process will trigger the activation of the relay driver, servo motor, LED, and buzzer. In this microcontroller, two-way data communication occurs between IoT and Raspberry PI 3. Raspberry acts as a server and MYSQL, data on Raspberry Pi 3 will be sent to the MYSQL database. Then the data in the database will appear on the website in real-time.

2.2. Circuit design

Software design focuses on designing the wiring or circuit of the device parts. This design consists of designing the input and output circuits, as well as the overall circuit. Following Figure 2 is the entire circuit design consisting of the components used, namely Raspberry Pi 3, gas sensor, KY-026 sensor, DHT11 sensor, servo motor, RFID sensor, PIR sensor, vibration sensor, pump motor, 4×4 keypad, relay and PCF8574 module. Figure 2 is the overall circuit design by using several electronic circuits the overall input and output schematic circuit will be connected to the Raspberry PI 3.

2.3. Hardware design

This design aims to plan something that will be made in mechanical form. Mechanical design is needed because mechanical design is used as a reference for creating the entire system. The results of the mechanical design. It can be seen in Figure 3, consisting of the components used, namely the gas sensor, KY-026 sensor, DHT11 sensor, servo motor, RFID sensor, PIR sensor, vibration sensor, pump motor, and 4×4 keypad. Figure 3 is the mechanical design for system development of an IoT-based smart home monitoring system with additional security features.

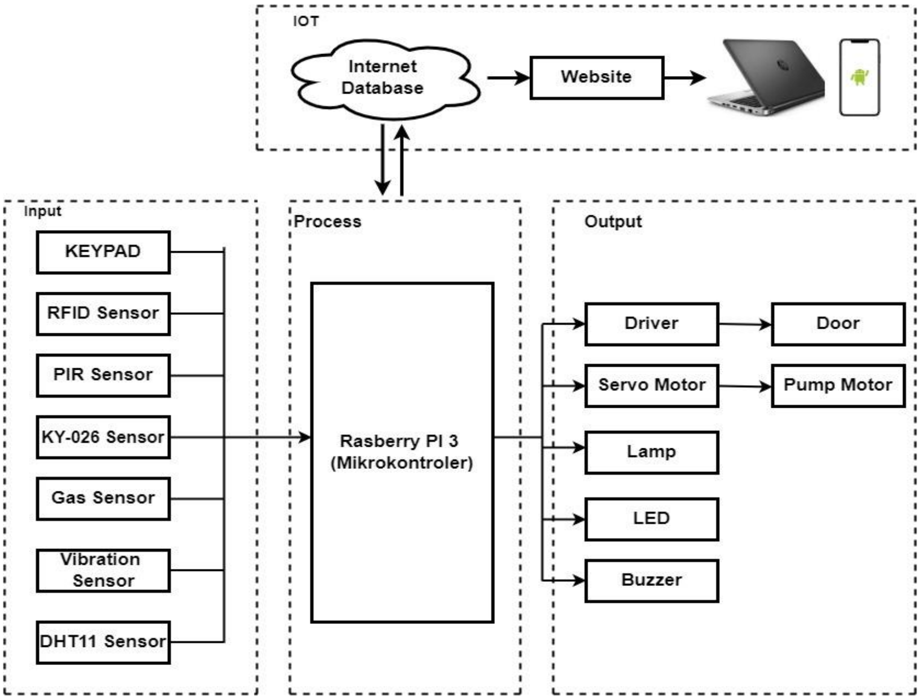


Figure 1. Block diagram of the system input, process, and output

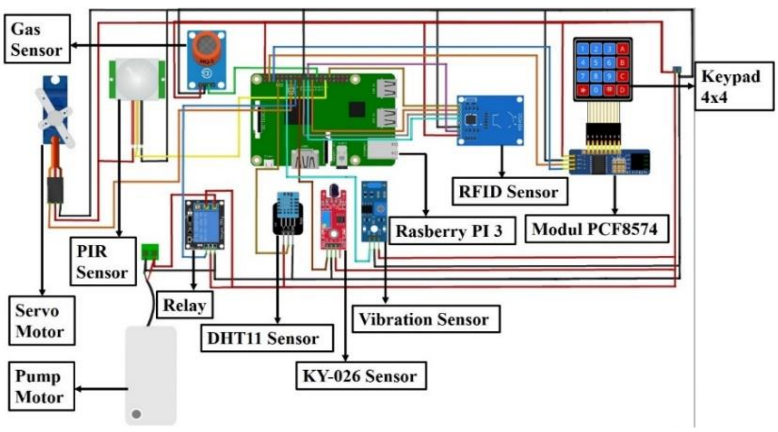


Figure 2. Overall circuit design

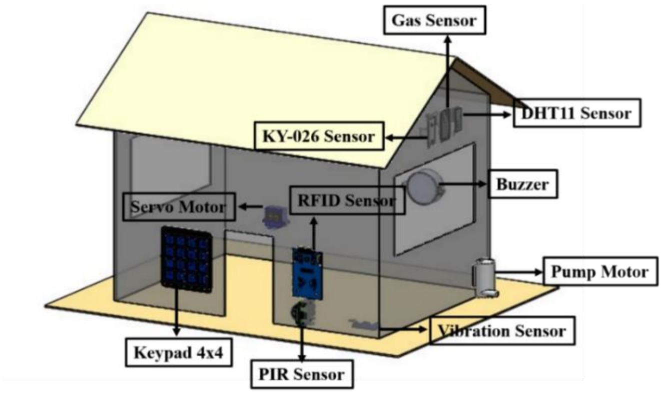


Figure 3. Smart home monitoring system design

3. RESULTS AND DISCUSSION

After working on the entire system, it is necessary to test and analyze the tools created. Testing is carried out to find out whether the components of the tool can work properly according to plan or not. Testing the voltage on the KY-026 sensor to determine whether a fire has been detected or not, the PIR sensor aims to determine the sensitivity of the sensor in detecting objects both at the closest and furthest distance from the object, and the buzzer to detect sound by inputting a voltage of 5 V, the measurement results can be seen in Table 1.

Table 1 is the result of voltage measurements on the KY-026 sensor, PIR sensor, and buzzer. When the KY-026 sensor detects a fire, the voltage measured on the sensor is 0 V and when the sensor does not detect a fire, the voltage measured on the sensor is 4.8 V. The PIR sensor will be active if it detects detectable human movement, the maximum distance that the PIR sensor can detect is 5 m, at this distance the reading is no longer very sensitive. If the buzzer receives voltage from the microcontroller's digital pin, the buzzer will be active.

The MQ-2 sensor is a smoke sensor that can read two conditions, namely analog data and digital data. In this test, measurements are made on the analog output. From the measurement results obtained, the smoke content value obtained was obtained by reading the comparison between the ratio value (rs/ro) and the ppm value. Rs is the resistance of the sensor at 1,000 ppm when H2 is in clean air and at various gas concentrations. The ratio of ratio readings with ppm values can be seen in Table 2. Table 2 is a comparison of Rs/Ro values with smoke gas levels. The formula for gas Level values is obtained from regression analysis between sensor resistance (Rs/Ro). To get the rs value fo flue gas use in (1).

$$Rs = \left(\frac{Vc-Rl}{Rl}\right) x\, VRl \quad (1)$$

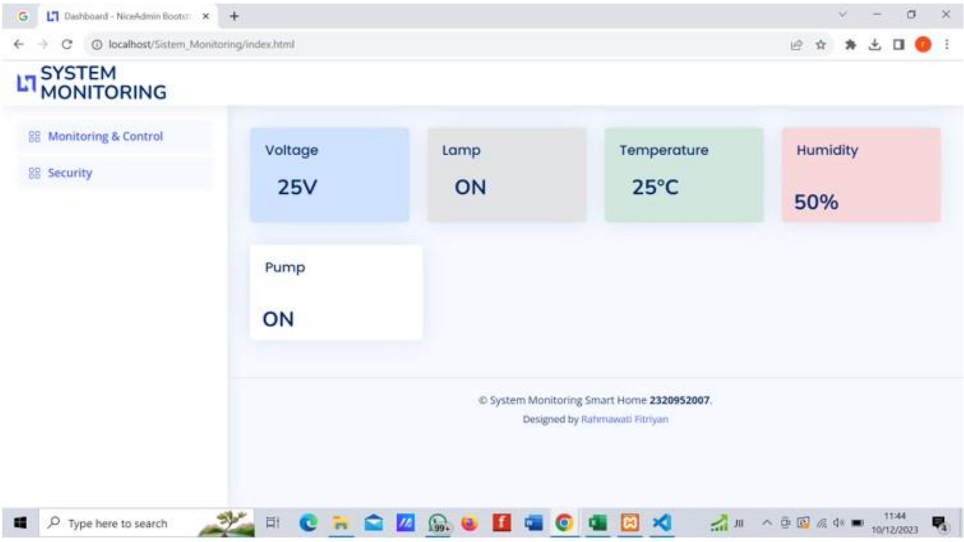
Information:
Rs = Resistance on the sensor
Vc = Voltage entering the sensor
Rl = Load resistance in the circuit
VRL = Output voltage from the sensor

Tests on the DHT11 sensor module use temperature and humidity detection methods with readings in the form of temperature conditions in degrees Celsius and humidity in percent units (%). The test is carried out by measuring the output voltage between the DHT11 sensor and the voltage it should be based on the thermometer temperature. The results of the measurement table can be seen in Table 3. Table 3 shows the measurement results of the DHT11 sensor. From the measurement results of the two samples above between the props and the temperature thermometer, there is no significant difference in temperature and humidity. The accuracy of the reading on the measuring instrument can cause the difference in temperature readings between the thermometer and DHT11.

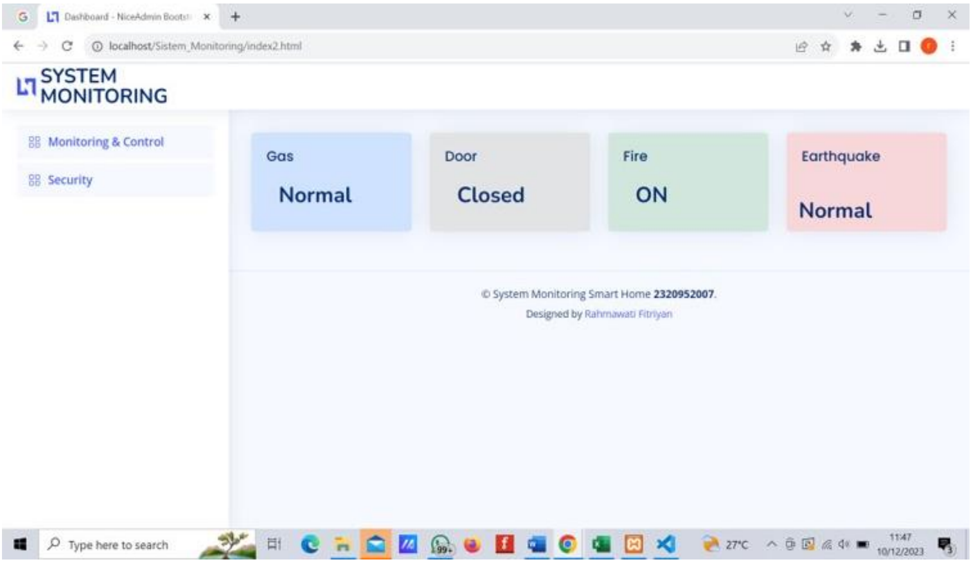
IoT-based smart home monitoring systems have been developed to meet the needs of energy management, security, and privacy. Through a stable internet connection, information from these sensors can be accessed and monitored in real-time via the web. This system can monitor and control several electronic devices at home remotely, such as opening/closing doors, turning on/off lights, and setting room temperature. The web design results can be seen in Figure 4. Figure 4 is a display of the IoT web-based smart home monitoring system with additional security features. The monitoring system web dashboard displays widgets added using JavaScript in the visual studio application, the monitoring display code can interact with the controlled Raspberry Pi. Figure 4(a) is a smart home monitoring system that displays voltage, light, temperature, humidity, and pump parameters for monitoring and control. Meanwhile, Figure 4(b) is a smart home security display that displays gas, door, fire, and earthquake safety parameters. This is different from previous research [26] which used Raspberry Pi for monitoring household electrical energy without security features. This research is part of a research roadmap for developing smart home monitoring and security systems in the future.

Table 1. Voltage measurement results for the KY-026 sensor, PIR sensor, and Buzzer

No	Sensor	Circumstances	Voltage (V)
1.	KY-026 sensor	Before fire detected	4.8
		Fire detected	0
2.	PIR sensor	1 m	4.97
		3 m	4.97
		5 m	4.97
		5.5 m	0
3.	Buzzer	ON	0
		OFF	5



(a)



(b)

Figure 4. Web-based smart home display (a) smart home monitoring system and (b) smart home security display

Table 2. Comparison of Rs/Ro values with smoke gas levels

Rs/Ro	Gas levels
2.98	8
2.84	15
2.63	31
2.51	41
2.3	89

Table 3. Measurement table results

No	DHT11 sensor		Thermometer
	Temperature	Humidity	
1.	25 ℃	95% RH	24 ℃
2.	26 ℃	93% RH	25 ℃
3.	27 ℃	95% RH	26 ℃

4. CONCLUSION

A web-based smart home monitoring system have been well designed and meet all desired needs. The IoT technology has been improved for energy efficiency and security. The system monitoring results show optimal performance, with the ability to detect changes in temperature, humidity levels, and the presence of occupants in the house. The system is also capable of providing instant notifications in emergencies or when suspicious behavior is detected. With the integration of this technology, homeowners can manage and control various aspects of daily life efficiently, creating a safer, more comfortable, and energy-efficient home environment.

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