Home Security and Fire Detection System Design Using IoT-based Microcontroller ATmega2560

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Abstract A smart home security system or SmartHome is a new technology in this modern era with the concept of IoT (Internet of Thing), namely by utilizing internet connectivity by connecting a microcontroller device as a data processor for input and output with other components such as sensors that can communicate via smartphones. The PIR sensor and the MQ-2 smoke detector are one of the important components in a security system both at home and in buildings. Based on statistical data sources at the National Police Headquarters, crime in cases of theft is increasing and statistical data from https://www.jakartafire.net/statistics causes and occurrence of fires are still quite high. Based on the above problems, the author's motivation in making a home security system and fire preventive based IoT using microcontroller ATmega2560 Wi-Fi. This design prototype uses the ATmega2560 microcontroller component as input and output data processing, the HC-SR501 PIR sensor as a motion detection sensor, the MQ-2 sensor as a sensor in reading smoke levels with the addition of other components such as a buzzer as warning sign information and LED as an indicator sensor is active. Monitoring media used is the Blynk application on the smartphone in real time when the sensor detects motion and smoke. In this study, the smoke detection system is set to detect smoke with a threshold value of > 100 ppm. The PIR sensor coding and testing program works well and is already integrated with Blynk. In the second measurement, the sensor has an average voltage value on the MQ-2 sensor output on the 3.53 VDC sensor while the PIR sensor measurement when the sensor detects movement of the output voltage is 0 VDC and when the sensor status idle is 3.3 VDC.

Keywords: SmartHome, IoT, Arduino, ATMega2560, Microcontroller.

Introduction

With the further development of IoT applications, we can now have a virtual guardian to secure our house from thief, or even fire. We also can monitor our house status from far. To implement that system, the monitoring system is equipped with motion sensor PIR HC-SR501 and sensor MQ-2. Both can be integrated with Blynk on smartphone and a microcontroller as data processing for real time information to the user. This system is always connected to the internet, so the user can monitor their house status through internet connection. This security and fire detection system is aiming for a safer house, with utilization of the latest technology for convenient monitoring. This system can be integrated with other communication applications for real time data transfer. The purpose of this project is building a relatively cheap, easy to use, easy to configure and modify, and fairly reliable simple SmartHome system.

Materials and methods

PIR Sensor

Figure 1. PIR Sensor.

The PIR sensor has a function of infrared rays detection. This sensor is a passive sensor, consist of pyroelectric detectors and Fresnel lens that will focussing the infrared to pyroelectric detectors. The sensor will detect the infrared signal change, and the output would be positive or negative based on the signal change. When it is idle, the output is zero.

MQ-2 Sensor

Sensor MQ-2 is an electrochemical sensor, detecting the molecule on the environment and convert it to electric signal. This sensor is usually utilized for detecting the gas leaks at industrial area or houses. The MQ-2 sensor can detect several gas molecules such as LPG, butane, methane, alcohol, hydrogen and smoke asap with adjustable sensitivity [6].

Figure 2. MQ-2 Sensor.

Arduino ATmega2560 R3

This microcontroller is a custom version of Arduino Mega R3, integrated with a microcontroller Atmel ATmega 2560 and Wi-Fi ESP8266. This microcontroller has a flash memory of 32 Mb and converter USB TTL CH340G in one board. All of the components on this microcontroller can be adjusted from DIP switch when in operating mode to work independently or simultaneously [1].

Figure 3. Arduino microcontroller ATmega2560 R3 Wi-Fi.

System Design

The security monitoring and fire detection system is integrated to Blynk server as IoT to communicate with the user smartphone through internet connection for real time data transfer. At this step, the data is measured from the sensor. Furthermore, the data will be analyzed for mechanical realization, or simulation for PIR and MQ-2 sensor. The result will be compared with the scale test. This system diagram block can be seen on Figure 4. The sensors are installed to the house mockup as shown on Figure 5 and Figure 6, for simulating real function and placement of the sensor.

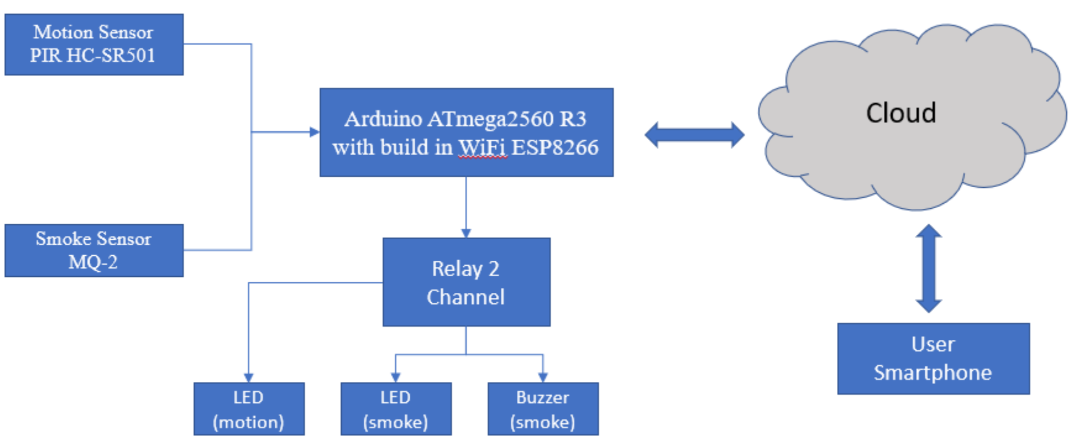


Figure 4. The diagram blocks.

Figure 5. House mockup design.

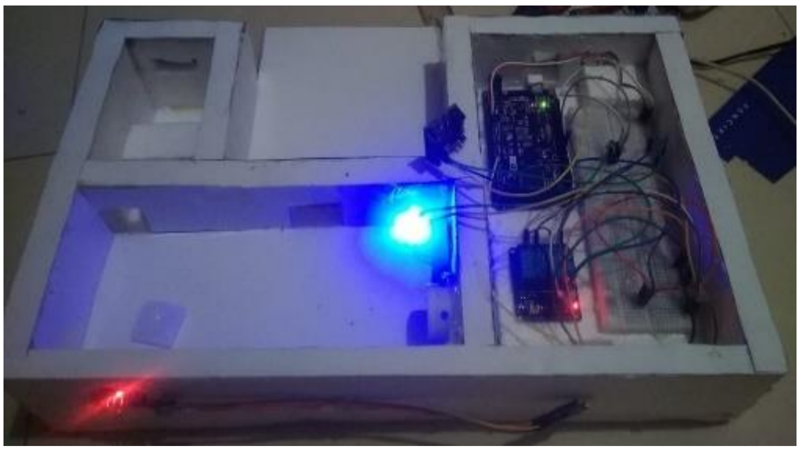


Figure 6. House mockup installation.

The system consists of 2 sensors in parallel. Both sensor reading status is sent to the user simultaneously. The flow chart diagram of the whole system is shown on Figure 7. Basically, this is a simple flow chart of the system. After the initialization, the microcontroller reads the output from both sensors, and send the current status the user through internet access. If there is any change from the sensor's output, the microcontroller also sends the messages to the user.

The Installation

This project uses some devices as follows:

1. Laptop, Intel ® Core i5, RAM 16 GB
2. Arduino ATmega2560 R3 with build in WiFi ESP8266
3. PIR Sensor
4. MQ-2 Sensor
5. Relay 2 channel
6. Buzzer
7. LED
8. Breadboard
9. Jumper cable

The microcontroller ATmega2560 is connected to the laptop, PIR sensor, MQ-2 sensor, buzzer, and 2 LEDs as an indicator if the sensor detects any motion and/or smoke. This was done for simulation and experimental needs. The monitoring system schematic diagram is shown on Figure 8.

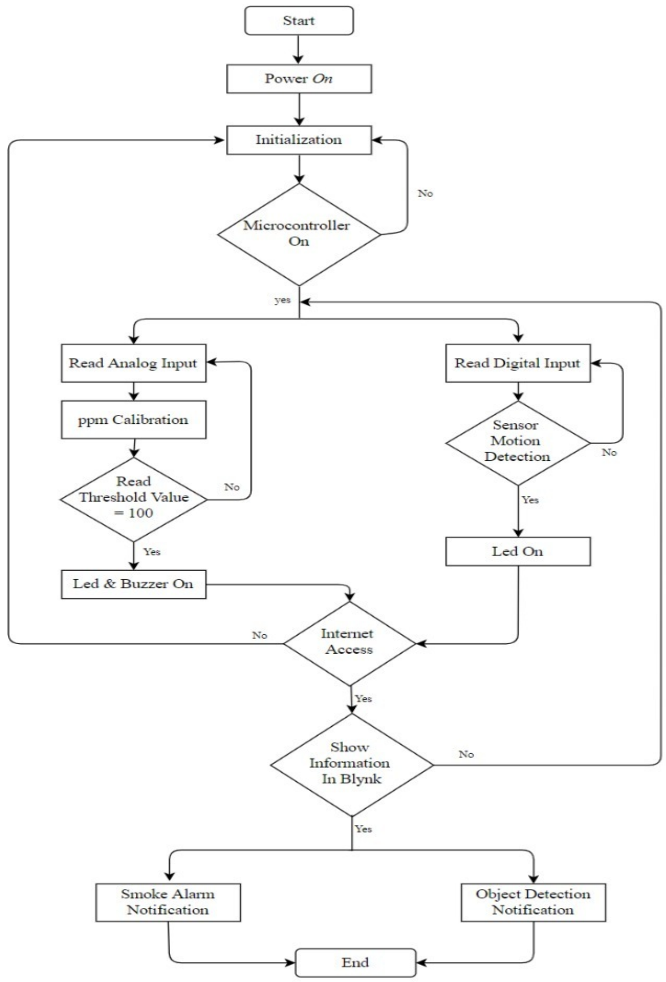


Figure 7. The whole system flow chart.

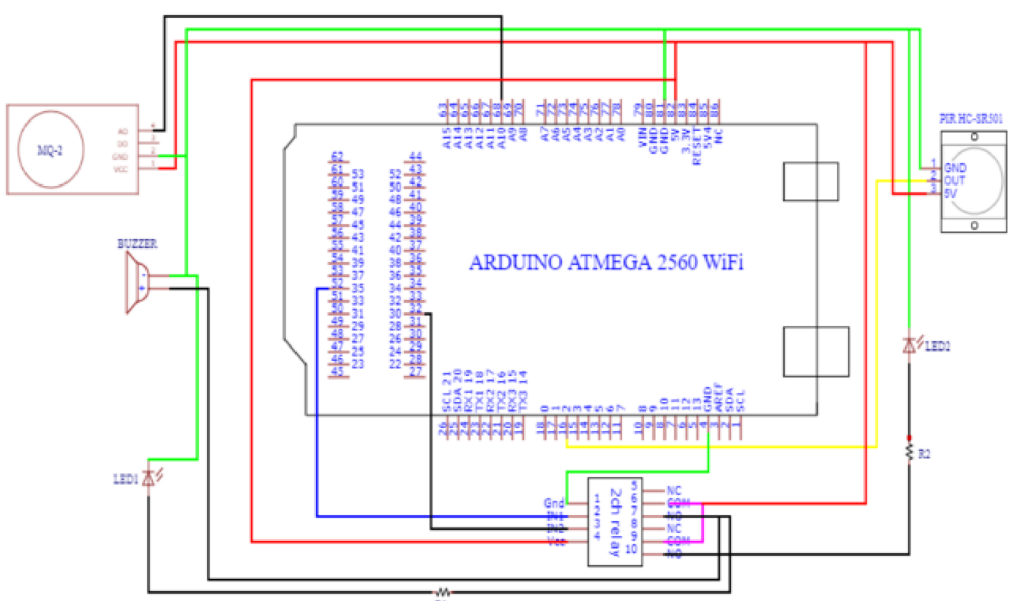


Figure 8. Schematic diagram.

The PIR sensor will detect any object motion, and send the signal to the microcontroller, then processed and command the relay to light up the LED as a motion indicator. The MQ-2 sensor will detect the fire possibilities if the smoke is above the threshold set on the microcontroller. Thus, the relay will activate the LED and buzzer as a smoke or fire indicator. The microcontroller pin installation can be seen on Table 1, and the connection to the sensor pin can be seen on Table 2.

Table 1. MQ-2 sensor pin configuration.

Microcontroller	MQ-2	Relay	*LED*	Buzzer
A10 Pin	A0 Pin	-	-	-
GND Pin	GND Pin	GND Pin	Negative Pin (-)	Negative Pin (-)
5V Pin	VCC Pin	VCC Pin	-	-
-	-	NO Pin	Positive Pin (+)	Positive Pin (+)
D52 Pin	-	IN1 Pin	-	-
5V Pin	-	COM Pin	-	-

Table 2. Motion sensor pin configuration.

Mikrokontroller	PIR	*Relay*	*LED*
GND Pin	GND Pin	GND Pin	Negative Pin (-)
D2 Pin	OUT Pin	-	-
VCC Pin	VCC Pin	COM Pin	-
D32 Pin	-	IN2 Pin	-
-	-	NO Pin	Positive Pin (+)

Dashboard monitoring system

The free platform Blynk is utilized for user interface with some features added as follows:

1. Values and labels for information on PIR and MQ-2 sensor, using virtual input integrated with Blynk.
2. LED as motion and smoke indicator.
3. Buzzer as fire alarm.

The user interface display on smartphone is shown on Figure 9 as follows.

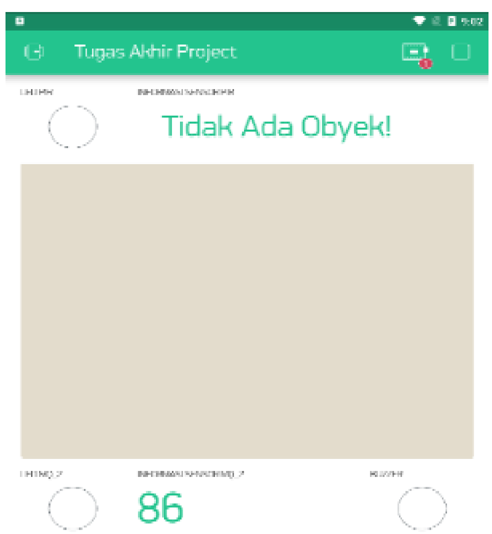
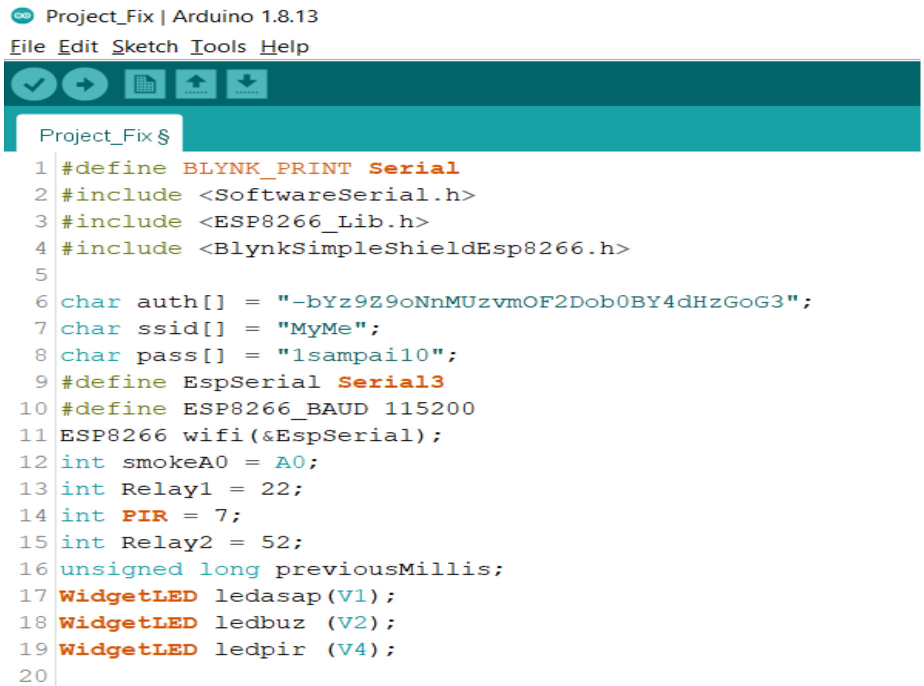


Figure 9. User interface on Blynk.

In this project, Arduino IDE is utilized to implement and run the codes for communicating the microcontroller to the sensor. The Arduino IDE consist of some declaration step as shown on Figure 10.




```
#define BLYNK_PRINT Serial
#include <SoftwareSerial.h>
#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>

char auth[] = "-bYz9Z9oNnMUzvmOF2Dob0BY4dHzGoG3";
char ssid[] = "MyMe";
char pass[] = "1sampai10";
#define EspSerial Serial3
#define ESP8266_BAUD 115200
ESP8266 wifi(&EspSerial);
int smokeA0 = A0;
int Relay1 = 22;
int PIR = 7;
int Relay2 = 52;
unsigned long previousMillis;
WidgetLED ledasap(V1);
WidgetLED ledbuz (V2);
WidgetLED ledpir (V4);

```

Figure 10. Arduino IDE declaration.

Void Setup and Void Loop function declare the input and output variable, and execute the program as shown on Figure 11.


```
void setup() {
  pinMode(smokeA0, INPUT);
  pinMode(Relay1, OUTPUT);
  pinMode(PIR, INPUT);
  pinMode(Relay2,OUTPUT);
    Serial.begin(9600);
    Serial3.begin(115200);
    delay(1000);
    EspSerial.begin(ESP8266_BAUD);
    delay(1000);
  Blynk.begin(auth, wifi, ssid, pass);
}
void loop(){
  unsigned long currentMillis = millis();
  int analogSensor = analogRead(smokeA0);
    Blynk.virtualWrite(V0, analogSensor);
  int sensorThres = 100;
    Serial.print("Pin A0: ");
    Serial.println(analogSensor);
  delay (1000);

 // Checks if it has reached the threshold value
  if (analogSensor > sensorThres)
  {
```

Figure 11. Void Setup and Void Loop.

System Analysis

The system information log can be seen on Figure 12. This is the status log of Arduino IDE serial monitor, displayed on Blynk.

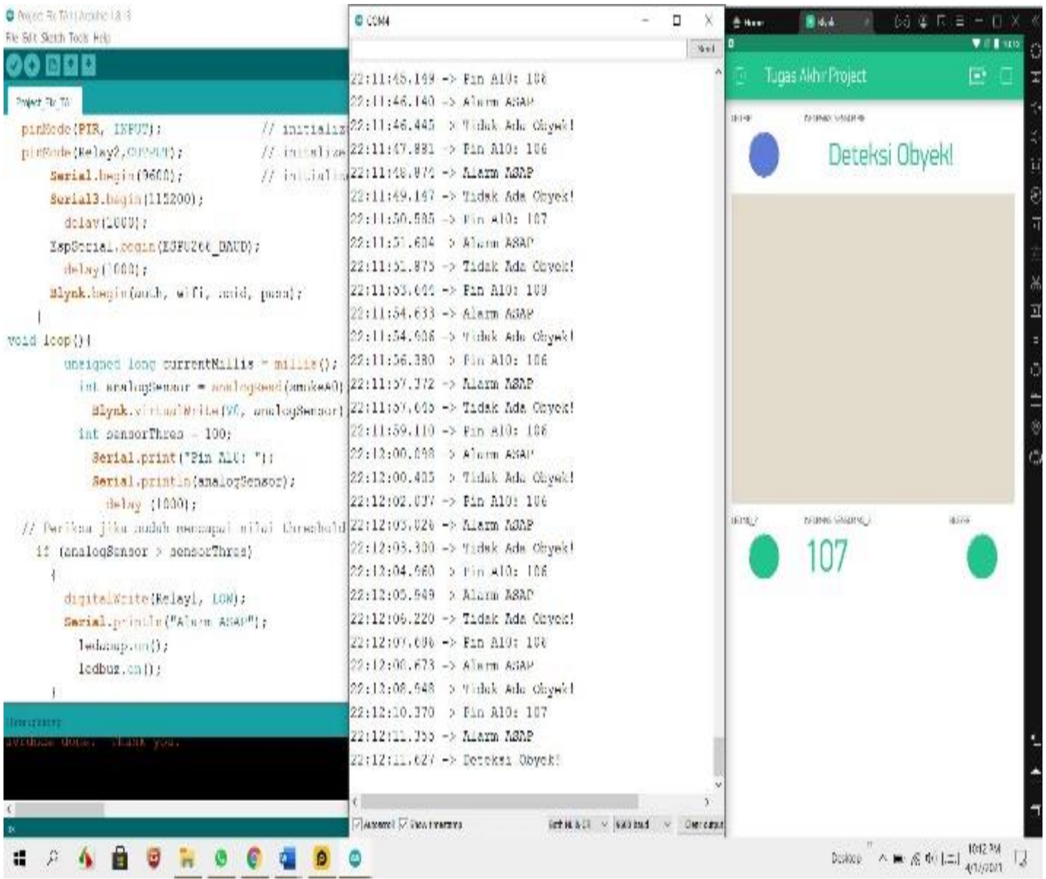


Figure 12. Status log display on Blynk.

The system working step is explained as follows:

1. PIR Sensor
   a. PIR Sensor is idle
   b. If the sensor detects any motion with 10 seconds delay, the sensor will transmit a signal to the microcontroller, and trigger the relay to turn the LED on as a motion indicator for any object passing in front of the PIR sensor. The system will send a message to user and will be displayed on Blynk with notification message "Object Detected", with adjustable short delay. If no motion detected, the notification message is "No Object Detected".
2. MQ-2 Sensor
   a. If MQ-2 sensor do not detects any smoke or on idle condition, the notification message "*Alarm* Asap Stop" will be displayed on Blynk.
   b. If the sensor detects smoke above the adjusted threshold (in this case >100ppm), the sensor will transmit the signal to microcontroller, and then the relay will turn the LED and buzzer on as a smoke alarm.

The threshold on the sensor is adjusted based on "Kementerian Lingkungan Hidup dan Kehutanan" as shown on Table 3. The good and accepted smoke pollution threshold are below 100 ppm.
The testing of the PIR sensor is using a moving human as the moving object. The distance is varied from 50 cm to 1000 cm. This is suitable for average room size. For the MQ-2 sensor, the pollutant is a cigarette smoke. The sensor reaction is compared to the commercial smoke sensor in order to adjust it sensitivity, based on data on Table 3.

Table 3. Air pollution index [8].

No	Description	Range	Explanation
1	Good category	0 - 50	Information in green
2	Medium category	51 - 100	Information in blue
3	Unhealthy category	101 - 199	Information in yellow
4	Very unhealthy category	200 - 299	Information in red
5	Dangerous category	300 - 500	Information in black

Results and discussion

Sensor data measurements

The data measurements from the sensors can be read as follows:

Table 4. PIR sensor testing result.

PIR Sensor Testing Result				
Test	Distance (cm)	Delay (s)	Status	PIR Output Voltage (VDC)
1	50	10	Object Detected	0
2	100	10	Object Detected	0
3	150	10	Object Detected	0
4	200	10	Object Detected	0
5	250	10	Object Detected	0
6	300	13	Object Detected	0
7	350	15	Object Detected	0
8	400	15	Object Detected	0
9	450	18	Object Detected	0
10	500	20	Object Detected	0
11	550	20	Object Detected	0
12	600	25	Object Detected	0
13	650	25	Object Detected	0
14	700	-	No Object Detected	3,32
15	750	-	No Object Detected	3,33
16	800	-	No Object Detected	3,33
17	850	-	No Object Detected	3,32
18	900	-	No Object Detected	3,33
19	950	-	No Object Detected	3,33
20	1000	-	No Object Detected	3,32

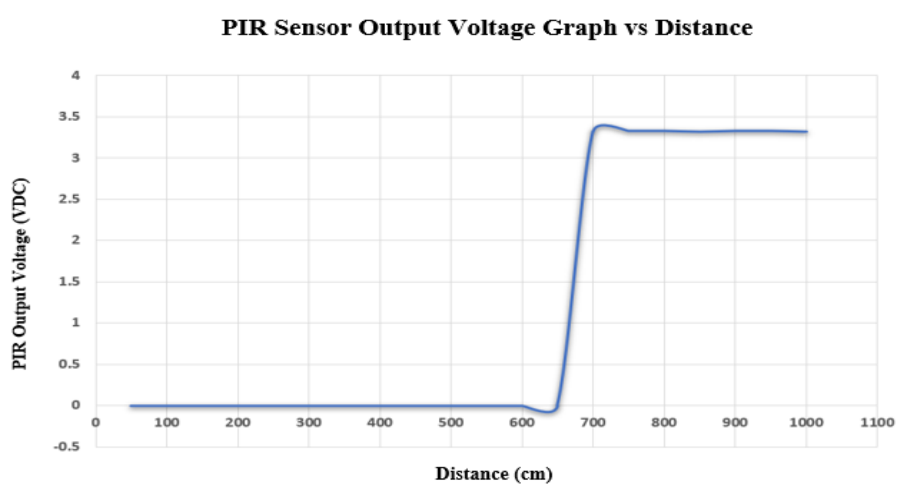


Figure 13. PIR sensor output vs distance.

Based on Table 4 and Figure 13, it can be concluded that the further the objects from the sensor, the greater the delay and the motion will be not detected at all. The optimal distance is up to 6.5 meters. As it is shown on Table 4, the output of the PIR sensor will change from 0 Volt if there is no detection of any moving object, to 3.32 Volt if the sensor detects any moving object within the range. The time delay also increases along with the distance from the object to the PIR sensor. The longest delay is 25 second. It means, the greater the distance from the sensor, the object needs move longer to be detected.

Table 5. MQ-2 sensor testing result.

MQ-2 Sensor Test (value threshold = 100; based on air pollution index)				
Test	Value Detected	LED	Buzzer	Message Display
1	85	off	off	Smoke Alarm Off
2	120	on	on	Smoke Alarm On
3	103	on	on	Smoke Alarm On
4	104	on	on	Smoke Alarm On
5	108	on	on	Smoke Alarm On
6	107	on	on	Smoke Alarm On
7	106	on	on	Smoke Alarm On
8	86	off	off	Smoke Alarm Off

As it is shown on Table 5, the MQ-2 smoke sensor and the alarm trigger is normally functioned. The smoke alarm will turn on if the air pollution index is above 100.

Conclusions

This project is only a prototype and needs some further development, but there are several conclusions from this project. Firstly, the threshold value of MQ-2 sensor can be adjusted according to the needs. This sensor also detects some gas contents such as LPG, propane, butane, methane and other combustible gas with different ppm value, so it is possible for further modification for specific needs. Secondly, the PIR sensor maximum distance to detects any motion is 6.5 meters from the object, and the object needs move approximately 25 second to be detected. This is suitable for most room size. Therefore, this prototype satisfies the original purpose of the project that is relatively cheap, easy to use, easy to configure and modify, and fairly reliable simple SmartHome system. Lastly, this prototype can simulate a simple home security system utilizing the IoT, and can be modified for further development.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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