Journal of Engineering and Sustainable Development
http://jeasd.uomustansiriyah.edu.iq/index.php
https://doi.org/10.31272/jeasd.25.2.2

Vol. 25, No. 02, March 2021
ISSN 2520-0917

DESIGN AND IMPLEMENTATION OF A SMART HOME GAS DETECTION BASED ON MOBILE NETWORK SYSTEM

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Received 21/7/2020 ***Accepted in revised form 18/10/2020*** ***Published 1/3/2021***

Abstract: The rapid development of smart home and deep learning attract many types of research to meet the needs of the homeowner that make the right decisions based on preset settings or based on user behavior in the smart home. And because some gases cause air pollution, affect human health, cause lung cancer, breathing problems. and cause a fire as well. Many gases in our home can pose many dangers. One of the risks of using LPG is leakage in cylinders, gas installations, stoves, or LPG heaters. This paper focused on using technological development to alert about a gas leak inside the home to preserve the general health of people. The proposed system, a gas sensor is used to measure the value of gas in the atmosphere. This part is an important part of the smart home, which is taking precautionary measures by using the gas sensor and controller, in addition to using a mobile network system to send an alert message to the user about gas leakage from the mentioned sources. The proposed system is characterized by its low cost and allows the homeowner to monitor the gas leak inside the home from outside.

Keywords: *Smart home; Remotely Controlled Home; ESP32; Home Automation; Gas detection.*

1. Introduction

Measuring environmental air pollution is a critical issue and cannot be ignored. house heating system and cooking using gas, industrial emissions, and other local human procedures are the main sources of toxic gases [1] and polycyclic aromatic hydrocarbons (PAH), heavy metals, and aerosols [2]. According to the World Health Organization (WHO), there are about three billion people burning biomass firewood and charcoal on open fires or smoke burning stoves for cooking and heating their homes.

Exposure to polluted air at home leads to 4.3 million premature deaths annually, and these numbers are constantly increasing, As air pollution is a cause of noncommunicable diseases, including ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD) and lung cancer, Inhaled particles from indoor air pollution (due to the non-combustion of solid fuel) are the cause of child deaths that have risen to more than 50%, most of them under 5 years of age due to pneumonia. Among these deaths are the following proportions[3]:

Table 1. Mortality rates

Death rate	The causative disease
27%	pneumonia
18%	stroke
27%	ischemic heart disease
20%	(COPD)
8%	Lung cancer.

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Air pollution gas levels should be measured at emission sites, that represent exposure to people[2]. The concentration of air pollutants may be higher near sources of heating and gas cooking, and therefore may require protection for people who live in these places and special measures of protection [4]. Due to the importance of this case, the mobile network system was used instead of the Internet, to ensure the availability of this service from the homeowner[5]. Also, the Internet of things service can be added to the system easily. The proposed system used the gas sensor (MQ-6) to read the gas level in the air, ESP32 as a controller, and SIM900 to connect to the mobile network.

2. Literature Review

In past years, there has been a trend to improve air pollution measurement techniques accurately in the city[6], where air pollution is measured using fixed but expensive fixed stations that require more space compared to variable or movable stations that can be connected anywhere such as public transport vehicles which require low cost and require less space. These stations are mainly used to measure the gases that make up the largest percentage in the indoor environment. Using modern technology and the Internet of Things, which allows sensors can communicate with the cloud. The authors introduced an air quality measurement system to monitor air quality using raspberry pi, cloud service, and various sensors[7]. Sarjerao et al. 2018, presented a system measuring CO, LPG,

CH4 value using MQ-9 and MQ-135, and displayed on the webpage and mobile application, by using ESP32 as a microcontroller. the system allow the user to see the pollution content by using a the webpage or mobile application[8]. Hidayat et al. 2017, presented a system measuring LPG value using MQ-2 and by using Arduino Uno as a microcontroller, and SIM800L. [9].

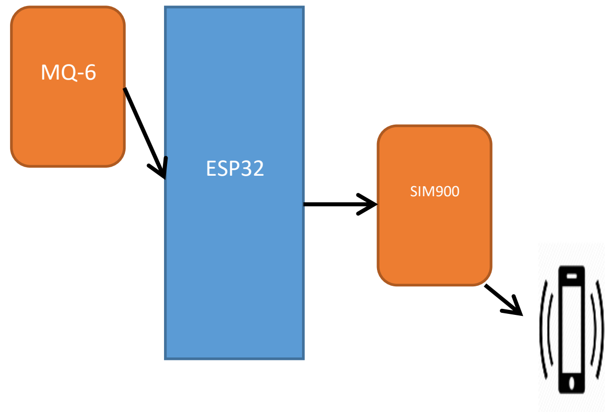

Figure 1. Architecture Model of the proposed system

3. System Design

The system architecture of a proposed system is shown in Figure 1. In this proposed system an MQ-6 gas sensor is used for measuring CO, LPG, CH4 [1], It is connected to near gas emission sources (cookers, heating systems, etc.). SIM900 is a miniature cellular module using to sending and receiving SMS. These components are connected to the ESP32 using connecting wires. ESP32 is connected to the GSM by SIM900.

4. Components information

4.1. ESP32:

It is one of the most popular board, its ability to as two performed, as a complete standalone system and a slave to a host MCU, is a low-cost device which supports both Wi-Fi functionality. it is a single-chip 2.4 GHz Wi-Fi, have 34 × programmable General Purpose Input/output pins (GPIOs) as shown in figure 2, using for contact with all sensors and devices, and It is characterized by the ability to work in an industrial environment with -40 ° C to + 125° C reliably[10]. Figure 2 shows the ESP32 module used in this system.

Figure 2. ESP32

4.2. MQ-6:

The sensor is used to detect different gases LPG, and iso-butane. with digital and analog output. There are several different kinds of gas sensors, but gas sensors of the MQ type are widely used and popular. Gas sensors are normally categorized according to the type of sensing device for which they are installed. Table 2 shows some of these types:

Table 2. MQ Types

Sensor Name	Gas to measure
MQ-2	Butane, LPG, Smoke, Methane
MQ-3	Alcohol, Smoke, Ethanol
MQ-4	Methane, CNG Gas
MQ-5	Natural gas, LPG
MQ-6	LPG, butane
MQ-7	Carbon Monoxide
MQ-8	Hydrogen Gas
MQ-9	Carbon Monoxide, flammable gasses

The gas sensor MQ-6 module is proposed in this system. It can be used to detect gas leakage and measure air quality as follows:

$$\text{Gas Leak} = \text{Concentration} \leq \text{Gas Spread} \leq 1023$$

$$\text{Air Quality} = \text{Gas leak} - 1023$$

Table 3 shows the specifications of the MQ-6[11]. The sensor conductivity is shown in Figure. 2 gets higher if the gas concentration is higher. The sensitivity of the MQ-6 sensor to propane, LPG, hydrogen, methane, and other vapors is considered exceptionally higher[12].

Table 3. MQ-6 Specifications

Name of the parameter	Specification
Gas Detection	300 to 10000 ppm
Analog Output Voltage	Clean air(0.1V-0.3V) and highest around 5V
Digital Output	0 and 1 (0.1V and 5V)
Heater Operating voltage	5.0V±0.1V AC or DC
Tem. Humidity	20℃±2℃；55%±5%RH
Load resistance	Variable

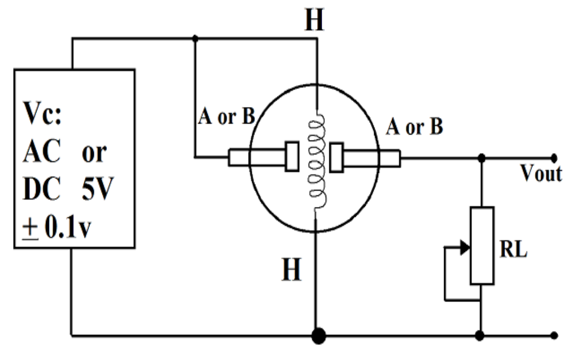

Figure 2. Working principle of the MQ-6

The module detects the existence of the flammable gas due to the heating components within the module's temperature rise. As a working principle, the conductivity of the sensor increases proportionally with the increase of the gas concentration when a gas leak is detected. With appropriate load resistance RL, the performance of the proposed sensor can be improved by complying with the following equation.

$$\mathrm{Ps} = \mathrm{Vc}^2 * \mathrm{Rs}/(\mathrm{Rs} + \mathrm{RL})^2$$

Where the Ps is the power of sensitivity body, Vc: Loop voltage, RS: Sensing resistance, and RL: Load resistance.

The resistance of the sensor (Rs) are:

$$\mathrm{Rs} = \frac{\mathrm{Vc}}{\mathrm{VRL} - 1} * \mathrm{RL}$$

Figure 3 shows the MQ-6 sensor module used in this system.

Figure 3. Gas sensor MQ-6

4.3. SIM900:

It is a miniature cellular module using to sending SMS[13] from the ESP32 when the MQ-6 sensor sent data to the ESP32. Figure 4 shows the SIM900 module used in this system.

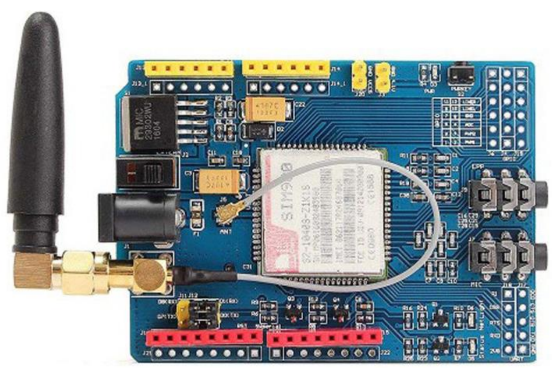

Figure 4. SIM900

4.4. Logic level converter:

Because of the difference in the voltage level between ESP32 and sensors, then LLC is used for passing data from high to low and/or low to high on all channels, this device can shift 3.3V up to 5V or 5V down to 3.3V. Figure 5 shows the LLC (4 channel) module used in this system.

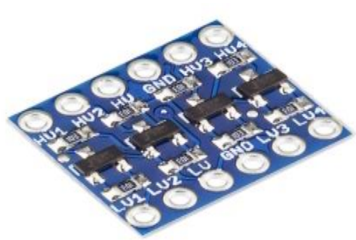

Figure 5. Logic Level Converter (4 Channel)

4.5. Breadboard power supply

It is a companion module, which provides 3v, 5v, and 12v to the proposed system. Figure 6 shows the Breadboard power supply module used in this system.

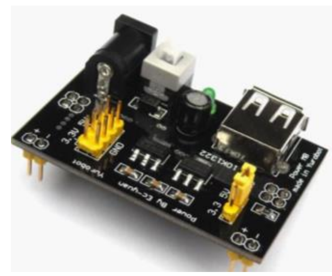

Figure 6. Breadboard power supply

5. Hardware and software aspect

After ESP32 initialization, The MQ-6 read the ratio of gases on the air and sends the signal to the ESP32. If there is a gas leak, the ESP32 will be sent a signal to the SIM900 that already have a specific message that sends it to the user to alarm him/her about the gas leak in this area. the system sends an alarm message to the home user after detecting gas on the air and if there is no response from the user after (3-minutes) the system will send a message to the emergency department (City police, civil defense, or any authority previously identified by the user in the system) with a specific address. This allows the user to monitor the state of the gas leak in the home from outside the house and take appropriate action. Figure 7 shows the block diagram of the proposed system and Figure 8 shows the flowchart of the system algorithm.

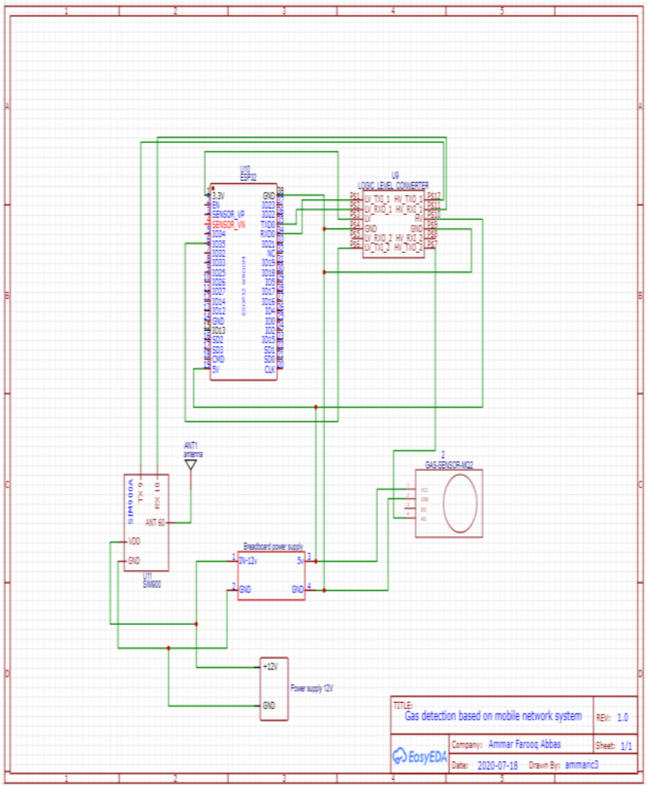

Figure 7. Block Diagram

ESP32 programmed by using the Integrated Development Environment (IDE) software. As shown in Figure 9:

```
sim_gas §
}
void loop()
{
  int gas_sensor = analogRead(A0); // read gas level
        Serial.print(" (gas_sensor)=");
        Serial.println (gas_sensor); // printed the value on the serial port

     if(gas_sensor >1023)
     {
         Serial.println("AT");
         delay(1000);
         Serial.println("AT+CMGF=1");
         delay(1000);
         Serial.println("AT+CMGS=\"+964xxxxxxxxxx\""); // Here we write the user phone number
         delay(1000);
         Serial.println(" Alarm - High level of gas "); // Here we write the Message to the home user
         Serial.write(26);
         delay(30000);
         Serial.print(" (gas_sensor2)=");
         Serial.println (gas_sensor); // printed the value on the serial port
          if(gas_sensor >1023)
       {
        Serial.println("AT");
         delay(1000);
         Serial.println("AT+CMGF=1");
         delay(1000);
         Serial.println("AT+CMGS=\"+964xxxxxxxxxx\""); // Here we write the user phone number
         delay(1000);
         Serial.println(" Alarm - High level of gas, Home Adress "); // Here we write the Message to the Emergency department
         Serial.write(26);
         delay(2000);

       }
     }
      else {
         delay(10000);
        Serial.print("0");
        Serial.print ("--");
       }
}
```

Figure 9. Code of the proposed system

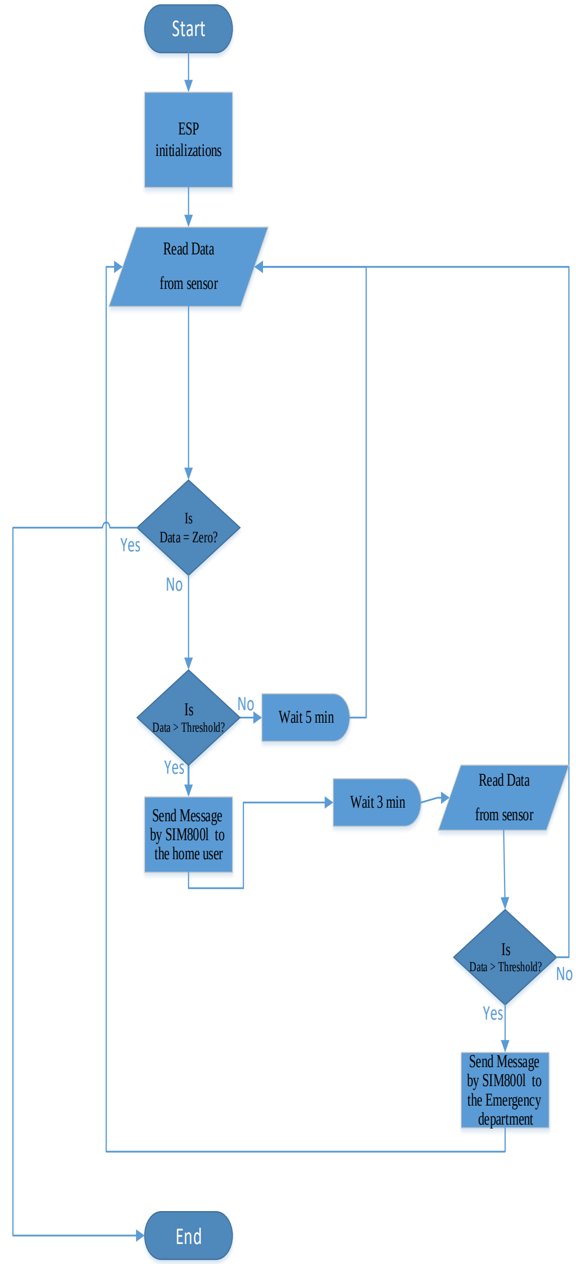

Figure 8. System algorithm

6. Results of the proposed system

The Port screen (Serial Port) is used to display the results as shown in Figure 10. Also, we used the PLX-DAQ for Excel as the tools to read the resalt data from the system. Table 4 shows the results for a specific time. Figure 11 shows the MQ-6 near the gas source (gas cooker), and Figure 12 shows the message received.

Table 4. Results

Date	Time	Gas level
1/09/2020	1:11:40 AM	985
1/09/2020	1:16:48 AM	1019
1/09/2020	1:21:56 AM	1015
1/09/2020	1:26:04 AM	1009
1/09/2020	1:31:12 AM	1047
1/09/2020	1:36:20 AM	1007
1/09/2020	1:41:28 AM	1023
1/09/2020	1:46:36 AM	1018
1/09/2020	1:51:44 AM	1019
1/09/2020	1:56:52 AM	1015
1/09/2020	2:01:00 AM	1021
1/09/2020	2:06:08 AM	960
1/09/2020	2:11:16 AM	980
1/09/2020	2:16:24 AM	989
1/09/2020	2:21:32 AM	1018
1/09/2020	2:26:40 AM	1010
1/09/2020	2:31:48 AM	959
1/09/2020	2:36:56 AM	961
1/09/2020	2:41:04 AM	1094
1/09/2020	2:44:05 AM	1196
1/09/2020	2:44:07 AM	965
1/09/2020	2:49:08 AM	965

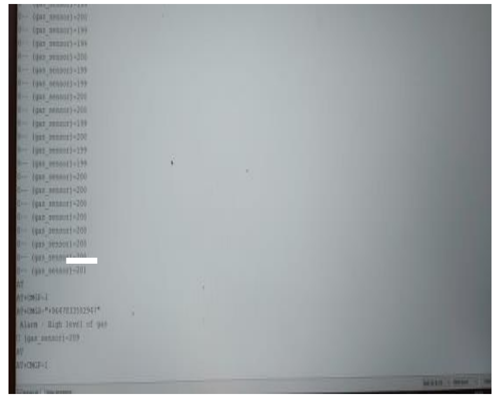

Figure 10. Serial port

Figure 11. The sensor near the gas cooker

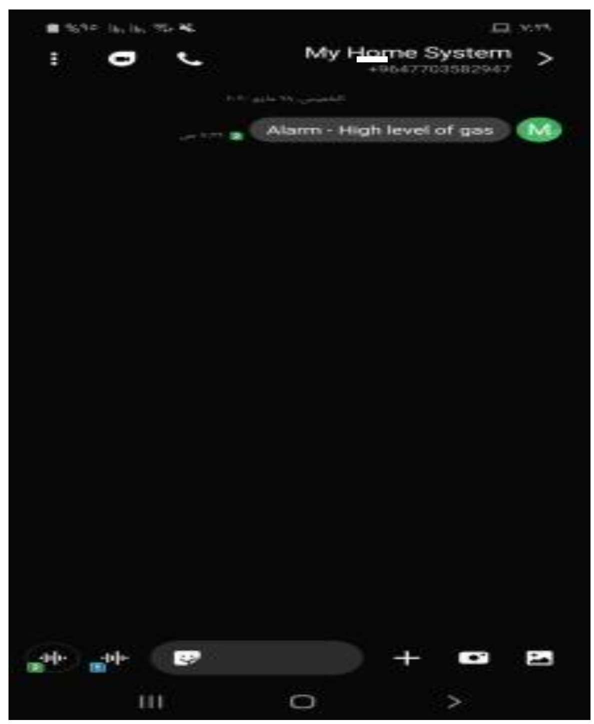

Figure 12. Phone message

7. Conclusions

Given the importance of maintaining the health condition of the human being and avoiding a catastrophe due to a gas leak inside the houses, so the proposed system has achieved excellent results by verifying the gas leak and sending a clear message to the user or the emergency department in the city at super speed, depending on the speed of the mobile phone network, and the sensor used It is characterized by that it does not sense the combustion cases (Flame, heat) (during the cooking process, for example), this specifically enables us to put it near cookers or heating appliances to get better results. It is also possible to determine the proportion of gas accepted in the atmosphere by adjusting the sensor. In the future, you can add the feature of sending a message via a website and using the Internet of Things platform It is currently available easily, such as (https://ubidots.com/) platform, which enables the user to monitor the status of the sensor in real-time, in addition to the possibility of taking immediate action remotely, such as operating a fan to withdraw gas and send it outside the home. Also adding more than one sensor inside the house depending on the number of gas leak sources (near the cook in the kitchen, near the heating system in the living room, etc.) in the same way.

8. Acknowledgments

The authors are grateful and Many thanks for Mustansiriyah University (www.uomustansiriyah.edu.iq) for its support to finish this paper. Special thanks to the anonymous reviewers for their valuable suggestions and constructive comments.

9. Conflict of interest

The publication of this article causes no conflict of interest.

10. Abbreviations

LPG	liquefied petroleum gas
LNG	liquefied natural gas
PAH	polycyclic aromatic hydrocarbons
WHO	World Health Organization
COPD	chronic obstructive pulmonary
RL	Load resistance
VRL	Voltage on the RL
Rs	Resistance of the sensor
Ps	Power of sensitivity body
LLC	Logic level converter

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