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PALESTINE POLYTECHNIC UNIVERSITY

College of Information Technology and Computer Engineering

Computer Engineering Department

Design and Development of Safety Monitoring System For Gas Leakage and Ventilation

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27 DEC 2022

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ABSTRACT

Every year we lose many lives due to gas leakage, lack of oxygen, or fires resulting from various heating methods or from cooking gas, as no one notices the leakage of these toxic and flammable gasses inside the house as a result of their inability to recognize the danger or avoid risks such as children and people who suffer from certain disabilities that limit the sense of smell and movement, especially in the recent period in which the Corona pandemic has spread. In this project, we will focus on preserving the safety of people and property, as well as reducing expected and unexpected accident rates, and reducing human and material losses in case of danger. Basically, we propose an (IoT) system to maintain adequate ventilation in living rooms and prevent fires.

The system takes several measures to make a quick reaction in the event of a fire or an increase in the levels of toxic gasses. So the system works to read the required values from the sensors, the reading will be transferred from the sensors to a microcontroller to be analyzed and processed, and then compared to the typical values to ensure that a defect does not occur. When a defect occurs, the system will alert the user to the presence of a defect by sending a text message and turning on the buzzer. At the same time the system will close the windows, it also turns on the water pump in the event of a fire. In the event of an increase in the percentage of toxic gasses, without the presence of a fire, the system will provide proper ventilation by opening sealed windows. The system also enables the user to monitor the status of the home through text messages. As a result, the system was built and tested to meet the project standards, and it was found to perform as expected and meet the project requirements. Therefore, our system can maintain adequate ventilation in the living rooms and prevent fires.

الملخص

في كل عام ، نفقد العديد من الأرواح بسبب تسرب الغاز أو نقص الأكسجين أو الحرائق الناتجة عن طرق التدفئة المختلفة أو من غاز الطهي ، فعندما لا يلاحظ احد تسرب هذه الغازات السامة والقابلة للاشتعال داخل المنزل نتيجة لعدم قدرتهم للتعرف على الخطر أو تجنب المخاطر ، مثل الأطفال والأشخاص الذين يعانون من إعاقات معينة تحد من حاسة الشم والحركة ،خصوصا في الفترة الأخيرة بعد انتشار جائحة كورونا . وفي هذا المشروع ، سنركز على الحفاظ على سلامة الأشخاص والممتلكات ، وكذلك تقليل معدلات الحوادث المتوقعة وغير المتوقعة ، وتقليل الخسائر البشرية والمادية في حالة الخطر. في الأساس ، نقترح نظام (IoT) للحفاظ على التهوية الكافية في غرف المعيشة ومنع الحرائق.

يتخذ النظام عدة إجراءات لعمل رد فعل سريع في حالة نشوب حريق أو زيادة مستويات الغازات السامة بحيث يعمل النظام على قراءة القيم المطلوبة من المستشعرات ، وسيتم نقل القراءة من المستشعر إلى متحكم دقيق وتحليلها ومعالجتها ، ثم مقارنتها بالقيم النموذجية لضمان عدم حدوث خطر . عند حدوث خلل، يقوم النظام بتنبيه المستخدم إلى وجود خلل عن طريق إرسال رسالة نصية وتشغيل الإنذار. في نفس الوقت يقوم النظام بإغلاق النوافذ وتشغيل مضخة المياه في حالة نشوب حريق. في حالة حدوث زيادة في نسبة الغازات السامة ، دون وجود حريق ، سيوفر النظام تهوية مناسبة عن طريق فتح النوافذ المغلقة. كما يمكن النظام المستخدم من مراقبة حالة المنزل من خلال الرسائل النصية. ونتيجة لذلك ، تم بناء النظام واختباره لتلبية معايير المشروع ، ووجد أنه يعمل على النحو المتوقع ويلبي متطلبات المشروع. لذلك ، يمكن لنظامنا الحفاظ على تهوية مناسبة في غرف المعيشة ومنع الحرائق.

ACKNOWLEDGEMENTS

In the name of "Allah", the most beneficent and merciful who gave us strength, knowledge and helped us to get through this project.

Working on this project has been an opportunity for gaining valuable experience. For that,we want to thank all the people who assisted us in getting the project done.

We would like to express our sincere appreciation to the graduation project supervisor,
Dr. Muhammad Aldasht for his guidance, continuous encouragement and support throughout the semester.

We are also thankful for all the instructors of the IT and Computer Systems Engineering Department who dedicated their time to share their knowledge and expect us to become hard-working and result oriented engineers.

Furthermore, we are grateful for Eng. Wael Takrouri for answering our questions and providing us with valuable suggestions and tips that helped us in our project, especially in the hardware issues.

Moreover, it is our pleasure to thank our families for their generous encouragement and continuous support throughout our project. For our friends, we are truly grateful for all your support and encouragement throughout this chapter of our lives.

Finally, we would like to thank all the people who helped and supported us even with their feelings.

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List of Abbreviations

IoT	Internet of Things
ppm	Parts per million. Equals 0.0001 percent
CO	Carbon Monoxide
CO_2	Carbon Dioxide
LBG	Liquefied Biogas
NH3	Ammonia
S	Sulfur
Benzene	C6H6

Chapter 1: Introduction

1.1 Overview

We always strive to maintain safety in our homes through preventing gas leaking and fires from occurring. In addition, various means and safety measures are implemented to alert us when a disturbance occurs even if we are far from our homes. So a set of technological and electrical techniques could be presented to overcome ventilation issues through building a smart solution that can alert us through SMS messages and alarms as well as implementing some measures to keep human beings safe and prevent material damage.

1.2 Motivation and Importance

Recently, we have witnessed a rise in the number of cases of suffocation and death due to gas leakage, lack of oxygen, or fires resulting from different heating methods or from cooking gas. Therefore, we strive to create a system that performs safety control measures that maintains the safety of people as well as property. Moreover, it reduces the rates of expected and unexpected accidents related to ventilation and gas leaking which reduces human and material losses in the event of a danger.

1.3 Problem Statement

Every year in winter, we witness disastrous incidents, like a fire breaking out and suffocation that occur at homes due to neglect and lack of attention. Unfortunately, this often results in the loss of precious lives and assets. The main reason for this terrible loss is the presence of toxic and flammable gasses in abnormal proportions inside a closed room. As a consequence, poisonous gas, such as Carbon Monoxide, CO, Carbon Dioxide, CO_2, and flammable gasses increase in the closed room while the breathing gas, Oxygen, drops down.

The real issue arises when no one takes notice of the toxic and flammable gas leakage inside the room. The people in charge of the house could be sleeping, running an errand away or they're simply unable to recognize the danger and avoid the risk, like kids and people with certain disabilities that limit their movements. Moreover, people who got infected with certain types of COVID-19 lost their sense of smell for a while, So in case of gas leakage, they are unable to detect the difference in gas proportion. Thus, they usually fail to perform safety countermeasures or ask for help.

Considering the amount of risk lack of awareness of gas leaking holds, a smart technological solution should be introduced and implemented to reduce risk and save lives.

1.4 Project Description

Our project is a system responsible for controlling safety in the room regarding ventilation and fire outbreaks. The smart system mainly focuses on creating a safe living environment inside the room as well as reducing the risk of losing home assets.

In order to achieve this goal, our system will maintain proper ventilation in the living room by continuously checking the presence of:

- fire or smoke
- three important types of gas which are cooking gas, Carbon Monoxide, and Carbon Dioxide.

The system takes appropriate measures according to the state of the rooms. When a fire or smoke is detected, the water pump is activated as the system alerts the user with alarms and a text message explaining the current condition. When a leak of toxic or flammable gasses is detected without the presence of fire or smoke The system will open all closed windows and alert the user through a text message that indicates danger and activates the alarm. Moreover, the user can request to check the room’s state and the system will reply through SMS.

1.5 Objectives

This project aims to:

- Provide a smart system that creates a safe environment and works on keeping an appropriate ventilation in the living room
- Preserving the people and children's safety inside the house through protecting them from suffocation hazards.
- Reduce the risk of losing house assets.
- Immediately take appropriate measures to minimize damages.

1.6 System Requirements:

The functional and non-functional requirements are described as follows:

1.6.1 Functional Requirements

The functional system requirements can be summarized as :

- Get the sensors' correct reading .
- The system must operate as quickly as possible .
- The user can monitor the safety status at home remotely and check how the gasses' balance is maintained.
- The user receives an alert in the event of a disturbance.
- The system will be able to perform countermeasures quickly in the event of a fire or an increase in the level of toxic gasses.

1.6.2 Non-Functional requirements

- Available : As long as power is present , the system is available .
- Effective :The efficiency of the system comes from identifying the damage caused inside the home and selecting the appropriate solution with high accuracy.
- Usability: The mechanism of the system is user friendly, and everyone can use it with very simple and short instructions.
- Accuracy:The system reads accurate data from the room in which different procedures will be performed upon it.
- Cost: The system design consists of low-cost hardware components, This makes it relatively affordable.
- Maintainability: The system's hardware components are available in the market and can be easily replaced if something malfunctions in one of its parts.
- Safety: The system maintains the safety of people and children inside the house, in addition to preserving the assets of the house. It's also not dangerous to place inside the room and doesn't cause harm to people if used properly.

1.7 Expected Results

At the end of this project, It is anticipated to build a system that will create a safe environment and work on keeping appropriate ventilation in the living room, which will help in maintaining the safety of people inside the house and protect them from suffocation in addition to reducing the risk of losing house assets.

1.8 Report Outline

This report is organized into five interrelated chapters supported by the necessary figures and illustrations as follows:

Chapter 1: Introduction

A general introduction to the research problem, motives, importance and objectives of the study, a brief description of the system, in addition to a list of requirements and expected results.

Chapter 2: Background

Reviews some previous studies in smart home design ,in addition to it explains in detail all the tools used in the design of the house .

Chapter 3: Design

Presents the theoretical framework of the subject and the basic physical laws in the installation of circuits, in addition to the stages and steps of implementation and detailed conceptual description of the system, detailed design, schematic diagrams, block diagrams and flowchart .

Chapter 4: System Implementation and Testing

This chapter presents hardware and software design applications, such as circuit interfaces, microcontrollers, and IDEs used to generate project codes, as well as results and discussion.

Chapter 5:Conclusion And Future work

It summarizes our project we have developed in addition to some features and plans for developing this work in the future.

Chapter 2: Background

2.1 Overview

This chapter briefly describes the theoretical background of the project and a short description of the hardware and software parts that are used in the system. The design system specifications and limitations are also discussed.

2.2 Literature Review

Modern solutions mainly focus on suppressing fire inside the house and preventing it from spreading through smoke detectors and water sprinklers. Some technological solutions are used to detect fire outbreaks like satellites and robots that have also been developed to detect cooking gas leakage inside the house. In addition, IoT solutions have been developed and applied to detect fire outbreaks. Several technological solutions have been provided to protect against fire and suffocation altogether for homes.

Here are some of the projects similar to ours that have been developed for the purpose of preserving lives and protecting assets:

1) Research from Universitas Pendidikan Indonesia considering Automation and Monitoring Smart Kitchen Based on the Internet of Things (IoT) [1]. The system is built so that it can constantly track and transmit different details about the kitchen's state. It monitors temperature and fire changes caused by the use of gas stoves in the kitchen. DHT11 sensor detects temperature variations in the kitchen, while an MQ-135 gas sensor detects Liquefied Petroleum Gas (LPG) leaks, an IR flame sensor detects flames, and PIR sensors detect human behavior. Besides, a relay in this system controls the fan, which controls the temperature and blows out gas in the case of a gas leak or smoke from the kitchen in case of a fire breaking out. This system can be managed and tracked through the internet at any time, even if the user is out of the kitchen, using laptops or Smartphones. In the event of a fire or gas leak, this device will sound an alarm and send information through SMS, e-mail, or in-app notification on a smartphone.

2) Another research from (International Conference on Information Technology (ICIT)) and published by IEEE titled "FireDS-IoT: A Fire Detection System for Smart-Home Based on IoT Data Analytics” [2]. Bhoi et al. developed a smart home IoT fire warning system that uses data collection, in decision tree machine learning

algorithms, and emergency response sensors. These devices simply read sensors and do not avoid fires directly.

3) In the market, there is “Fire Avert”, which is made in the United States, plugs into your stove outlet, and monitors (response to) smoke detector activation. When it receives a signal, the switches turn off the electricity from the outlet.[3]

2.3 Hardware System Components

This section shows the hardware components used in the project, and how they are used.

1) Microcontroller:

There are different options of the microcontrollers that can be used in our project.

First Design Option: Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), and a 16 MHz crystal oscillator. It contains everything needed to support the microcontroller. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.[4]

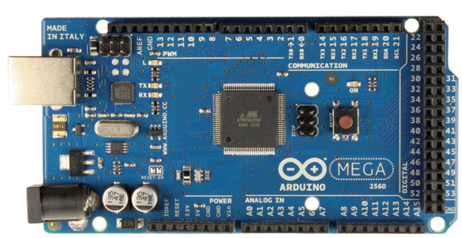

Figure 2.1 :Arduino Mega 2560[5]

Second Design Option: Raspberry Pi :

Raspberry Is a small ,single-board computer. It has a 64-bit quad-core ARMv8 processor and uses a Raspbian distribution of Linux for its default operating system (OS).

The Raspberry Pi computer is essentially a wireless Internet capable system-on-a-chip (SoC) with 1 GB RAM, connection ports, a Micro SD card slot, camera and display interfaces and an audio/video jack. Table 2.1 summarizes the main features that may affect our choice. (Figure 2.2) [6]

Figure 2.2:Raspberry Pi [7]

Table 2.1 Microcontrollers comparison

Feature	**Arduino Mega**	**Raspberry Pi**
Programming	Easy	Easy
Size(mm)	68.6 × 53.3	85 x 56
Memory size	32 KB	1 GB
clock	16 MHz	1.4 GHz
Cost	Low cost	More expensive
Wi-Fi	Need additional module or shields to connect to internet	On-board wifi

Chosen Design Option

Even though Raspberry Pi features are more advanced, Arduino Mega microcontroller is chosen for these reasons:

- Mega Provides all features and pins that are required
- Arduino mega is available in the market and affordable unlike Raspberry Pi microcontrollers. So if a damage occurs, it’s easy to replace.
- Arduino Mega is not as sensitive as Raspberry Pi. So it’s less likely to be damaged and burned.[8]

2) Sensors:

1) **Gas Sensor (MQ-9):**

Sensitive material of the MQ-9 gas sensor is SnO2, which has lower conductivity in clean air. It detects gas by cycling on high and low temperature, and detects CO when low temperature (heated by 1.5V). The sensor's conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it detects Methane, Propane etc combustible gas and cleans the other gasses adsorbed under low temperature. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-9 gas sensor has high sensitivity to Carbon Monoxide, Methane and LPG. The sensor could be used to detect different gasses contains CO and combustible gasses, it is with low cost and suitable for different application. [9]

Figure 2.3: Gas Sensor (MQ-9)[10]

2) **Temperature and Humidity sensor (DHT11):**

This sensor (Figure 2.4) measures the temperature in Celsius /Fahrenheit. Its temperature measuring range is from 0 to 50 degrees Celsius with +-2 degrees accuracy. Also, it is able to measure humidity.[11]

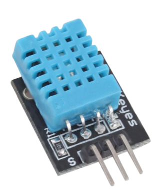

Figure 2.4:Temperature and Humidity sensor (DHT11)[12]

3) **MQ-135 Gas sensor**

The MQ-135 Gas sensor can detect gasses like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gasses and smoke. Similar to other MQ series gas sensors, this sensor also has a digital and analog output pin. When the level of these gasses go beyond a threshold limit in the air the digital pin goes high. This threshold value can be set by using the on-board potentiometer. The analog output pin, outputs an analog voltage which can be used to approximate the level of these gasses in the atmosphere.[13]

Figure 2.6: MQ-135 Gas sensor[14]

4) **Flame Sensor:**

A sensor which is most sensitive to a normal light is known as a flame sensor. That's why this sensor module is used in flame alarms. It detects flame otherwise wavelength within the range of 760 nm – 1100 nm from the light source. This sensor can be easily damaged to high temperatures. So this sensor can be placed at a certain distance from the flame. The flame detection can be done from a 100cm distance and the detection angle will be 600. The output of this sensor is an analog signal or digital signal. These sensors are used in fire fighting robots like as a flame alarm.[15]

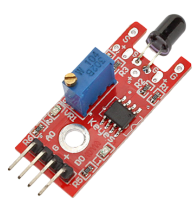

Figure 2.7: Flame Sensor[16]

Previously, we have mentioned the possibility of using an oxygen sensor, however, the oxygen sensor is not available in the market and purchasing one online would take a lot of time. So, after consulting with some safety and public health professionals. We have decided that the mentioned sensors above meet the system requirements and we will not use an oxygen sensor.

3) Breadboard:

This simplifies connecting the components together and will be used for testing.(Figure 2.8)

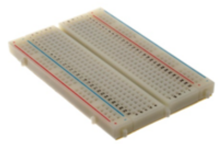

Figure 2.8: Breadboard[17]

4) Global System for Mobile Communication (GSM):

Global System for Mobile Communication (GSM) is a standard used in cellular communication networks. Amongst all cell technologies in use nowadays, GSM is one of the most widespread, GSM modules offer connectivity along with wireless data communication transfer. These devices are light and easy to use as well as have a surprisingly low power consumption for the amount of work they can do. They can be used for tracking communication projects, linking together a remote site monitoring system with your LAN, as well as many other applications, a GSM module is a specialized type of device which accepts a SIM card, and operates over a subscription to a mobile operator, just like a cell phone or pager. From the mobile operator's perspective, a GSM modem looks like a phone—the difference between a cell phone and a module is the flexibility in applications.[18]

Figure 2.9: GSM [19]

5) Buzzer

It is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers include alarm devices and timers. In our case, it will be used as an alarm to alert the user when the system detects a fire.[20]

Figure 2.10: Piezo Buzzer[21]

6) Water pump:

12v diaphragm pump 6v small mini water pump household. The water pump works using the water suction method which drains the water through its inlet and releases it through the outlet[22]. We will use in our system to put down any fire breakouts that occur in the house.[23]

Figure 2.11: Water pump[24]

7) Linear Actuator:

An actuator is part of a device or machine that helps it achieve physical movements by converting energy, often electrical, air, or hydraulic, into mechanical force. Simply put, it is the component in any machine that enables movement.[25]

Figure 2.12:Linear Actuator[26]

8) Relay:

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.In our project, two relays will be used, one to operate the pump and the second to operate the actuator.[27]

Figure 2.13: Relay[28]

2.4 System Software Component

This section will provide some information about the main programs and software environments that will be used in this project.

- **Arduino IDE:**

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

2.5 System Constraints

1) The system needs to be practical and easy to use by everyone regardless of age and medical history.
2) It should be available at the market and applicable at homes.
3) It should be able to distinguish between normal and abnormal, dangerous, changes in gas balance inside the house. i.e. false alarm rate should be as minimum as possible.

Chapter 3: Design

3.1 Overview

This chapter discusses the overall design of the system and the way its components are integrated together. Block diagram and schematic diagram for the system design are presented in the chapter. In addition to some details about the algorithms we are going to use.

3.2 Detailed Design

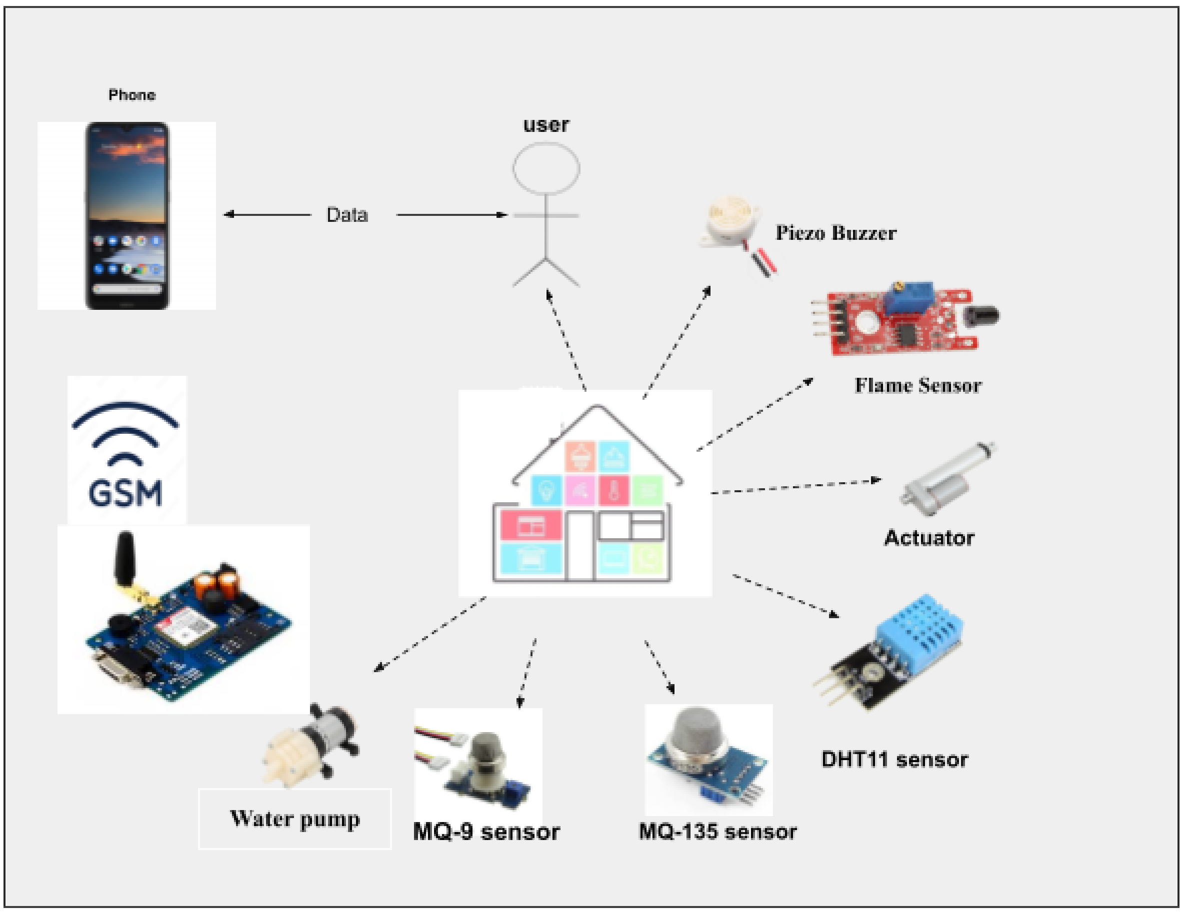

Figure 3.1 :System Design

The system design shown in Figure 3.1 provides an overview of the major components of the system and the connections between them. The system consists of advanced sensors that help provide security for individuals inside the home. The system communicates with external parties to complete its specified function. The system contains a mobile phone to provide individuals inside the house with information about the environmental conditions inside the house when needed by reading the required values from the sensors or alerting the user in the event of a fire or an imbalance in the proportion of toxic gasses inside the house by means of a text message or by operating the buzzer.

3.3 Schematic Diagram

1) **MQ9 Sensor**
   Note: the same schematic could be used to describe the connection between *MQ135* and Arduino Mega 2560.

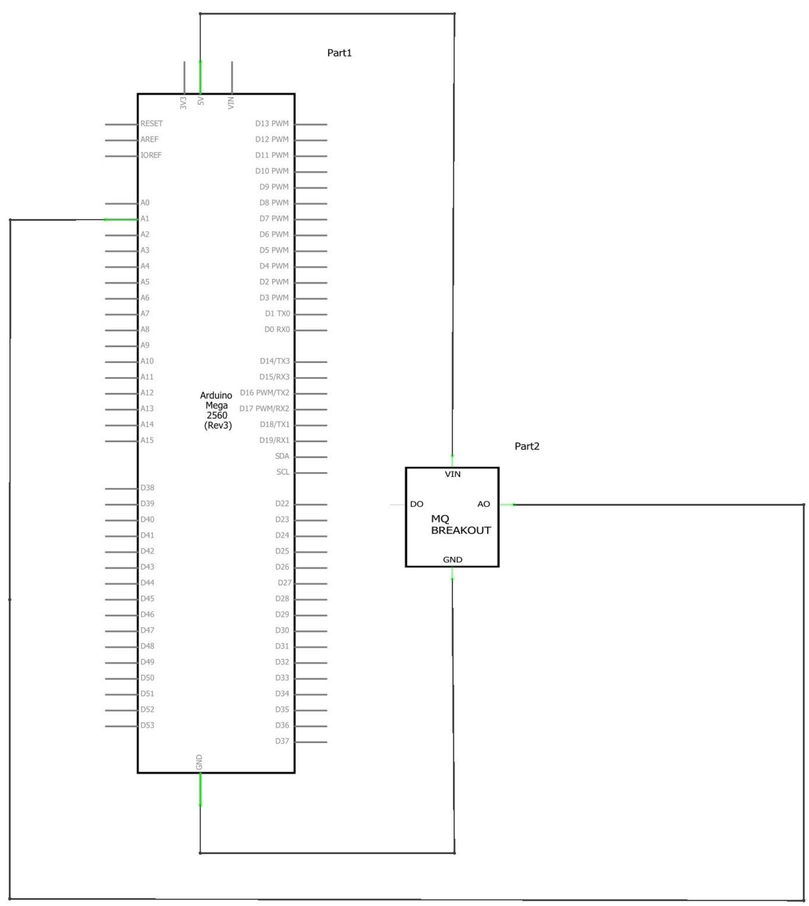

Figure 3.2: MQ9 Sensor Schematic Diagram

2) Flame Sensor

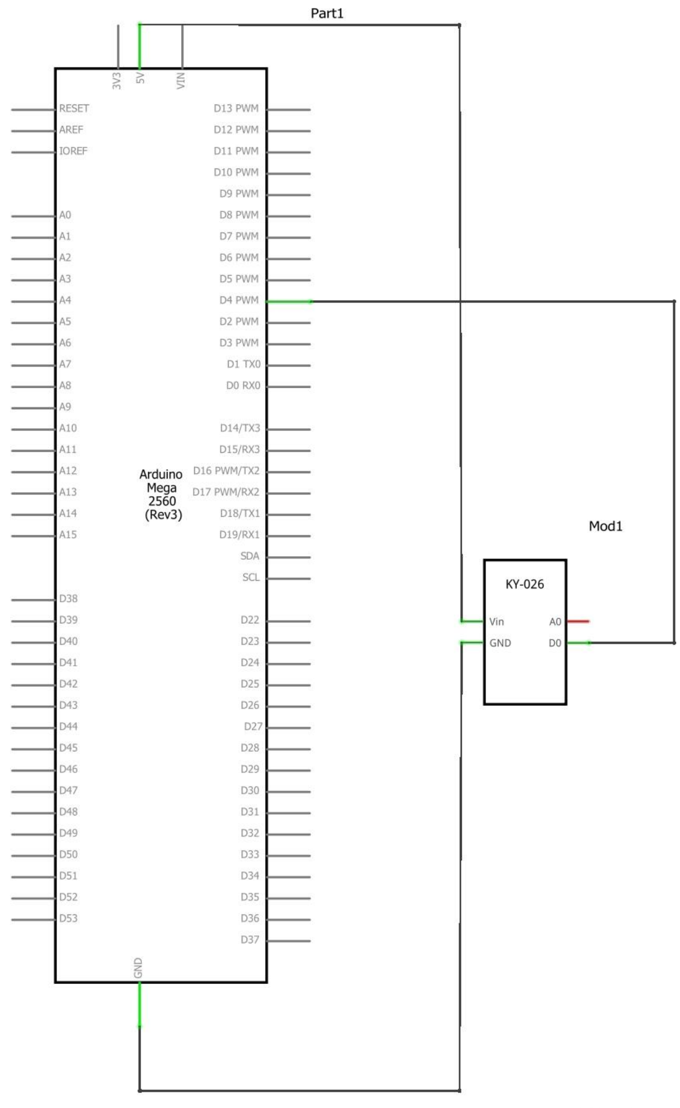

Figure 3.3: FlameSensor Schematic Diagram

3) DHT11 Sensor

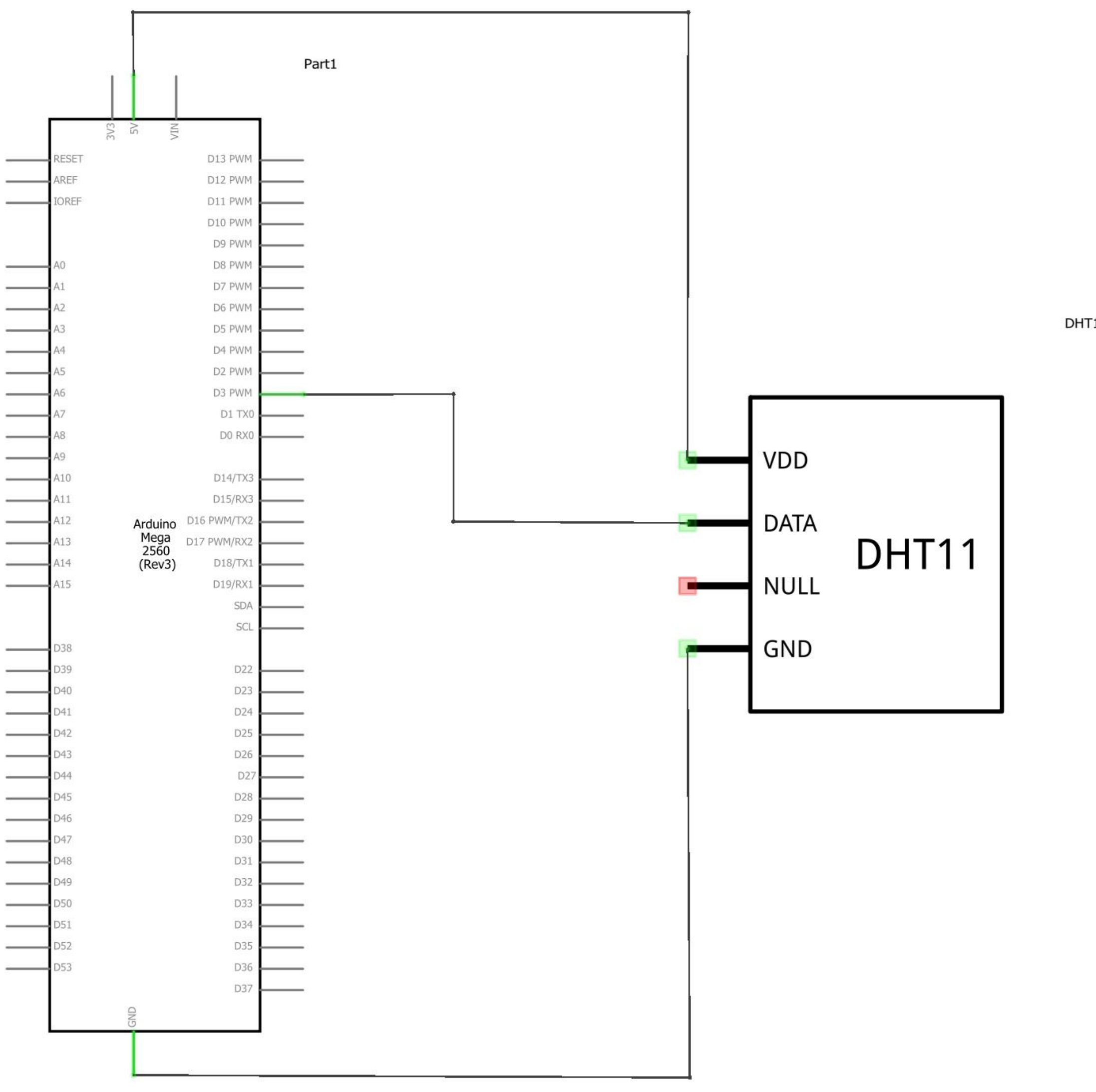

Figure 3.4: DHT11 Sensor Schematic Diagram

System Schematic Diagram

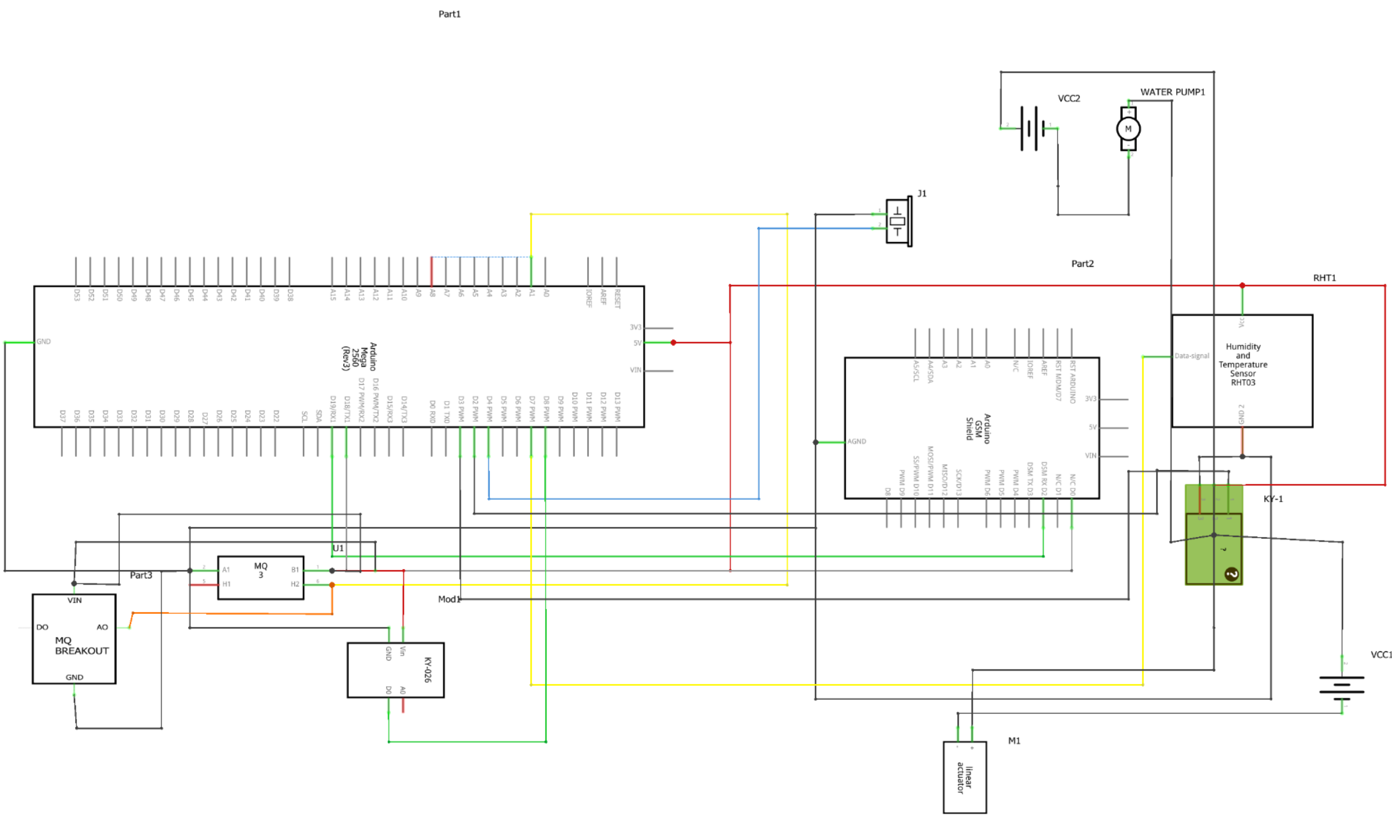

Figure 3.5: Schematic diagram

Figure 3.2 shows the schematic diagram of the system that defines the logical connections between the components on the circuit board. The GSM module is connected to the TX1 and RX1 on the microcontroller. Each of the sensors is connected to a different pin, MQ9 and MQ135 connected to analog pins and the flame sensor is connected to a digital pin on the microcontroller. The actuator and water pump are connected through relays. For the actuator relays we need two digital pins and one digital pin for the water pump relay on the microcontroller.

3.4 Block Diagram

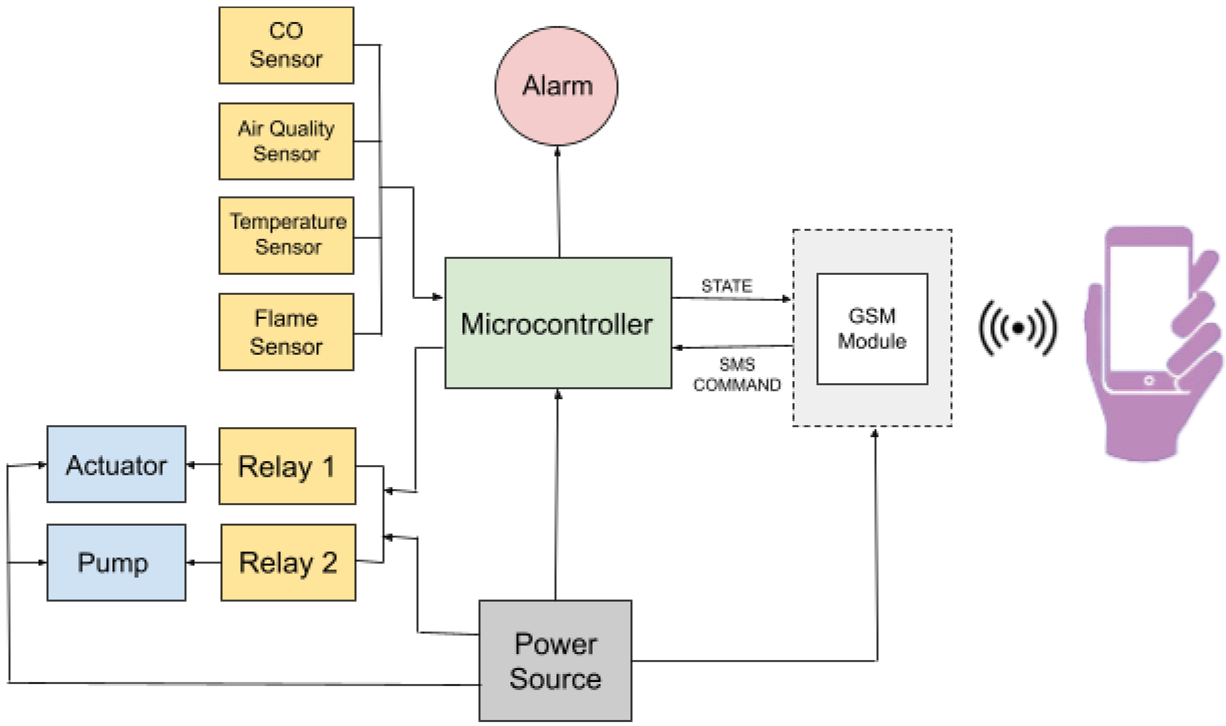

Figure 3.6: Block diagram

Figure 3.3 shows the principal parts and functions of the system represented by blocks which are connected by lines to show the relationship between them. The proposed system consists of a GSM module SIM900, an Arduino microcontroller, two relays, four sensors, and an alarm. The whole circuit can be powered by a 12-volt wall adapter.

The microcontroller constantly reads data from the sensors. It compares the current values with a specified threshold and acts upon them accordingly. The relays act as an intermediate between the microcontroller and electric devices. The microcontroller singles the relays to either turn the water pump on or off as well as open or close the window using the linear actuator.

A valid SIM card needs to be inserted into the GSM module which will send and receive SMS messages to and from the user. The Arduino microcontroller communicates with the module using serial communication protocol and the Arduino will decode and check the incoming SMS. the user can request data read from sensors. In return, the Arduino sends this data to the user via GSM. In some cases, the Arduino sends alarming messages to the user without the user requesting it. The different procedures performed are specified in the following flowchart in Figure 3.4

3.5 Flow Chart

3.5.1 Flow Chart of the system

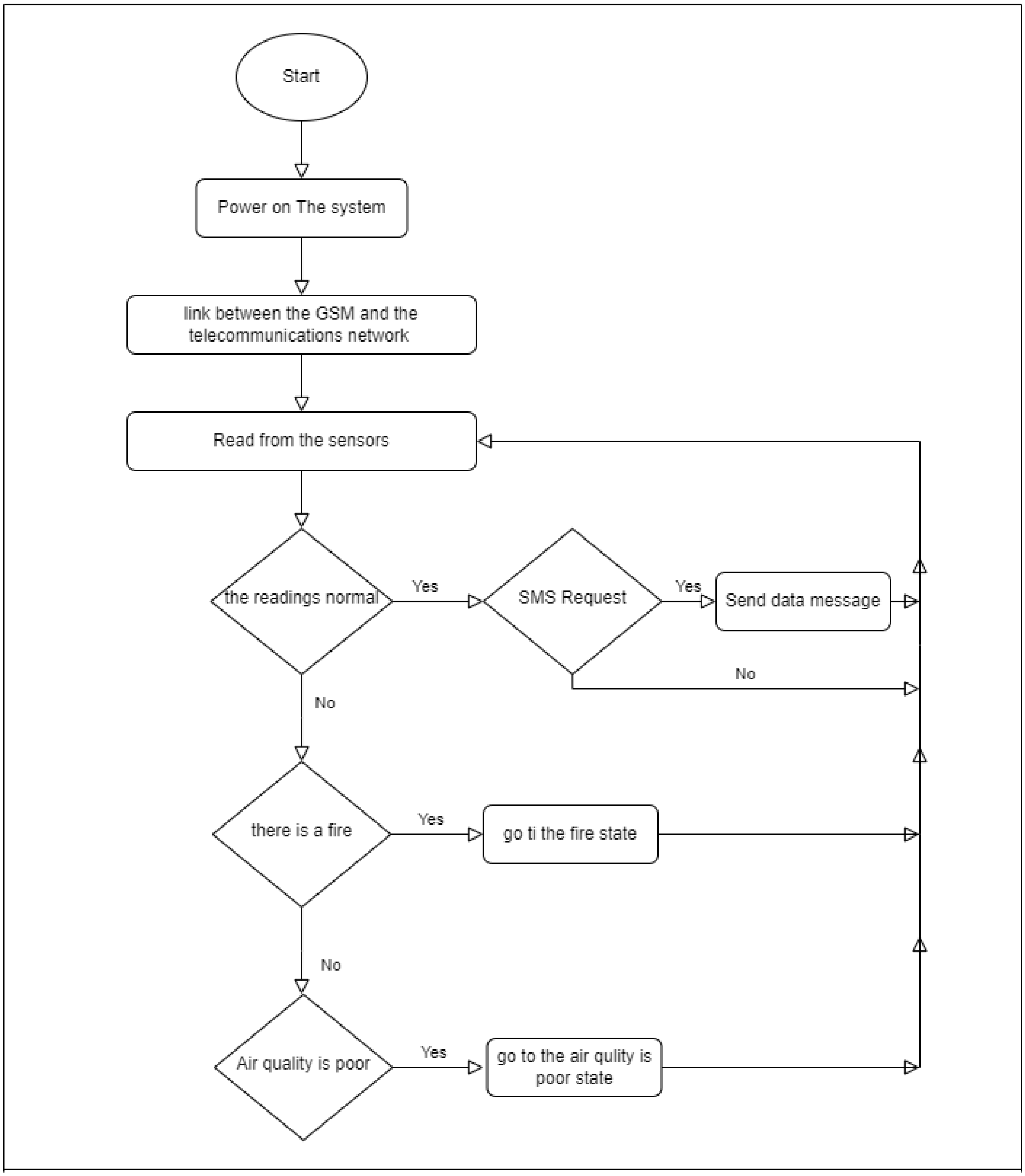

Figure 3.7: Flow Chart of the system

3.5.2 Fire State Flow Chart:

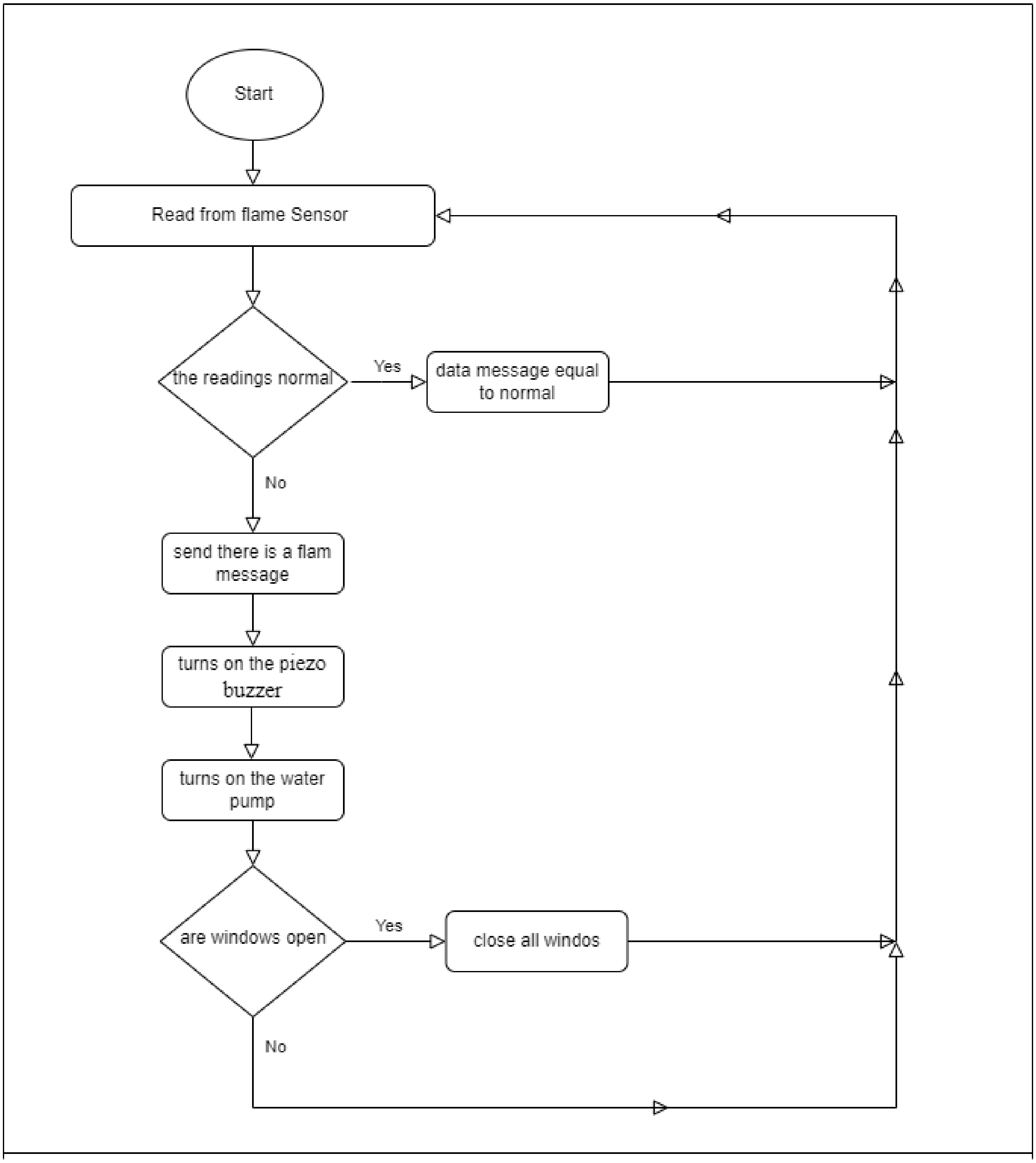

Figure 3.8: Fire State Flow Chart

3.5.3 Poor Air Quality State Flow Chart:

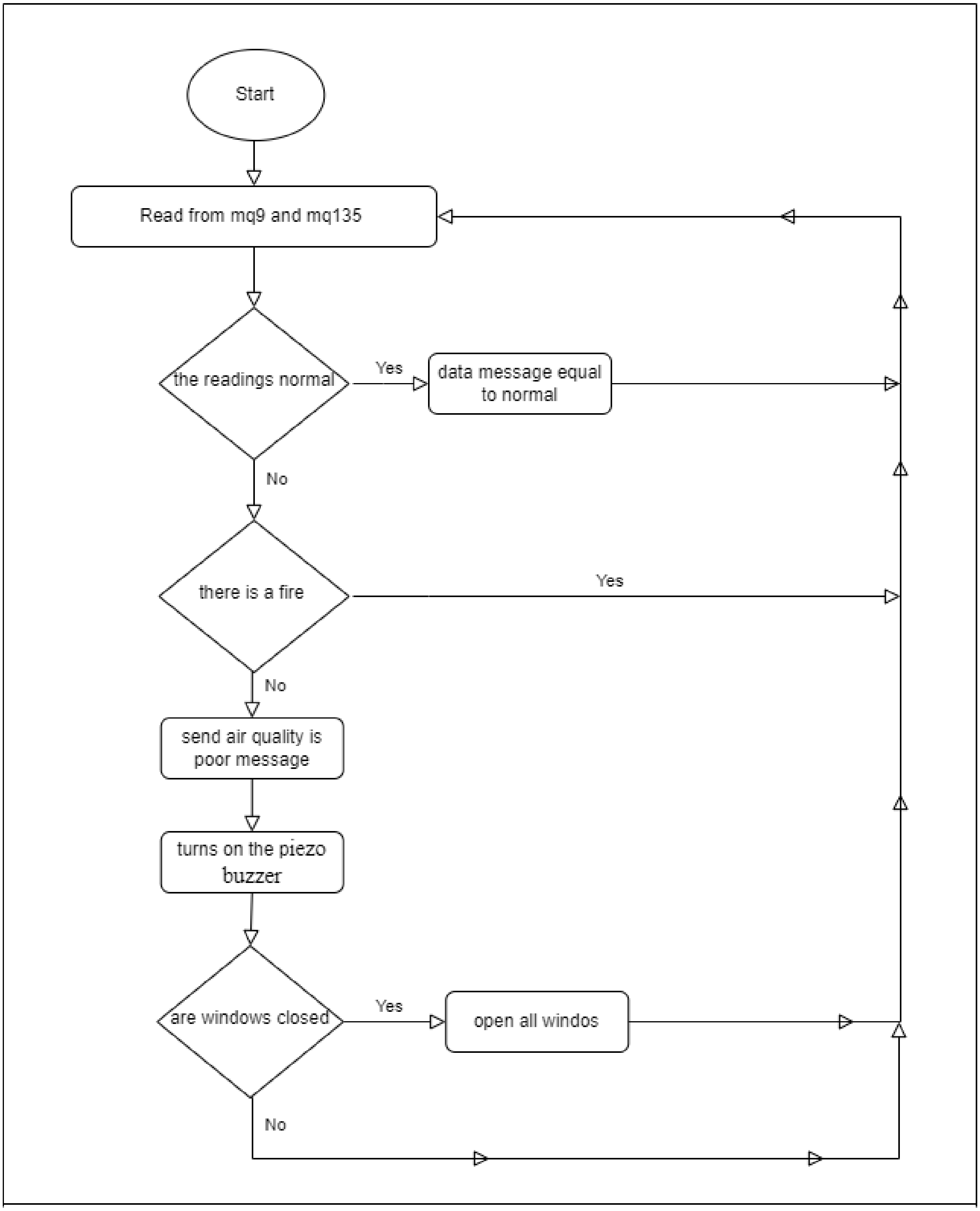

Figure 3.9: Poor Air Quality State Flowchart

Chapter 4: System Implementation and Testing

4.1 Overview

This Chapter presents the set of procedures performed to build the system design. It describes the hardware components connection as well as software development. On the other hand, we will address some of the issues and challenges faced throughout the implementation and testing process.

4.2 Hardware and Software Implementation

Here we talk about the hardware connections between the components and how they were programmed to communicate with each other.

The main component is the Arduino Mega 2560 microcontroller which is connected with the other system's components as follows:

4.2.1 Hardware Implementation

1) Gas Sensor MQ9

- Connect the VCC pin of the sensor to the 5V pin of the Arduino Mega.
- Connect the GND pin of the sensor to the GND pin of the Arduino Mega.
- Connect the AO pin of the sensor to the A0 pin of the Arduino Mega.

2) Gas Sensor MQ135

- Connect the VCC pin of the sensor to the 5V pin of the Arduino Mega.
- Connect the GND pin of the sensor to the GND pin of the Arduino Mega.
- Connect the AO pin of the sensor to the A1 pin of the Arduino Mega.

3) Temperature and Humidity sensor (DHT11) .

- Connect the VCC pin of the sensor to the 5V pin of the Arduino Mega
- Connect the GND pin of the sensor to the GND pin of the Arduino Mega
- Connect the IO pin of the sensor to pin 3 on Arduino Mega

4) Flame Sensor

This sensor is sensitive to light, so we adjusted its sensitivity according to our prototype room using a potentiometer.

Connect the flame sensor with the Arduino Mega:

- Connect the VCC pin of the sensor to the 5V pin of the Arduino Mega
- Connect the GND pin of the sensor to the GND pin of the Arduino Mega
- Connect the D0 pin of the sensor to pin 4 of the Arduino Mega

5) GSM SIM900 Module

- Connect the RX pin of the GSM board to the TX1 of the Arduino Mega
- Connect the TX pin of the GSM board to the RX1 of the Arduino Mega
- Connect the GND to the GND pin on the Arduino Mega
- Connect the 12 DC voltage to the GSM board Mega

7) Connect Buzzer with the Arduino Mega.

- Connect the Buzzer positive (Red) wire to pin 2 of the Arduino Mega
- Connect the Buzzer negative (black) wire to the GND of the Arduino Mega

8) Linear Actuator

To connect and control the linear actuator, we need a 2-relay module to act as an intermediate between the Arduino Mega and the actuator.

Linear Actuator needs to be connected to a power source to function properly, so we used a 12 volt adapter and connected it to the relay and actuator as follows:

- Connect the actuator positive (Red) wire of the battery to the positive (Red) wire of the actuator.
- Connect the actuator negative (black) wire of the battery to the NO pin on the relay
- Connect the actuator negative (black) wire of the battery to COM pin on the relay
- To connect the relay to the actuator.

Connecting 2-relay module to Arduino Mega:

- Connect the relay VCC to the 5V pin of the Arduino Mega
- Connect the relay GND to the GND pin of the Arduino Mega

- Connect the IN1 to the digital pin 5 of the Arduino Mega.
- Connect the IN2 to the digital pin 6 of the Arduino Mega.

9) Water Pump

The connection of the water pump is similar to the connection of the linear actuator. We need a 2-relay module to act as an intermediate between the Arduino Mega and the water pump as it also needs a 12 volts adapter to function properly. The connection is as follows:

- Connect the actuator positive (Red) wire of the battery to the positive (Red) wire of the actuator.
- Connect the actuator negative (black) wire of the battery to the NO pin on the relay
- Connect the actuator negative (black) wire of the battery to COM pin on the relay
- To connect the relay to the actuator.

Connecting 2-relay module to Arduino Mega:

- Connect the relay VCC to the 5V pin of the Arduino Mega
- Connect the relay GND to the GND pin of the Arduino Mega
- Connect the IN1 to the digital pin 7 of the Arduino Mega.
- Connect the IN2 to the digital pin 8 of the Arduino Mega.

Figure 4.1 shows the connecting and wiring diagram of the system together with the microcontroller.

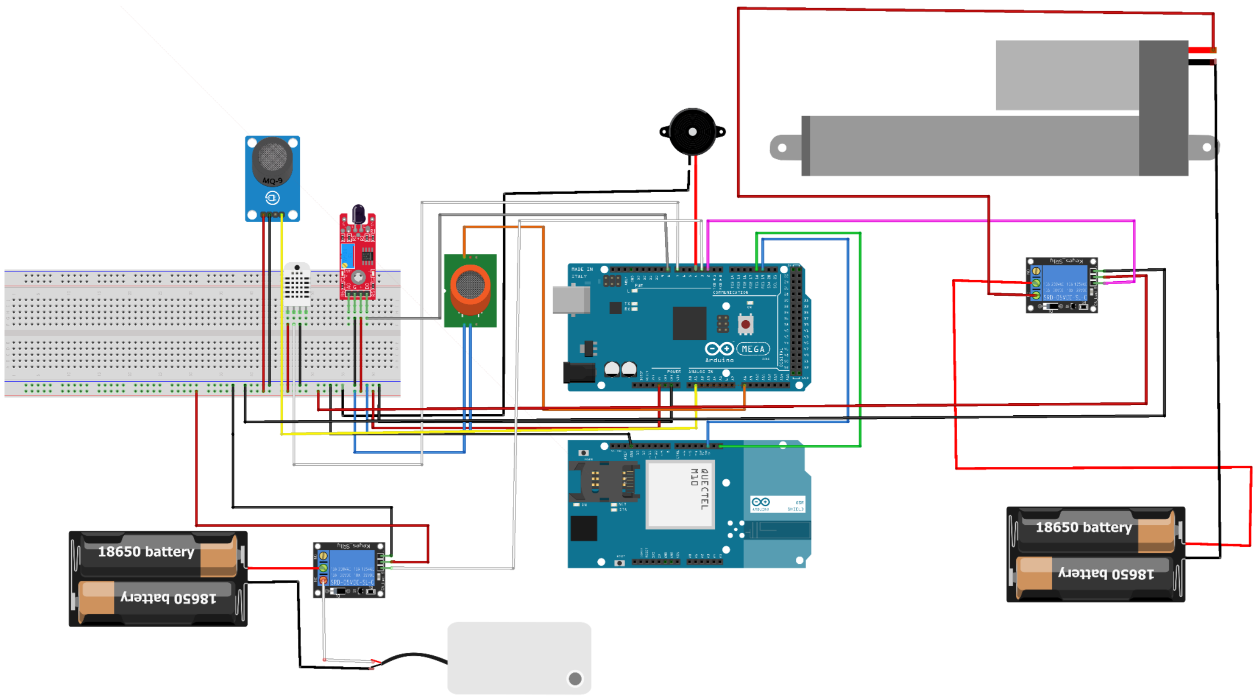

Figure 4.1: Wiring Diagram of the system

4.2.2 Software Implementation

4.2.2.1 Sensors Calibrating

➔ MQ9 Sensor

The MQ9 sensor needs 24-48 hours of preheating time before calibrating it. So we connected the power supply and left it for about 25 hours ,This sensor measures the gas concentration based on resistance ratio between R0 (sensor resistance) and Rs (Internal resistance of the sensor which changes by gas concentration).In order to calculate this ratio we apply the following steps:

- ❖ The sensor needs to be installed in clean air
- ❖ We average the sensor value from 100 data to achieve a stable value.

Code of Calibrating:

```
//Average
  for(int x = 0 ; x < 100 ; x++)
 {
  sensorValue = sensorValue + analogRead(A0);
 }
 sensorValue = sensorValue/100.0;
```

- Using the previous value, Sensor voltage is calculated

```
sensor_volt = (sensorValue/1024)*5.0;
```

- According to RL resistance (which can be found in the datasheet and in our case, 5K), we calculate Rs.

```
RS_air = (5.0-sensor_volt)/sensor_volt;
```

- Then according to the table available in the datasheet, R0 can be found.

```
R0 = RS_air/9.9; // According to MQ9 datasheet table
```

- The next step is to calculate the ratio between R0 and RS

```
ratio = RS_gas / R0; // ratio = RS/R0
//-----------------------------------------------------------/
```

- The final step is to find the gas concentration in PPM with the help of Figure 4.1 which shows MQ9 sensitivity characteristics for several gasses

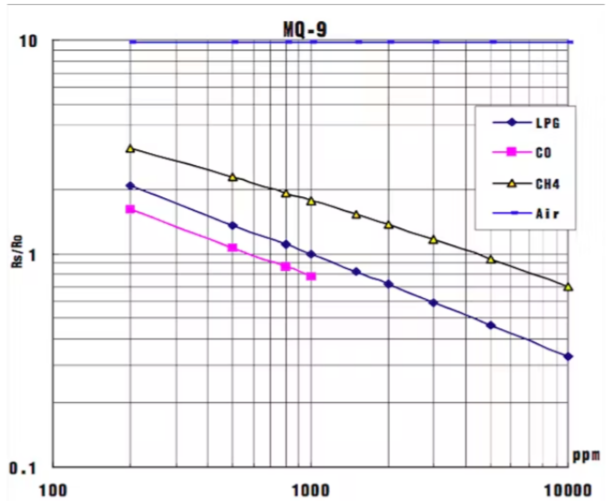

Figure 4.2: MQ9 Sensitivity Characteristics for Several Gasses[29]

➔ **MQ135 Sensor**

MQ135 functions almost the same way as MQ9. So, all the previous steps will be repeated except for little changes.

RL = 20kΩ which is provided in the datasheet as well as Figure 4.2.

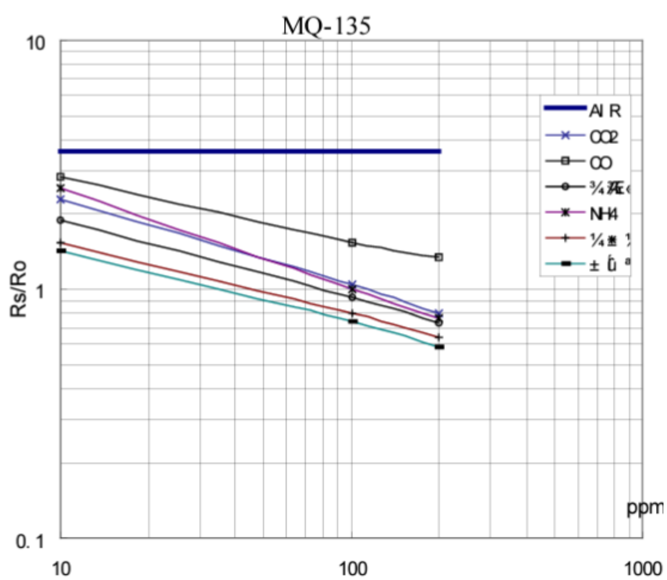

Figure 4.3: MQ135 Sensitivity Characteristics for Several Gasses[30]

- After calibration, we can decide on the threshold suitable for the room
- Then we uploaded a different code that reads the sensor values and adds it to the system with the threshold.

4.2.2.2 Arduino Code Implementation:

The Arduino IDE was used to program the Arduino Mega 2560 microcontroller and write the code, The code consists from these main concepts or functionalities:

- Reading data from sensors: MQ-9 Gas sensor, DHT11 sensor, MQ-135 Gas sensor and Flame sensor
- Controlling the water pump through a relay.
- Controlling the linear actuator through relays(actuator).
- Receive SMS commands from GSM
- Output data on the buzzer and GSM.

4.3 Validation and Testing

1) MQ9 Sensor

After connecting the MQ9 Sensor to the arduino and uploading the right code, the sensor started reading data and measuring the concentration of CO, CH4 and LPG. The following figures show the reading of gas concentration in normal and abnormal states.

```
09:36:09.282 -> ** Values from MQ-9 ****
09:36:09.321 -> |    LPG   |  CH4 |   CO  |
09:36:09.370 -> |    7.10     |     10.65     |     3.73     |
09:36:09.893 -> |    7.10     |     10.65     |     3.73     |
09:36:10.431 -> |    7.10     |     10.65     |     3.73     |
09:36:10.960 -> |    7.10     |     10.65     |     3.73     |
09:36:11.508 -> |    7.13     |     10.71     |     3.75     |
09:36:12.101 -> |    7.17     |     10.77     |     3.77     |
```

Figure 4.4: MQ9 Readings In Normal State

```
09:37:01.883 -> |    549.69    |    2066.90    |    324.26    |
09:37:02.449 -> |    737.69    |    2951.69    |    438.57    |
09:37:02.997 -> |    986.63    |    4198.00    |    591.12    |
09:37:03.546 -> |    1313.13    |    5935.21    |    792.72
09:37:04.073 -> |    1590.25    |    7484.61    |    964.91
09:37:04.643 -> |    1750.37    |    8406.92    |    1064.77
09:37:05.191 -> |    1813.89    |    8777.89    |    1104.45
09:37:05.718 -> |    2023.88    |    10023.49    |    1235.90
```

Figure 4.5: MQ9 Readings In Abnormal State

2) MQ135 Sensor

After connecting the MQ135 Sensor to the arduino and uploading the right code, the sensor started reading data and measuring the concentration of CO, CO2, ALcohol, Toluen, NH4 and Acetone. The following figures show the reading of gas concentration in normal and abnormal states.

```
09:40:00.693 -> ** Values from MQ-135 ****
09:40:00.725 -> |   CO   |  Alcohol |   CO2  |  Toluen  |  NH4  |  Aceton  |
09:40:00.792 -> |  3.91  |   1.32   |  402.83  |  0.55  |  4.30  |  0.46  |
09:40:01.352 -> |  3.88  |   1.31   |  402.81  |  0.54  |  4.28  |  0.46  |
09:40:01.907 -> |  3.84  |   1.30   |  402.79  |  0.54  |  4.26  |  0.46  |
09:40:02.444 -> |  3.88  |   1.31   |  402.81  |  0.54  |  4.28  |  0.46  |
09:40:03.013 -> |  3.84  |   1.30   |  402.79  |  0.54  |  4.26  |  0.46  |
09:40:03.567 -> |  3.81  |   1.29   |  402.78  |  0.53  |  4.24  |  0.45  |
```

Figure 4.6: MQ135 Readings In Normal State

09:40:46.197 ->	3.41	1.18	402.38	0.48	3.95	0.41
09:40:46.767 ->	188.79	30.15	447.37	16.22	49.17	12.79
09:40:47.319 ->	184.34	29.57	446.55	15.88	48.43	12.54
09:40:47.874 ->	181.43	29.20	446.02	15.66	47.95	12.37
09:40:48.425 ->	232.44	35.67	455.10	19.46	56.03	15.29
09:40:48.991 ->	273.19	40.64	461.96	22.41	62.01	17.55
09:40:49.561 ->	372.95	52.25	477.70	29.43	75.40	22.91
09:40:50.126 ->	363.82	51.22	476.31	28.80	74.24	22.43
09:40:50.686 ->	318.96	46.05	469.35	25.66	68.35	20.04

Figure 4.7 MQ135 Readings In Abnormal State

3) GSM Shield SIM900

First we apply 12 Volt to the shield, we write a code in which it enables the shield to send and receive messages. After uploading we get these results which indicates that the GSM shield works just fine as it shows in Figure 4.7.

The GSM constantly checks if there’s a request from the user to check the state of the room. The GSM passes the request to the microcontroller which in return sends back the current temperature and air quality of the room. In case of a defect in gas proportion, the GSM sends a warning SMS to the user “ Air Quality is Poor” . when a fire breaks out, it sends a warning “FLAME!”. Moreover, if both cases are applied, the GSM only sends one SMS which is “FLAME!”

Figure 4.8: GSM Shield Receiving Message and Replying to it

4.4 Implementation Issues and Challenges

During the course of the project implementation, we faced many obstacles and had to overcome several challenges to reach the most suitable design of the system that achieves the system's objectives. These challenges and issues could be summarized as follows:

1) During the planning phase, we decided to use components that suit the system's requirements. However, some of the components were hard to obtain. Therefore, it was inevitable to look for a substitute. these components are:

- Raspberry Pi Microcontroller: The features of Raspberry Pi are more advanced and suitable for our system. However, its price increased to more than double and it's no longer in stock. On the other hand, ordering one would take more than a month to arrive. The Solution was to use Arduino Mega Microcontroller as a substitute. Its features meet the system's requirements and it's affordable.
- Oxygen Sensor: this sensor detects Oxygen gas rate in the room. The problem is that it's not available in the Palestinian market. After some research, we decided that this sensor is not crucial for the system to function properly. So, it was eliminated.

2) Computational issues: Each sensor has to be treated differently to get the proper data in which it's processed and different procedures are achieved accordingly. Here are some examples;

- MQ9 and MQ135 are sensors that detect various gas types such as Carbon Monoxide and Carbon Dioxide. They need sensitivity adjustment and to be calibrated through observations for sensor readings and mathematical equations. This step is important to get the suitable threshold value for each different room. However, these observations take at least 24 hours before moving on to the next step to calculate the suitable threshold for that specific room.
- Flame sensor is designed to detect any fire that breaks out. The issue is that it's sensitive to light and if not adjusted properly, it could mistake strong lightning for fire. Therefore it's important to adjust its sensitivity through the potentiometer for each different room.

3) During the implementation of the GSM module, the module board burnt due to applying more power than it could take. So, we had to purchase another one.

4) A major issue we encountered occurred while interfacing the arduino board with the wifi shield ESP-01. This shield takes internet access through port 80, however, this port is usually closed for security purposes. To overcome this issue, another network needs to be established. This solution could be impractical and expensive for most users.
   A reliable substitute is to use a GSM module which achieves the system's requirements and displays data when requested as well as other features explained above. Moreover it's affordable, user friendly and simple.

4.5 Results and Discussion

In our results, and after preparing the electrical circuits, connecting them to each other, and installing them in the model that was designed, the goal of this project was successfully achieved. Where the system makes a quick reaction in the event of a fire or an increase in the levels of toxic gasses so that the system reads the required values from the sensors, after which the reading is transferred from the sensor to a microcontroller, analyzed and processed, and work is done correctly in the event of a defect where the system Alerts the user to a defect by sending a text message and turning on the warning. At the same time, the system closes the windows and turns on the water pump in the event of a fire. In the event of an increase in the proportion of toxic gasses, without a fire, the system will provide adequate ventilation by opening sealed windows. The system also enables the user to monitor the home status through text messages.

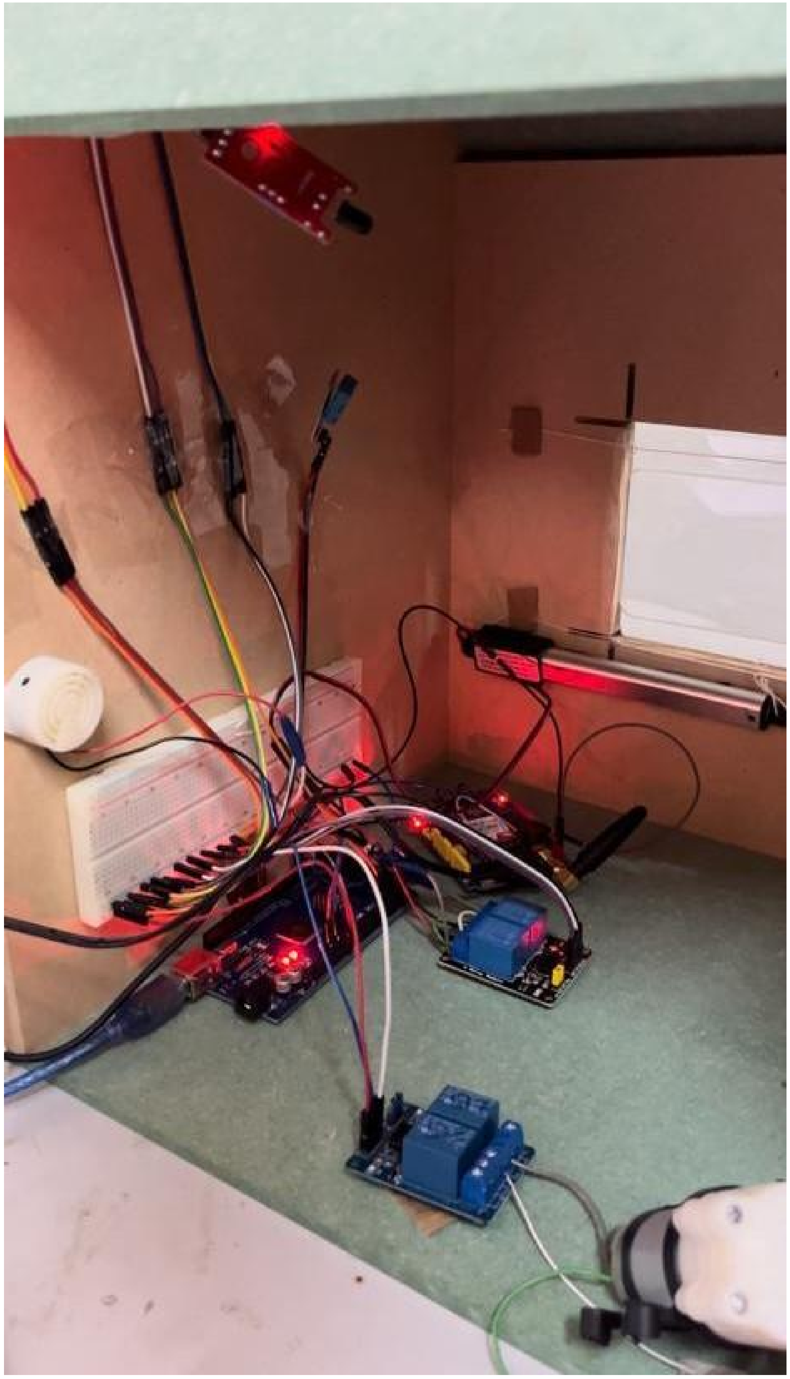

Figure 4.9: The Final Result of the Prototype

Finally, after preparing the circuits, a prototype model of the house was designed (see Figure 4.9), then the circuits were installed in the model.finally, we tested it to work as required and achieved the goal of this project.

Chapter 5: Conclusion And Future work

This chapter summarizes the project's outcomes, presents the main goals that were accomplished, and suggests future work that may be accomplished later on.

5.1 Concluding Remarks

Smart homes are redeveloped homes to suit the needs of the individual and to facilitate the process of living and safety inside the home, where environmental systems are integrated in terms of energy use, temperature control, lighting, sound, and others.

In this project, we have built a smart house based on some electronic circuits responsible for controlling the safety of the house in terms of ventilation and fires. Where this system works to maintain proper ventilation inside the living room by continuously examining the gasses inside the room through several sensors. The data will then be presented to the user in case they wish to check the status of the house. In the event of any defect in the level of gasses from its normal level, an alert is sent to the user in the event to notify them of the current condition of the room and specifies whether it’s a fire breaking out or an abnormal gas changes inside the room. Concurrently, safety measures are taken depending on the condition, such as opening windows for ventilation or in the event of a fire Sprinklers and extinguishers are activated to prevent the fire from spreading.

We were able to successfully build the system and achieve our goal of providing a safety control measures system that creates a safe environment, maintains proper ventilation in the living room, and keeps people and children safe inside the home by protecting them from suffocation hazards. As it also reduces the risk of losing home assets.

5.2 Future work

Future modifications can be carried out so system performance and efficiency is improved, these modifications include:

1) In the event that the system user does not respond to the alerts, measures are taken to call the emergency number immediately.
2) Connect the system to the cloud and Internet to get reports at any time.
3) Linking the system to a mobile application to control the system remotely.

Summary

In this project, we have addressed the dangers of leaked gas in the home that goes unnoticed associated with poor ventilation which results in fire breakouts or suffocation and subsequently, the loss of lives as well as property damage. Hence, we have proposed a system that ensures individual safety at home and reduces the risk of losing house assets. the system is connected with sensors to keep the gas balance in check and perform safety measures when a defect occurs by alerting the user and taking some procedures such as opening the window in case of a leak of gasses or turning on the water pump and closing the window in case of a fire outbreak. The data read from sensors is presented to the user through SMS messages.

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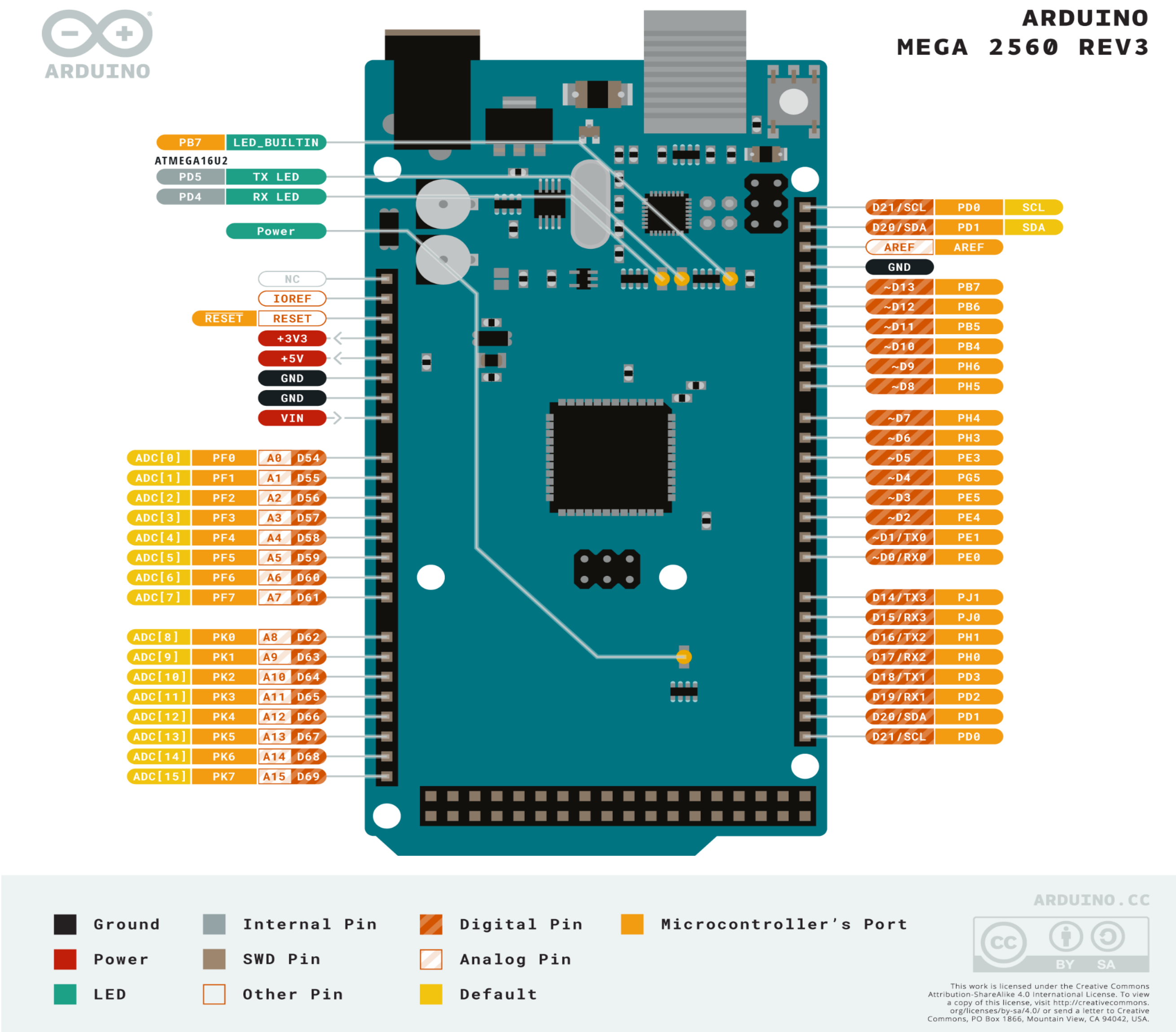
Appendices



ARDUINO
ARDUINO
MEGA 2560 REV3
PB7 LED_BUILTIN
ATMEGA16U2
PD5 TX LED
PD4 RX LED
Power
NC
IOREF
RESET RESET
+3V3
+5V
GND
GND
VIN
ADC[0] PF0 A0 D54
ADC[1] PF1 A1 D55
ADC[2] PF2 A2 D56
ADC[3] PF3 A3 D57
ADC[4] PF4 A4 D58
ADC[5] PF5 A5 D59
ADC[6] PF6 A6 D60
ADC[7] PF7 A7 D61
ADC[8] PK0 A8 D62
ADC[9] PK1 A9 D63
ADC[10] PK2 A10 D64
ADC[11] PK3 A11 D65
ADC[12] PK4 A12 D66
ADC[13] PK5 A13 D67
ADC[14] PK6 A14 D68
ADC[15] PK7 A15 D69
D21/SCL PD0 SCL
D20/SDA PD1 SDA
AREF AREF
GND
~D13 PB7
~D12 PB6
~D11 PB5
~D10 PB4
~D9 PH6
~D8 PH5
~D7 PH4
~D6 PH3
~D5 PE3
~D4 PG5
~D3 PE5
~D2 PE4
~D1/TX0 PE1
~D0/RX0 PE0
D14/TX3 PJ1
D15/RX3 PJ0
D16/TX2 PH1
D17/RX2 PH0
D18/TX1 PD3
D19/RX1 PD2
D20/SDA PD1
D21/SCL PD0
Ground
Internal Pin
Digital Pin
Microcontroller's Port
Power
SWD Pin
Analog Pin
LED
Other Pin
Default
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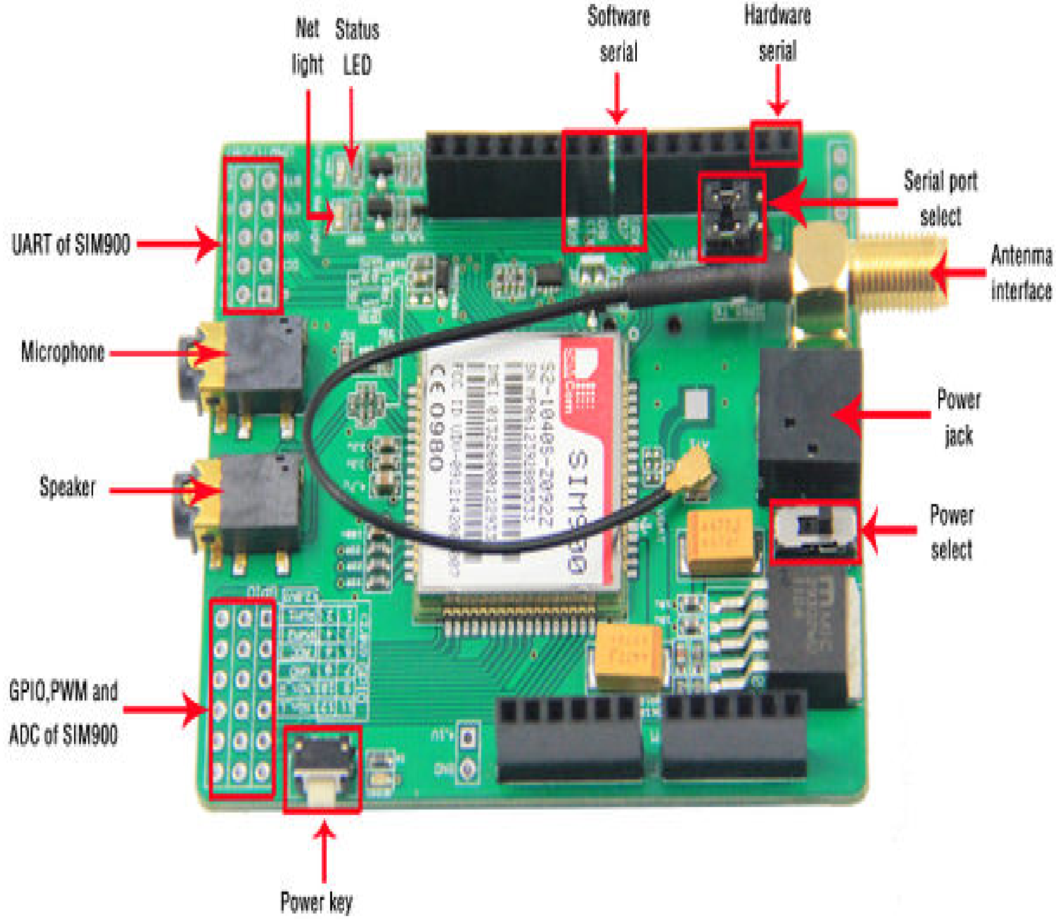
Net light
Status LED
Software serial
Hardware serial
Serial port select
Antenna interface
UART of SIM900
Microphone
Power jack
Speaker
Power select
GPIO,PWM and ADC of SIM900
Power key