DEVELOPMENT OF INTEGRATED SMART FIRE ALERT SYSTEM BY USING SOLAR POWER SUPPLY

MUHAMMAD IRFAN BIN MOHD AZUWI

Bachelor of Engineering Technology
(Energy & Environment)

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name	:	MUHAMMAD IRFAN BIN MOHD AZUWI
Date of Birth	:	
Title	:	DESIGN A SMART FIRE ALERT SYSTEM
Academic Session	:	2021/22

I declare that this thesis is classified as:

☐	CONFIDENTIAL	(Contains confidential information under the Official Secret Act 1997)*
☐	RESTRICTED	(Contains restricted information as specified by the organization where research was done)*
☐	OPEN ACCESS	I agree that my thesis to be published as online open access (Full Text)

I acknowledge that Universiti Malaysia Pahang reserves the following rights:

1. The Thesis is the Property of Universiti Malaysia Pahang
2. The Library of Universiti Malaysia Pahang has the right to make copies of the thesis for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

_______________________	_______________________
(Student's Signature)	(Supervisor's Signature)
_______________________	_______________________
Muhammad Irfan Bin Mohd Azuwi Date: 15 February 2022	Dr. Noor Intan Shafinas binti Muhammad Date: 15 February 2022

DECLARATION OF THESIS AND COPYRIGHT

NOTE : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach a thesis declaration letter.

THESIS DECLARATION LETTER (OPTIONAL)

Librarian,
Perpustakaan Universiti Malaysia Pahang,
Universiti Malaysia Pahang,
Lebuhraya Tun Razak,
26300, Gambang, Kuantan.

Dear Sir,

CLASSIFICATION OF THESIS AS RESTRICTED

Please be informed that the following thesis is classified as RESTRICTED for a period of three (3) years from the date of this letter. The reasons for this classification are as listed below.

Author's Name
Thesis Title

Reasons (i)

(ii)

(iii)

Thank you.

Yours faithfully,

____
(Supervisor's Signature)

Date:

Stamp:

Note: This letter should be written by the supervisor, addressed to the Librarian, *Perpustakaan Universiti Malaysia Pahang* with its copy attached to the thesis.

SUPERVISOR's DECLARATION

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Degree of Bachelor of Engineering Technology in Energy and Environmental.

____

(Supervisor's Signature)

Full Name : DR. NOOR INTAN SHAFINAS BINTI MUHAMMAD

Position : SENIOR LECTURER, FACULTY OF CIVIL ENGINEERING TECHNOLOGY, UNIVERSITI MALAYSIA PAHANG

Date : 15 February 2022

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : MUHAMMAD IRFAN BIN MOHD AZUWI

ID Number : TC18040

Date : 15 February 2022

DEVELOPMENT OF INTEGRATED
SMART FIRE ALERT SYSTEM BY USING
SOLAR POWER SUPPLY

MUHAMMAD IRFAN BIN MOHD AZUWI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering Technology in Energy and Environment

Faculty of Civil Engineering Technology
UNIVERSITI MALAYSIA PAHANG

FEBRUARY 2022

ACKNOWLEDGEMENTS

I would want to take this opportunity to thanks everyone who has helped me along the way with this project. Throughout the project, I am grateful for their invaluable constructive critique, aspirational direction, and pleasant advised. Without the advice and support of various persons who extended and gave their important assistance in the preparation and completion of this project, I would not have been able to accomplish it. Dr. Noor Intan Shafinas binti Muhammad as my supervisor, is exceedingly grateful and indebted to me for sharing her knowledge and providing me with honest and important guidance and encouragement throughout.

I also want to express my gratitude to the Faculty of Civil Engineering Technology (FTKA) for providing me with all the essential research facilities. I'd would want to express my gratitude to all my friends, lecturers, senior student, teaching engineers, and others who helped me with advice and engaging talks. I am grateful to them for giving their perspectives on a variety of project-related challenges. This project could not have been completed without their enthusiastic participation and feedback. The advice and support obtained from everyone was key to the project's success.

I acknowledge my sincere indebtedness and gratitude to our parentsfor their love, dream and sacrifice throughout our life. We cannot find the appropriate words that could properly describe our appreciation for their devotion, support and faith in our ability to attain our goals. Special thanks should be given to our committee members. We would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

ABSTRACT

Fire have been identified as a dangerous disaster that may result in many destructions and loses compare to other disasters. Fires in the early detection and early warning are two important ways to extinguish the fire promptly and avoid great casualties and property loss. This thesis project aims to design a home fire alarm and SMS notification system with solar powered Arduino-based utilizing GSM Module. The project's purpose is to improve premise safety, with the main purpose of preventing fires from affecting residents and property inside the home. It involves the use of an Arduino Uno board and an ATmega328 chip powered by photovoltaic (PV) system and lithium-ion battery. The ATmega328 is the main controller, and it is responsible for controlling the home fire alarm system, which is triggered by the flame sensor module and smoke sensor. The user will receive an alarm message via a short message service (SMS) using the GSM module. When the system detects temperature of 40 degrees Celsius or above in the house, it will immediately display an alert warning on the LCD display and send an SMS alert to the owners. This system can help users to improve their safety standards by providing a quick response in the case of an accident. Users will soon be able to protect their lives and property from disasters as a result of this. If and when the developed device is commercialized, it will help in the minimization of uncontrolled fires by 50% by alerting of dangerous conditions prior to a fire outbreak.

Keywords – SMS (Short Messaging Service), Fire alarm, Detection system, GSM module, Photovoltaic technology

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Research Background

Fires have been identified as a dangerous disaster that can result in destruction, property loss, and loss of life among the disasters that have occurred in the local area. When compared to other disasters, fires have been frequent, devastating, and influential disasters in many disasters (Mahzan, 2018). With the rapid development of urban building, the likelihood of a major fire or other special disaster has risen year after year. According to the statistic stated by the Fire and Rescue Department of Malaysia (JBPM), in 2016 almost 5500 fire cases reported are concerned with the households followed by transportations, electrical appliances and leaking gasses (JBPM, 2017). Fires in the households are often triggered by many common factors investigated which are from cooking equipment, smoking in the house, electrical appliances, candles, curious children, faulty wiring and many more. If the fire occurs when the residents are in the house, the possibility to extinguish the fire is a bit high. It is because the residents themselves can take immediate precaution from the fire to be spread all over by using a fire extinguisher or calling the fireman immediately.

In Malaysia, every building should have a Fire Fighting System to prevent a building from fire. To protect against fire in time we need to have effectively working fire detecting devices. Fire protection, in terms of construction, is the means to inhibit or mitigate the ignition, growth and spread of fire and its effects through the built environment. The insurance industry has struggled for centuries to reduce risk from fire, and only in the past 50 years, have life safety systems and building codes mature.

Another factor that contributes to these fire cases is the lack of proper maintenance or servicing schedule for the firefighting equipment. After the firefighting equipment has been installed, the Malaysian Fire and Rescue Department needs to do the test and approve the systems before they can be used by customers. The firefighting system must be maintained after receiving approval from the Malaysian Fire and Rescue Department (BOMBA) to ensure that it is in good working order.

For this project, the development of a home fire alert is built based on the Arduino board as the main controller board that interacts with Global System for Mobile (GSM) module which works in the communication part. The interaction is for the user to know the current situation in the house. This system works totally on wireless network communication as GSM module is performed by sending a Short Message Service (SMS) to the user. The microcontroller inside the Arduino board is used as the mastermind of the circuit where it controls the circuit flows and execute all the decisions as well.

The GSM Module is responsible for the communication part of the circuit. It takes information from the Arduino on where to send information and what information needs to be sent. It uses a GSM SIM card for communication purposes. It is just a modem that uses serial communication to interface with and needs Hayes compatible AT commands for communicating with the Arduino. The alert message and the phone number of the recipient are given by the user through the project codes. As soon as fire is detected (temperature will hit a certain temperature limit) an SMS will be sent to the recipient's phone number from the SIM card inserted into the module for giving information to the user upon fire detection in the house.

1.2 Problem Statement

Emergency procedures must also be in place and practiced ensuring safe evacuation in the event of a fire. Employers must develop and revise emergency preparedness plans and procedures, as well as take the necessary precautions for firefighting and workplace evacuation (HSA, 2006). If there would be a fire in the building, it should be identified immediately. Then an alert was issued so that everybody can safely evacuate. Early detection and alert would maximize the time available for evacuation, allowing people to safely evacuate before the fire takes hold and prevents the escape routes.

In many cases, a fire starts on the ground floor and spreads to the upperfloors. Smoke quickly spreads to the second floor due to a lack of ventilation, causing suffocation to those who live there. According to a senior official of Dubai Civil Defense, more than 70 percent of deaths from fire accidents were caused by suffocation (Agarib, 2016). In a house fire, the effects of heat and smoke/fumes are typically more rapid than the effects of the direct flame injury; however, an evaluationof the body surface area affected by burns should also be performed. Death may be because of breathing the products of fire/ burning, principally carbon monoxide, but also cyanide and many other toxic by-products of combustion. Alternatively, smoke inhalation can cause death.

Fire alarm systems are in place to do two major things; detect fire and alert occupants of the fire while giving them enough time to vacate the area. It is ideal that these always function properly and detect fire, but there are a few situations where that is not the case. ORR Protection Systems Company conducted a study and discovered that 3,986fire detection systems had a failure rate of 0.32% (Carter, 2008). Commercial buildings, hotels, and hospitals frequently have high ceilings, which provide a spacious and inviting environment. High ceilings, on the other hand, can cause issues with heat and smoke detectors. When the heat from a fire rises, it cools, delaying the triggering of a ceiling-mounted alarm. Detectors positioned on ceilings also pose a problem for regular maintenance. The higher up on the ceiling or wall the detector is placed, the harder it is to clean and perform the routine quality test.

Because of advancements in technology and electronics, it seems that no two fire alarm systems are alike. Regardless other systems are newer and more advanced than others, they do have the same basic functions and controls. The requirement for both primary and secondary power supplies to ensure life safety even during a power failure is one of the most common features of fire alarm systems of almost any generation. The secondary power source would be from storage batteries located inside the fire alarm panel or in a separate enclosure nearby, since most buildings with fire alarm systems do not have backup electrical power (Havel, 2011).

1.3 Objective

In this project, three objectives need to be achieved as stated below.

1. To develop a programming coding for smart fire detection system for early response.
2. To measure the performance of the system.
3. To evaluate the solar panel for power supply.

1.4 Scope of Study

The study will focus on developing a smoke and fire alert system using SMS. The process of developing the proposed system involved a combination of hardware and software. The prototype consists of a processing unit, detector, and notifier. This system allows the user to monitor the condition of their building remotely. Besides, the user will be informed through Short Messaging Services (SMS) when any fire or smoke is detected. The focus of this project is on the application of Short Messaging Services in smoke and fire alert systems. Therefore, the effectiveness and efficiency of the detector will not be taken into consideration.

There are four main scopes of study for this project. The first scope is to design and fabricate a smoke and fire alert system by using sensors to detect the presence of smoke and fire, then notify people about it using SMS. The second scope is to develop programming associated with smoke and fire alert systems using SMS with C++ language. The third scope is designing the smoke and fire alert system using SMS that is supported by GSM module and powered by a solar panel. The last scope is to determine the efficiency of the system by using 1:10 scale testing prototype.

Some remote monitoring systems can be designed using wireless sensor networks, ethernet, and other digital technologies, but they have issues such as being too complex, expensive, and lacking in redundancy, as well as low compactness. All of this led to the development of an SMS-based fire alarm and detection system that uses an SMS system that is configured to report to a specific number. It is a low-cost fire alarm system that dependably ensures fire safety and can be simply placed in homes, factories, offices, and restaurants, among other places. The proposed system can monitor a larger industrial or residential area by placing many modules, each for one level or unit. The goal of this project is to employ SMS to build a dependable and fast-response fire alarm system (Izang, 2018)

A fire detection system's primary goal is to alert building inhabitants of an emergency so that they can evacuate. Identify different stages of a fire, such as smoldering or blazing. Fire suppression systems are activated and monitored. Notifying organized help, such as fire departments, to conduct firefighting operations and monitor processes for irregularities that could result in a fire. Automatic fire detection and control has become a significant tool for protecting property and businesses from fire, and it helps to reduce fires in buildings and industries. The primary function of an automatic fire detector is to detect a developing fire quickly and sound an alarm to alert individuals on the premises to evacuate immediately (Elechi et al., 2017).

The hardware architecture and software details are divided into two primary portions in the design and development of this project. The design of the circuit and the prototype of the project were built in the hardware architecture. During software development, the entire prototype was controlled by computer codes (Mahzan, 2018).

1.5 The Importance of The Study

According to Fire and Rescue Department statistics, over 6,000 structures in Malaysia were damaged by fire each year in 2016, killing over 1,000 people. Even when a smoke alarm was present, just 18.3 percent of alarms successfully notified residents. This suggests that the current automatic fire alarm system is insufficiently intelligent to lessen the risk of a fire disaster. When the occupants are gone from their home, they are unaware that their home is on fire. Furthermore, if the fire service is not notified promptly, the fire may swiftly spread to nearby buildings. This is especially important if the burning building is a high-rise one (Suparman & Jong, 2019).

The problem of building fires in society is increasing every year. It will not only endanger human life, but it will also cause property harm. As a result, it is critical to develop a more dependable smoke alarm system capable of reducing property and life losses. Short Messaging Services (SMS) is utilized in this project to construct a comprehensive smoke and fire alert system that can monitor and alert the user in the event of a fire. SMS stands for short message service, and it is a network that is linked to a cell phone. A system that uses SMS technology is intelligent enough to let each device communicate and share information to complete a task.

In this study, a new concept of smoke and fire alert systems based on the SMS approach is discussed. The main contributions are as follow:

- Review the existing smoke and fire alert system.
- Identify the problems and challenges of using the conventional smoke and fire alert system.
- Use the C++ language as a code writing tool for Arduino Uno.
- Use the GSM Module to provide communication between the system and human.
- Use the solar panel and the solar power manager as a backup power supply to the system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a review of past research efforts related to the fire and smoke detector with the development of a low cost, portable, and reliable microcontroller based automated fire alarm system for remotely alerting any fire incidents in the household or industrial premises. A substantial literature has been studied on GSM network module that has been used to deliver alert messages and can work in normal GSM bands. This study also included a linear integrated temperature and smoke sensor that detects temperature beyond preset value whereas a semiconductor type sensor detects the presence of smoke or gas from fire hazards. The review is organized chronologically to offer insight into how past research efforts have laid the groundwork for subsequent studies, including the present research effort. The review is detailed so that the present research effort can be properly tailored to add to the present body of literature as well as to justly the scope and direction of the present research effort.

2.2 Existing Fire Detection System

2.2.1 Fire Detection System with GSM Using Arduino

The importance of fire safety throughout daily life is being understated. At the institute, in the industries, in the home, and the automation of the home, safety precautions must be implemented. The system includes a MQ-05 sensor to detect SnO2 (tin dioxide), which has a lower conductivity than normal air. When a gas is present, the conductivity of the sensor rises in parallel with the gas concentration. An Arduino is utilized, along with components such as an exhaust fan, a buzzer, a GSM module, an LED, and the MQ-05 sensor. The Arduino is programmed in such a way that if there is a leak, the microcontroller detects it and sends an alert through the buzzer, LED, and a message is sent to the relevant cellphone number after a 5-second delay, a command given by "Arduino Uno" (Simmi Sharma, 2017).

2.2.2 Fire Detectors Review and Design of An Automated Quick Responsive Fire Alarm System Based on SMS

A review of existing fire-detector types was accomplished, as well as the development of a low-cost, portable, and dependable microcontroller-based automated fire alarm system for remotely alerting any fire occurrences in residential or industrial locations. The aim is to deliver a short message (SMS) through GSM network to a distant property owner efficiently and accurately. A linear integrated temperature sensor detects a temperature above a specified pressure, whereas a semiconductor type sensor detects smoke or gas from fire hazards. The ATMega8L AVR microprocessor is connected to the sensor units through a common data line. The alert messages were sent using a SIM300CZ GSM kit-based network module that can operate in standard GSM bands. The system is implemented on a printed circuit board (PCB) and tested under different experimental conditions to evaluate its performance (Asif, 2014).

2.2.3 Development of Fire Alarm System Using Raspberry Pi and Arduino Uno

When a fire occurs, the projected fire alarm system detects the presence of smoke in the air and collects visuals via a camera installed within a room. Raspberry Pi and Arduino Uno were the embedded systems used to create this fire alarm system. The capacity to remotely transmit an alert when a fire is detected is a major feature of the system. The system will need the user confirmation to report the event to the Firefighter using Short Message Service (SMS). The advantage of using this system is it will reduce the possibility of false alerts reported to the Firefighter. The camera will only capture an image, so this system will consume a little storage and power (Bahrudin, 2013).

2.2.4 Developed Intelligent Fire Alarm System

Developed an intelligent fire alarm system for the development of technology applications to commercialize the growth of the fire alarm market. A control panel, alarm initiating devices, notification appliances, and the necessary auxiliary equipment for a complete Fire Alarm System are included in the system (Elbehiery, 2018).

2.3 Types of Smoke Detector

Due to their differing operating principles, the two most prevalent types of smoke sensors, photoelectric and ionization, respond differently to flame and non-flaming fires. Photoelectric smoke sensors function on the light-scattering concept, in which a light-emitting diode (LED) is commonly projected across an open cell, and a detector on the opposite side detects the light scattered when smoke particle aggregates enter the cell. Radioactive materials used to create ions in the air space between two electrodes in the standard design of ionization-type smoke detectors, and the potential difference of a third collection electrode, which is located in between the first two electrodes, is monitored. The ions attach to the aggregates when smoke aggregates reach the air gap between the electrodes, increasing the potential difference at the collection electrode. The sensitivity of ionization-type smoke sensors reduces as particle size rises, in contrast to photoelectric-type sensors (Roemer, EmilyJ, West, Kesley L., Northrup, Jessica B., Iverson, Jana, 2016).

2.3.1 Photoelectric Smoke Sensor

The intensity of a light beam travelling through air is affected by smoke created by a fire. The beam might be blocked or obscured by smoke. Because of the reflection of light off the smoke particles, it can also cause light to scatter. Smoke detectors that use photoelectric technology detect smoke by detecting the effects of smoke on light. Most photoelectric smoke detectors are of the spot type and work on the principle of light scattering. A light-emitting diode (LED) is shone into a space which is not ordinarily visible to a photosensitive device, such as a photodiode. When smoke particles cross the light path, light is scattered over the photosensitive device, causing the detector to respond (Sensor, 2021).

2.3.2 Ionization Smoke Sensor

Two electrically charged plates plus a radioactive source (usually Americium 241) for ionizing the air between the plates make up a conventional ionization chamber. Particles from the radioactive source collide with air molecules, dislodging their electrons. The molecules become positively charged ions as they lose electrons. Negatively charged ions form as other molecules gains electrons. There is an equal number of positive and negative ions produced. The negatively charged electrical plate attracts positively charged ions, while the positively charged plate attracts negatively charged ions. This produces a modest ionization current, which may be monitored by electronic circuitry attached to the plates (the detector's "normal" condition) (Sensor, 2021).

2.4 Power Supply

Power supply is an electrical device that supplies electrical power to an electrical load. The purpose of a power supply is to transfer electrical from a source to exact value of voltage, current and frequency to the load. There are power supplies that are stand-alone while other are built into the load appliances.

2.4.1 Solar Panel (PV-Cell)

Solar panels convert the sun's energy, which is in the form of light, into electricity. Solar panels are available for a wide range of applications, including powering individual gadgets, electronic devices, and vehicle batteries. While the average consumer may associate solar panels with residential rooftop assemblies, they are available for a wide range of applications, including powering individual gadgets, electronic devices, and vehicle batteries. The solar cell, also known as a photovoltaic, or PV cell, is the smallest component of a solar panel; each PV cell converts sunlight into electricity. A "module" or panel is a collection of two or more cells arranged in a group; an array is a collection of two or more panels (Shivakumar, Markal, & Hanumanthappa, 2020).

2.4.2 Battery

An electric battery is a device that consists of one or more electrochemical cells and is used to power electrical equipment such as flashlights, smart phones, and electric cars. The positive terminal of a battery is the cathode, and the negative terminal is the anode when it is supplying electric power. The negative terminal is the source of electrons, which flow and supply energy to an external device when connected to an external circuit. When a battery is connected to an external circuit, electrolytes within the battery can circulate as ions, allowing chemical reactions to be completed at the terminals and thereby delivering energy to the external circuit. The movement of those ions within the battery causes current to flow out of the battery, allowing work to be done. Historically, the term "battery" referred to a device made up of numerous cells, but its meaning has broadened to include devices made up of a single cell. The battery is a 12-volt direct current battery that stores the charge and powers the system when needed (Shivakumar, Markal, & Hanumanthappa, 2020).

CHAPTER 3

METHODOLOGY

3.1 Process Framework

The hardware architecture and software details are divided into two primary parts in the design and development of this project. The design of the circuit and the prototype of the project were built in the hardware architecture. Figure 1 shows the flows for the whole project. First, the designing of the circuit and testing model followed by assembling all the hardware components. During software development, the entire prototype was controlled by programming codes.

During the system start up, the microcontroller tests all the hardware to confirm hardware errors. For proper power management, it then shuts down the GSM module. In steady condition, the 'Run' white LED will turn on and the LCD will display the values for temperature, smoke concentration and humidity of the surrounding. When a sensor reading falls outside of the average range as shown in Figure 2, which are 40^{o}C (Mahzan, 2018) for temperature and 400PPM (OHS, 2016) for smoke concentration, the Arduino Uno will send the signal to GSM module, allowing it to connect to the network and sending a message to the user. Also, the buzzer and 'Alert' red LED will trigger while the LCD will display "FIRE ALERT!! CALL 9-1-1". This provides the user with a better understanding of the environmental conditions in his home or office. If a combination of readings meets the preset criteria for a fire, an alert message is sent to the server.

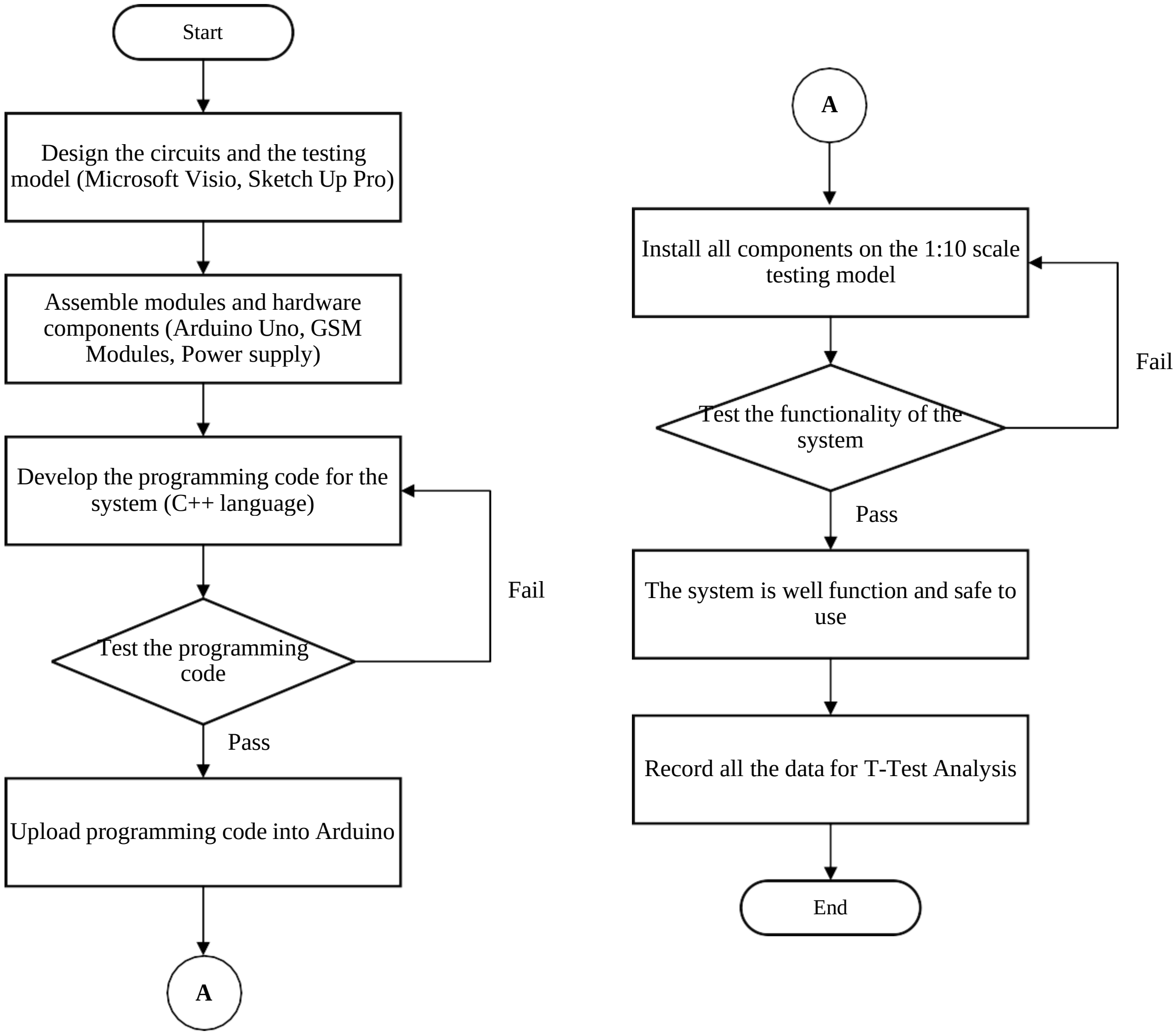


Figure 1: Flowchart of The Project

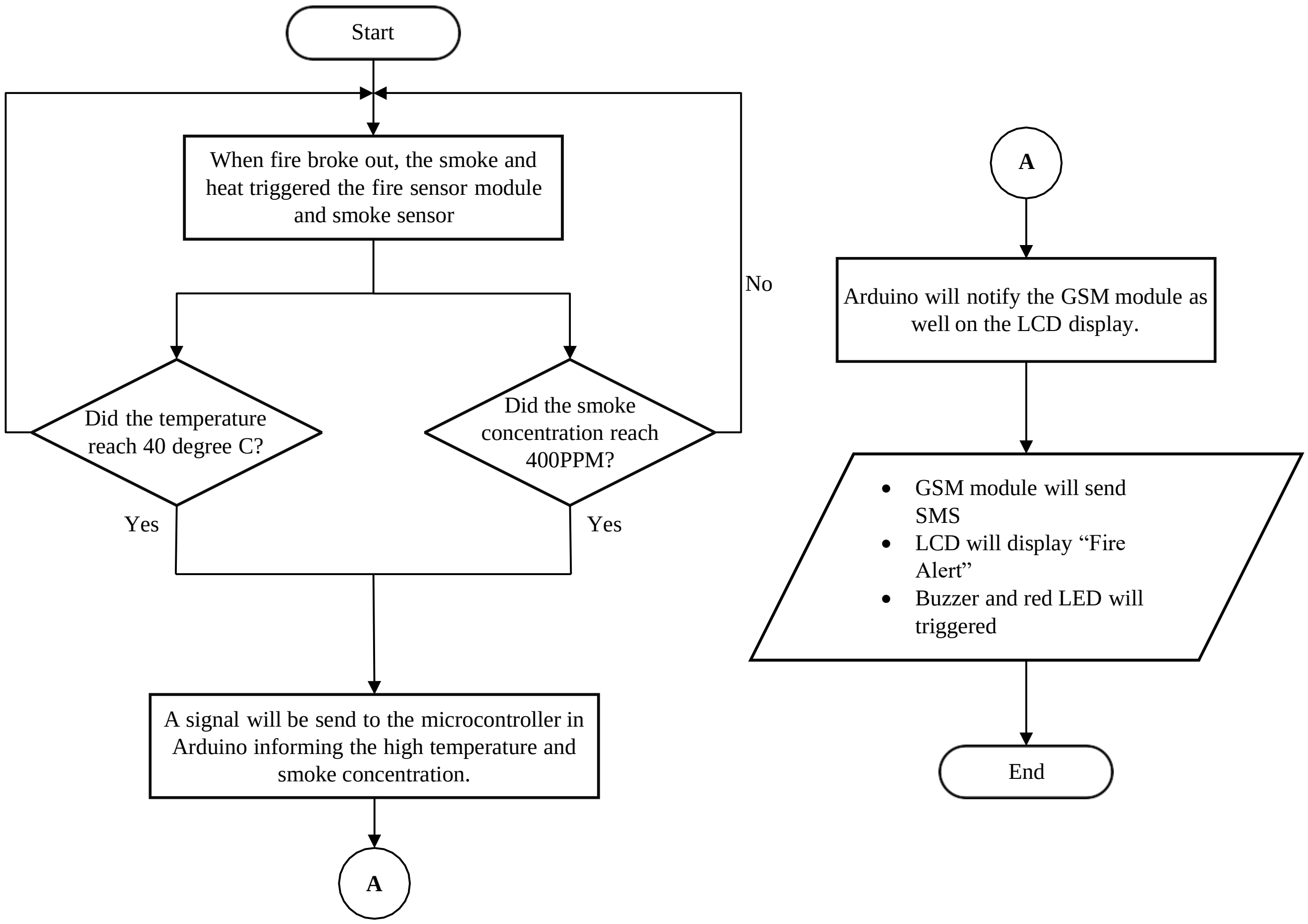


Figure 2: Flowchart for Programming

3.2 Programming Codes Using Arduino IDE Software

The Arduino IDE (Integrated Development Environment) is used to write the computer code and upload this code to the physical board as shown in Figure 3. The Arduino IDE is quite straightforward, which is perhaps one of the reasons Arduino has become so popular. Arduino IDE can be confidently declaring compatibility and currently one of the most important requirements for a new microcontroller board.

All §

```
#include <dht.h>
#include <SoftwareSerial.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#define dht_apin A0 //Declaration for temperature & humidity sensor (analog)
#define smokeMQ A3  //Declaration for smoke sensor (analog)
SoftwareSerial mySerial(2, 3);
char msg;
char call;
dht DHT;
int buzzer = 4;
int led_red = 5;
int led_yellow = 6;

LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x27 for a 16 chars and 2 line display

void setup()
{

  mySerial.begin(9600);
  Serial.begin(9600);
  delay(500);
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Smart Fire");
  lcd.setCursor(0,1);
  lcd.print("Alert System");
  pinMode(buzzer, OUTPUT);
  pinMode(led_white, OUTPUT);
  pinMode(led_yellow, OUTPUT);
  Serial.println("Smart Fire Alert System\n\n");  //Display on Serial  Monitor
  delay(1000);

void loop()
{
     int temp, humidity, smokeRead;
     temp = DHT.temperature;
     humidity = DHT.humidity;
     DHT.read11(dht_apin);
     smokeRead = analogRead(smokeMQ);

     Serial.print("Humidity =   ");
     Serial.print(humidity); // measure the humidity
     Serial.print("%\n");
     Serial.print("Temperature = ");
     Serial.print(temp); //measure the temperature
     Serial.println("C");
     Serial.print("Smoke reading = ");
     Serial.print(smokeRead); //measure the smoke concentration
     Serial.print(" PPM\n");
     Serial.print("\n");

     lcd.clear();
     lcd.setCursor(0,0);
     lcd.print("TEMP");
     lcd.setCursor(6,0);
     lcd.print("SMO");
     lcd.setCursor(10,0);
     lcd.print("HUMID");
     lcd.setCursor(0,1);
     lcd.print(temp); //display the temperature
     lcd.setCursor(6,1);
     lcd.print(smokeRead); //display the smoke concentration
     lcd.setCursor(10,1);
     lcd.print(humidity);//display the  humidity
```

```
if (smokeRead > 400 && temp > 40) // Fire occurrence
    {
      tone(buzzer, 100);
      digitalWrite(led_yellow, HIGH);
      digitalWrite(led_white, LOW);
      SendMessage();

      lcd.clear();
      lcd.setCursor(0,0);
      lcd.print("FIRE ALERT!!!"); // will be displayed on LCD
      lcd.setCursor(0,1);
      lcd.print("CALL 9-1-1"); // will be displayed on LCD
    }

 else // Normal condition
    {
      noTone(buzzer);
      digitalWrite(led_white, HIGH);
      digitalWrite(led_yellow, LOW);
    }

 delay(5000);

}


void SendMessage() // Command for SMS delivery
{
  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay for 1 second
  mySerial.println("AT+CMGS=\"+60145334348\"\r"); // Insert the phone number
  delay(1000);
  mySerial.println("There's a fire ");// The SMS text you want to send
  delay(100);
  mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
}
```

Figure 3: Programming Coding

3.3 Wiring Diagram

The overall project schematic wiring diagram is shown in Figure 4. The schematic wiring diagram has three important units. The first unit is the Control/Display Unit that consists of Arduino Uno (microcontroller), GSM module, ON/OFF switch, white and red LEDs, buzzer, and LCD display. The next unit is the Power Supply Unit that consists of a solar power manager, lithium-ion battery, solar panel, and USB cable for connecting with charger. Lastly is the Sensor Unit that has smoke and temperature/humidity sensors inside.

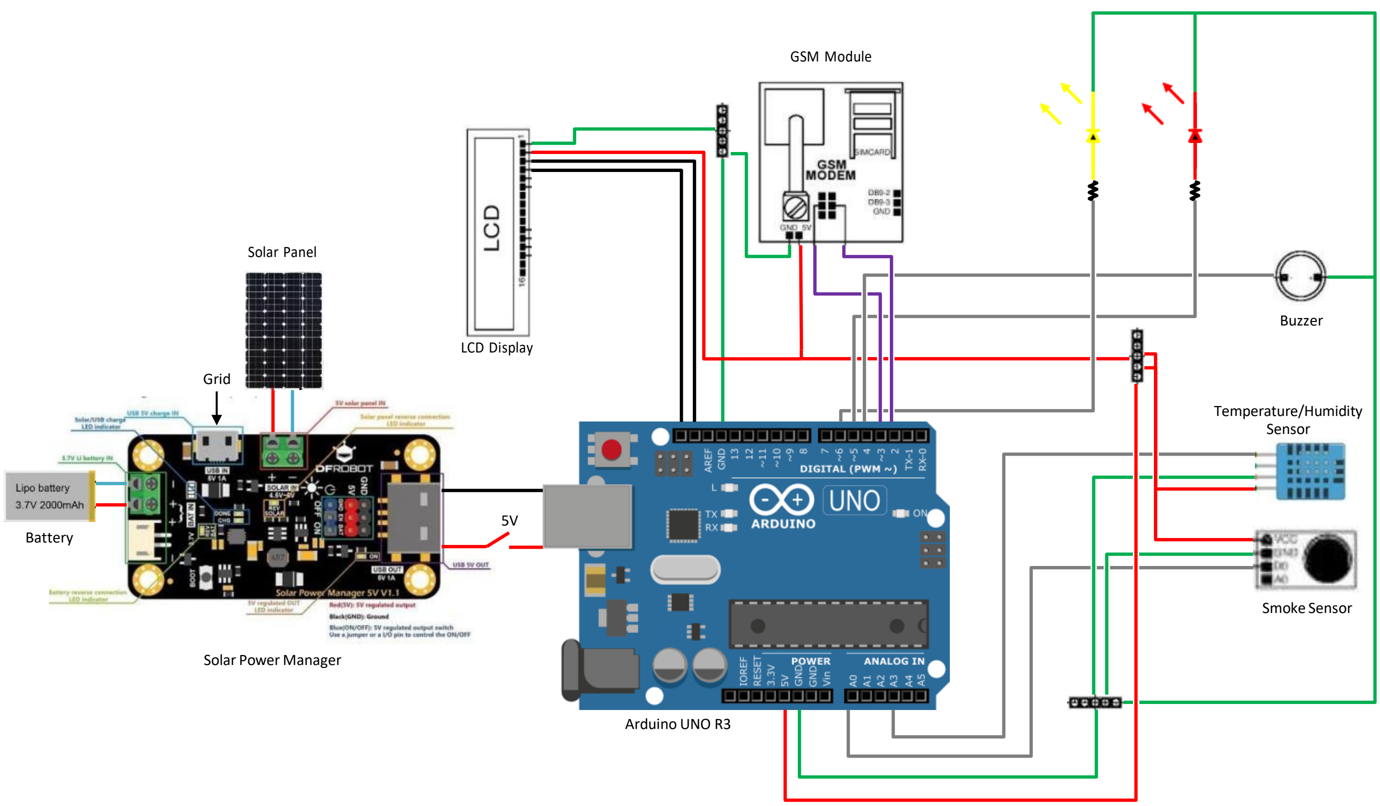


Figure 4: Schematic Wiring Diagram for Solar Power Smart Fire Alert System

3.4 Proposed System

The essential condition that allows the component and module to function efficiently is given considerable attention in the research. This section covers all the components as well as their functions. The main challenge in engineering design is to articulate the design requirements effectively and efficiently.

3.4.1 Control/Display Unit

The Control/Display Unit is the most important system part. This unit will control all the input and output signals for the whole system. Figure 5 shows the Control/Display Unit.

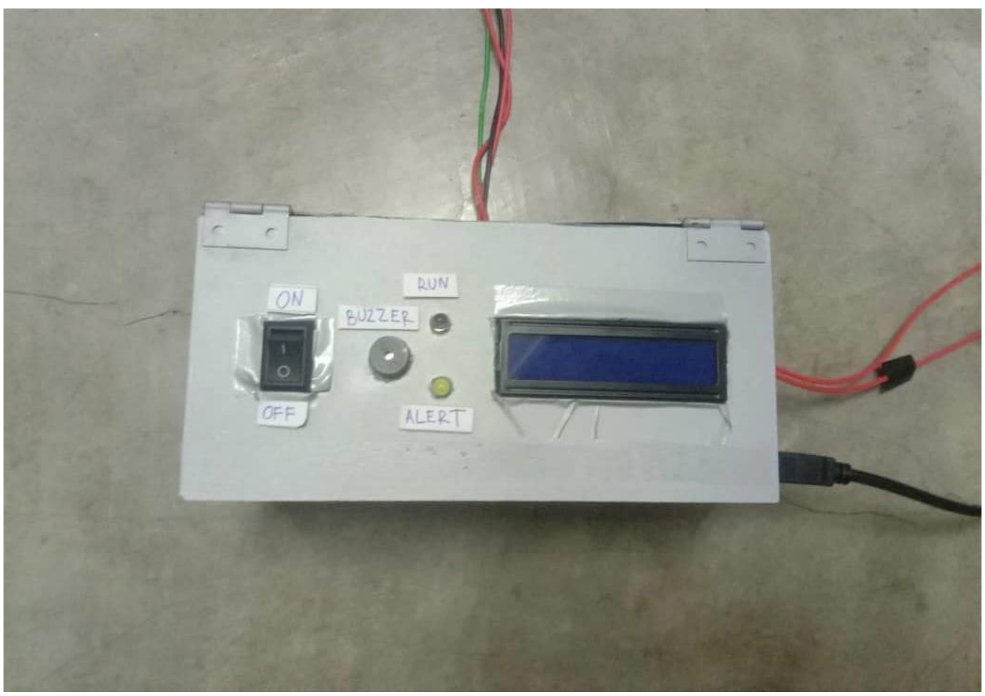


Figure 5: Control/Display Unit

Arduino Uno

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline- package (DIP) ATmega328 AVR microcontroller. There are 20 digital input/output pins on it (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). It may be programmed using the Arduino computer program, which is simple to use. The Arduino has a large presence in the community, making it a simple way to get started with smart devices. The R3 is the third, and latest, revision of the Arduino Uno. Figure 6 shows the Arduino UNO that is used in this project.

Figure 6: Arduino Uno

G.S.M Module

Global System for Mobile Communications or GSM is the world's most popular standard for mobile telephone systems. The SIM900 Quad-band/SIM900A Dual-band GSM/GPRS module includes a breakout board and a basic system. It uses AT instructions to communicate with controllers (GSM 07.07, 07.05 and SIMCOM enhanced AT Commands). The abbreviation AT stands for Attention. The software power on and reset functions are supported by this module. In the system, a fixed number is utilized to do various functions such as messaging and calling as shown in Figure 7.

Figure 7: GSM Module

LCD1602 (16X2) Liquid Crystal Display

A liquid crystal display (LCD) is an electrical display module that produces a visible image using liquid crystal. The 162 LCD is a basic module that can be found in many DIY projects and circuits. The 16x2 corresponds to a two-line display with 16 characters per line. Each character is presented in a 5x7 pixel matrix on this LCD. Most LCDs contain Hitachi HD4478 controller. CG-RAM is the main component in making custom characters. It stores the custom characters once declared in the code. CG-RAM size is 64 bytes providing the option of creating eight characters at a time. Each character is eight bytes in size. Figure 8 shows the LCD display that is used in this project.

Figure 8: 16x2 LCD Display

ON/OFF Switch

Switches are common components in a wide range of electronic circuits, allowing power to be turned on and off. The switch can then be used as an on-off switch in the circuit, allowing it to turn on or off individual devices in the circuit or the entire circuit. Figure 9 shows the switch that is used in this project.

Figure 9: ON/OFF switch

Light Emitting Diode (LED)

LED stands for light emitting diode. In comparison to incandescent light bulbs, LED lighting products produce light up to 90% more effectively. A microchip receives an electrical current, which ignites the tiny light sources known as LEDs, resulting in visible light. The heat generated by LEDs is absorbed into a heat sink to prevent performance difficulties. LEDs are also available in variety of colors as shown in Figure 10.

Figure 10: LEDs

Buzzer (PCB Mount)

An audio signaling device, such as a mechanical, electromechanical, or piezoelectric buzzer PCB Mount 5V or beeper, is a mechanical, electromechanical, or piezoelectric device(piezo for short) as shown in Figure 11. Alarm clocks, timers, and confirmation of human input such as a mouse click, or keyboard are all common uses for buzzers and beepers. An electromagnet produces a loud, repeated sound in an electric buzzer.

Figure 11: Buzzer

3.4.2 Power Supply Unit

Power Supply Unit provides electrical power to the system. This unit will control all the Direct Current (DC) from outside sources to be fed into the whole system. Figure 12 shows the Power Supply Unit.

Figure 12: Power Supply Unit

Solar Power Manager 5V

Solar Power Manager 5V is a high-efficiency and low-power solar power management module for 5V solar panels. It has an MPPT (Maximum Power Point Tracking) capability that maximizes solar panel efficiency. Aside from being a solar charger, the module can charge a 3.7V Li battery using a USB charger at up to 900mA. The 5V 1A output ON/OFF controlled DC-DC converters meet the needs of various solar power projects and low-power applications. The module also has several protection features, such as reverse battery/solar panel connection protection, output over temperature protection, and current/short circuit protection, all of which help to increase the system's stability and safety. Battery Capacity Indicator can also be implemented to check the current battery charging condition. Figure xxx shows the xxx that is used in this project as in Figure 13.

Figure 13: Solar Power Manager

Lithium-ion Rechargeable Battery 3.7V 1300mah

Batteries made of lithium-ion polymer (commonly known as 'lipo' or 'lipoly') are thin,light, and powerful. When fully charged, the output ranges from 4.2V to 3.7V. The capacity of this battery is 1300mAh as shown in Figure 14. As indicated, the batteries come with a genuine 2-pin JST-PH connector already attached. The suggested charging is at 1/2C or even less – 500 mA max in this case which can be get from a USB port.

Figure 14: Lithium-ion (Li-Po) Battery

Solar Cell/Panel 5V 250MA (1.25W)

This Solar Cell/Panel 5V 250mA (1.25W) has high-efficiency polycrystalline cells mounted on a fiberglass PCB and covered with epoxy resin, which preserves the cells without lowering their efficiency. The panel is relatively sturdy and light, and it is quite durable and dependable. This solar panel use the free energy from the sun to power a useful appliance with this solar panel. This solar panel also comes with wire/lead pre- soldered, which saves the time from having to connect/solder wires to it. It can be used to power Arduino as well as charge mobile phones, home lighting, and other low-power devices. It may also be used for science projects, solar power water pumps, and small solar power systems. Figure 15 shows the Solar PV panel 5V 250mA (1.25W).

Figure 15: Solar PV Panel 5V 250mA (1.25W)

3.4.3 Sensor Unit

Sensor Unit act as the sensing units for the system. This unit will measure the values for temperature, smoke concentration, and humidity then send the signal to the microcontroller. Figure 16 shows the Sensor Unit.

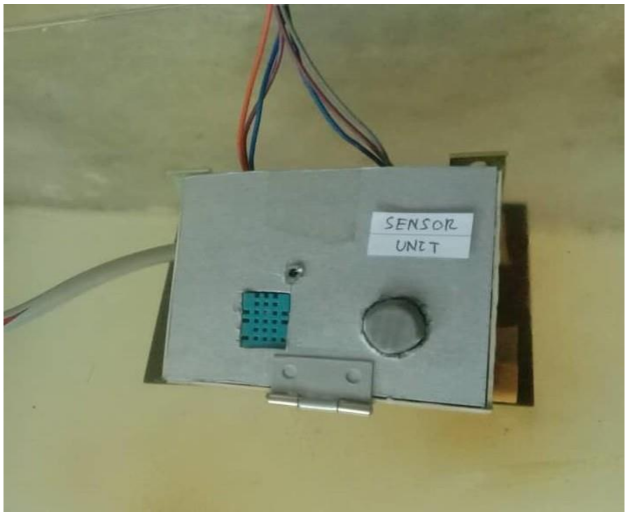


Figure 16: Sensor Unit

MQ-02 Gas/Smoke Sensor

The MQ-02 Gas Sensor Module is a dependable gas sensor that can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane, and Carbon Monoxide in the air. The MQ-02gas sensor is one of the most widely utilized in the MQ sensor series. It is a Metal Oxide Semiconductor (MOS) type Gas Sensor, also known as Chemiresistors because the detection is based on a change in the sensing of the resistance of material when the gas encountered it using a simple voltage divider network, concentrations of gas can be detected. MQ-02 Gas sensor works on 5V DC and draws around 800mW. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations anywhere from 200 to 10000 ppm. Figure 17 shows the MQ-02 smoke sensor.

Figure 17: Smoke Sensor MQ-02

DHT-11 Temperature/Humidity Sensor

A temperature and humidity sensor complex with a calibrated digital signal output is included in the DHT11 temperature & humidity Sensor as shown in Figure 18. It offers high dependability and outstanding long-term stability by utilizing an innovative digital-signal-acquisition technique as well as temperature and humidity sensing technologies. This sensor links to a high-performance 8-bit microcontroller and combines a resistive-type humidity measurement component and an NTC temperature measuring component, providing great quality, fast response, anti-interference ability, and cost-effectiveness. Add the range value that this sensor can detect

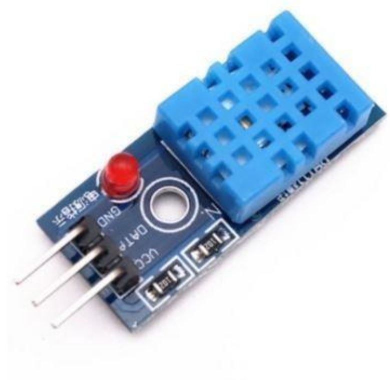


Figure 18: DHT-11 Temperature/Humidity sensor

CHAPTER 4

RESULT AND DISCUSSION

4.1 Display Data in Arduino IDE Serial Monitor

Figure 19 shows the display results in Arduino IDE Serial Monitor. The Serial Monitor was set to port “COM5” to get the values for “Humidity”, “Temperature” and “Smoke reading”. All the values had an interval of 10 seconds for every measurement.

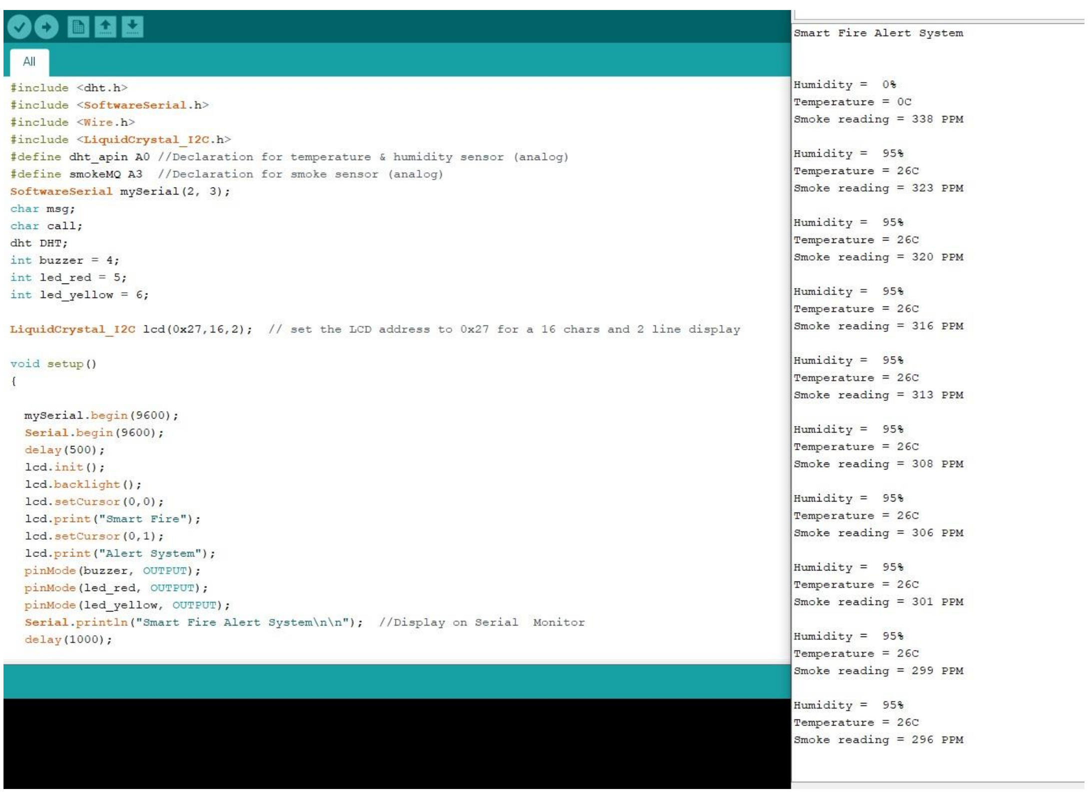


Figure 19: Measured Data from Arduino IDE Serial Monitor

4.2 Display Data on The System

This system can be fully monitored through the LCD as it was equipped with a Control/Display Unit to display all the information needed to make the data monitoring process easier. This system has two states which are “RUN” state in normal condition and “ALERT” state when the fire occur.

4.2.1 RUN State

RUN state is the normal condition where nothing happens. In this state, the “RUN” white LED will turn on and the LCD display will show the information as shown in Figure 20.

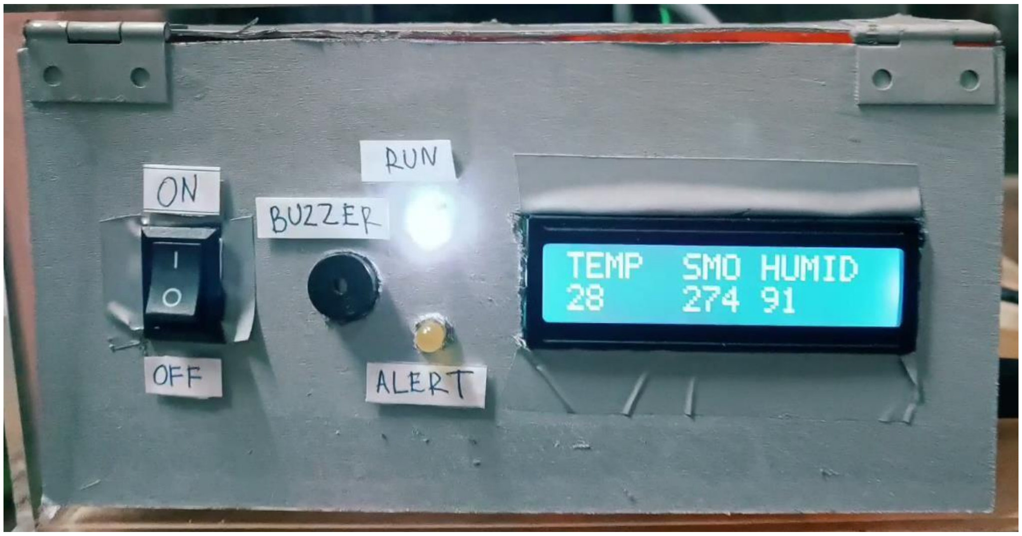


Figure 20: Displayed Information During RUN State (Normal Condition)

4.2.2 ALERT State

ALERT state is when fire occurs. In this state, the “ALERT” red LED will turn on, the buzzer will trigger and the microcontroller will send the signal to the GSM Module to send a message to the user. The LCD display will show “FIRE ALERT!!! CALL 9-1-1” and the user will get a SMS as shown in Figure 21.

Figure 21: Displayed Information on LCD and SMS During ALERT State (Fire Occurs)

4.2.3 Testing the Accuracy of The System

The sample is evaluated with the combustion of coconut husk and paper as a result of the experiment. A different amount of paper and coconut husk is tested for each, which is 10 grams and 5 grams, respectively. The testing period is 5 minutes, with data recorded every 10 seconds. The values that are measured are temperature, smoke concentration and humidity. All of these values were displayed on the LCD display and Arduino IDE Serial Monitor.

Table 1: Analysis of Output on LCD Display

Condition	State	LED		LCD DISPLAY
		White	Red	
Normal	RUN	ON	OFF	“TEMP SMO HUMID”
Fire occurs	ALERT	OFF	ON	“FIRE ALERT!!! CALL 9-1-1”

The system works as expected when it was installed into the testing model (Appendix A). The sensors produce repeating, or similar, output every time the model house's environmental trigger, such as high temperatures and smoke pollution, occurs. This indicates reliability. In addition, the technology quickly identifies the location of the environmental abnormality. All In all, it gives a dependable system for early detection of fire and smoke hazards. Figure 22 shows the testing of the system to gather the data.

Figure 22: System Testing

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This project was aimed to help premise owners in overcoming the problem of fire spreading when the owner is not present in the building. Unpredictable or critical situations always occur without the owners' notice in the building or residential areas. According to the findings, a home warning system is suitable and functional for owners to secure their homes. In fact, when compared to other existing alarm systems on the market, the system designed is inexpensive and simple to install in homes. Because of the DHT-11 sensor's employment in the system, the capacity of the system to detect heat or high temperatures is undeniable. Due to its versatility and simplicity of use, this system may be used in a range of locations, including homes, hostels, hotel industries, factories, automobile industries, and a variety of other settings involving crowds, people, or valuable objects. Users can simply place the device in their desired area to protect it from the presence of fire. When the temperature hits the setpoint (40°C), the device sends a text message to the users to inform them. This will make users aware of unforeseeable events and urge them quickly respond to avoid disaster.

5.2 Recommendation

The testing results have verified the accuracy and efficacy of the solar power smart fire alert system. The design of the system is also successful in terms of functionality. However, certain improvements might be considered to increase accuracy and efficiency. The following are some study topics to consider:

- Using IoT system for better functionality and practicality as it has access to the network.
- Add more sensors that can detect various types of harmful gases as well as a higher range of detection limit, for improvement of accuracy.
- Using a real scale testing method such as implement the system into real premises to simulate the real fire occurrence with various types of combustion materials.

REFERENCES

Bahrudin, M. S. (2013). Development of Fire Alarm System using Raspberry Pi and Arduino Uno. International Conference on Electrical, Electronics and System Engineering, 43.

Carter, S. (2008). Inspection, Testing and Maintenance Records: A Window into System Reliability. Retrieved from NFPA.org: http://www.nfpa.org/~/media/files/news-and-research/resources/research-foundation/foundation-proceedings/carter.pdf?la=en

Elbehiery. (2018). Developed Intelligent Fire Alarm System. International Journal of Computer Trends and Technology (IJCTT), 58.

Elechi, P. (2017). Design and Implementation of an Improved Smoke Detection System. European Journal of Electrical Engineering and Computer Science, 1(3), 1–9. https://doi.org/10.24018/ejece.2017.1.3.9

Havel, G. (2011). Fire Alarm Backup Power. Retrieved from fireengineering.com: https://www.fireengineering.com/fire-prevention-protection/fire-alarm-backup-power/#gref

HSA. (2006). Guide to the Safety, Health and Welfare at Work Act, 2005. Republic of Ireland: HEALTH AND SAFETY AUTHORITY HEADQUARTERS.

Izang, A. A. (2018). An SMS Based Fire Alarm and Detection System. International Journal of Computer Trends and Technology, 58(1), 58–61. https://doi.org/10.14445/22312803/ijctt-v58p109

JBPM. (2017). Statistik Kebakaran Mengikut Jenis Kebakaran 2016. Retrieved from http://www.data.gov.my.

Mahzan, N. N. (2018). Design of an Arduino-based home fire alarm system with GSM module. Journal of Physics: Conference Series, 1.

Mahzan, N. N., Enzai, N. I. M., Zin, N. M., & Noh, K. S. S. K. M. (2018). Design of an Arduino-based home fire alarm system with GSM module. Journal of Physics: Conference Series, 1019(1). https://doi.org/10.1088/1742-6596/1019/1/012079

OHS. (2016). *Carbon Dioxide Detection and Indoor Air Quality Control*. Retrieved from ohsonline.com: https://ohsonline.com/Articles/2016/04/01/Carbon-Dioxide-Detection-and-Indoor-Air-Quality-Control.aspx?m=1&Page=2

Roemer, Emily J., West, Kesley L., Northrup, Jessica B., Iverson, Jana, M. (2016). Evaluation Of Smoke and Gas Sensor Responses for Fires of Common Mine Combustibles Inoka. Physiology & Behavior, 176(12), 139–148.

Shivakumar, Markal, K. K., & Hanumanthappa. (2020). Solar Powered Automated Siren using Arduino Uno. International Research Journal of Engineering and Technology (IRJET) Volume: 07 Issue, 1309.

Suparman, M. A. Bin, & Jong, S. L. (2019). Automatic smoke detection system with favorite platform using internet of things (IoT). Indonesian Journal of Electrical Engineering and Computer Science, 15(2), 1102–1108. https://doi.org/10.11591/ijeecs.v15.i2.pp1102-1108.

Simmi Sharma, D. S. (2017). Fire Detection System with GSM Using Arduino. Imperial Journal of Interdisciplinary Research (IJIR), 2243.

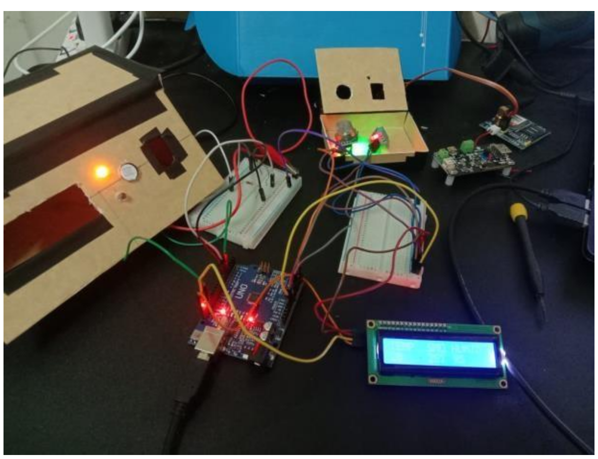
APPENDICES

Appendix A:

Picture of Solar Power Smart Fire Alert System model

Appendix B:

Hardware and wiring connection testing



Appendix C:

Displays on LCD during wiring testing