Faculty of Electrical Technology and Engineering

DEVELOPMENT OF GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM) BASED PHOTOELECTRIC SMOKE DETECTOR DEVICE WITH SHORT MESSAGE SERVICE (SMS) ALERT

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Bachelor of Electrical Engineering Technology with Honours

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Date : 14/02/2024

DEDICATION

To my cherished family,

The foundations upon which this senior project has been built are your unwavering love, support, and understanding. Your support inspired me to strive for excellence and got me through the tough times. I am grateful for your steadfast faith in me.

To my wonderful supervisor,

Your guidance, expertise, and coaching have been invaluable throughout this journey. The current state of this project can be attributed to your persistence, constructive feedback, and dedication to my scholarly advancement. I truly value your advice and assistance.

To my amazing colleagues,

This endeavor was enjoyable and satisfying because of your unwavering support, late-night brainstorming sessions, and friendship. Your belief in me and your encouragement were a constant source of motivation. I am appreciative of you being my supporters.

To my prestigious college,

I am grateful for the university's resources, supportive environment, and opportunity to expand my horizons while concentrating on my education. My skills have been considerably shaped by the range of study opportunities and academic support available.

This project serves as evidence of the combined assistance and guidance I received from my supervisor, friends, family, and university. I sincerely thank each and every one of you for your contributions to this work; your assistance has been essential.

With sincere gratitude,

[NUR NATASHA BINTI KAMARUDDIN]

ABSTRACT

Smoke detectors are essential pieces of equipment in the field of fire safety, acting as the first line of defense against possible catastrophes. These devices have historically performed well in their principal duty of sounding an auditory alarm to notify building occupants when smoke is detected. On the other hand, as technology develops further, more complex and flexible solutions are becoming apparent. This project explores innovation by suggesting the creation of a sophisticated solar-powered smoke detector system. To improve the functionality of traditional smoke detectors, an Arduino Uno microcontroller, a MQ-7 smoke sensor, and a GSM module for SMS notifications are integrated. Traditional alarms work well for alerting people inside a building, but they might not be sufficient in situations where distant alerts are necessary, in noisy environments, or in empty buildings. The main objective of the research is to get over these restrictions and develop a smoke detection system that is excellent at detecting smoke and high temperatures, but also has the added benefit of remote warnings, which enables it to be flexible in a variety of situations. This project is a major step in the right direction toward bridging the gap between conventional fire safety procedures and the changing requirements of modern settings.

ABSTRAK

Pengesan asap adalah peralatan penting dalam bidang keselamatan kebakaran, bertindak sebagai barisan pertahanan pertama terhadap kemungkinan malapetaka. Peranti ini dari segi sejarah telah menunjukkan prestasi yang baik dalam tugas utama mereka membunyikan penggera pendengaran untuk memberitahu penghuni bangunan apabila asap dikesan. Sebaliknya, apabila teknologi berkembang lebih jauh, penyelesaian yang lebih kompleks dan fleksibel semakin ketara. Projek ini meneroka inovasi dengan mencadangkan penciptaan sistem pengesan asap berkuasa solar yang canggih. Untuk meningkatkan kefungsian pengesan asap tradisional, mikropengawal Arduino Uno, sensor asap MQ-7 dan modul GSM untuk pemberitahuan SMS disepadukan. Penggera tradisional berfungsi dengan baik untuk memberi amaran kepada orang di dalam bangunan, tetapi ia mungkin tidak mencukupi dalam situasi di mana amaran jauh diperlukan, dalam persekitaran yang bising atau dalam bangunan kosong. Objektif utama penyelidikan adalah untuk mengatasi sekatan ini dan membangunkan sistem pengesanan asap yang sangat baik dalam mengesan asap dan suhu tinggi, tetapi juga mempunyai manfaat tambahan amaran jauh, yang membolehkannya fleksibel dalam pelbagai situasi. Projek ini merupakan langkah utama ke arah yang betul ke arah merapatkan jurang antara prosedur keselamatan kebakaran konvensional dan keperluan perubahan tetapan moden.

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Finally, I would like to thank all fellow colleagues and classmates, the Faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

Last but not least, I hope that this project development can help others consumers in always getting ready in any situation that insists fire or danger smoke.

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LIST OF SYMBOLS

V	-	Voltage
A	-	Ampere
W	-	Watt
Wh	-	Watt-hour
Ah	-	Ampere-hour

LIST OF ABBREVIATIONS

PV	-	Photovoltaic
Li-Ion	-	Lithium-ion
LED	-	Light-Emitting-Diode
GSM	-	Global System for Mobile Communication
AC	-	Alternate Current
DC	-	Direct Current
ADC	-	Analog Digital Converter
RAM	-	Random Access Memory
ROM	-	Read-only Memory
USB	-	Universal Serial Bus
IC	-	Integrated Circuit
AVR	-	Automatic Voltage Regulator
PWM	-	Pulse Width Modulation
FPGA	-	Field-Programmable Gate Array
PCB	-	Printed Circuit Board
DOD	-	Depth of Discharge
DOA	-	Days of Autonomy
PSH	-	Peak Sun Hour
SMS	-	Short Message Service
LCD	-	Liquid-Crystal Display
MQTT	-	Message Queuing Telemetry Transport
IoT	-	Internet of Things
LDR	-	Light Dependent Resistor
SoC	-	System-On-Chip
GPU	-	Graphics Processing Unit
PC	-	Personal Computer
SD	-	Secure Digital
I/O	-	Input / Output
ICSP	-	In-Circuit System Programming
IDE	-	Integrated Development Environment
GPIO	-	General-Purpose Input/Output
Wi-Fi	-	Wireless Fidelity
IR	-	Infrared radiation
BBTM	-	Battery Bank Temperature Multiplier

INTRODUCTION

1.1 Background

Fire has been discovered by mankind many years ago. Fire incidents can cause significant damage and loss of life, particularly when they are not detected and responded to quickly. Traditional fire alarm systems are effective in alerting occupants of a building or premises, but they may not be sufficient in providing remote notification or alerts in case of smoke detection. This can be particularly challenging in situations where the building is unoccupied or where traditional alarm sounds may not be effective, such as in noisy environments or in areas with hearing-impaired individuals. There are several goals in managing fire. A well-managed fire may be quite beneficial. A wildfire, on the other hand, has the potential to destroy everything.

The origins of the smoke detector can be traced back to the early twentieth century, when various researchers and inventors began investigating the development of fire detection systems. The first commercially available smoke detectors were introduced in the 1960s, and they have since become an essential safety feature in buildings and homes, but traditional smoke detectors may not be effective in situations where no one is present in the building or premises to hear the alarm. Due to increasingly advanced technology, the smoke detector project is an innovative safety system that detects smoke and fire in buildings and premises and sends SMS alerts to designated phone numbers. The project includes the integration of hardware and software components such as a smoke sensor, Arduino board, GSM module, and buzzer.

The development of a GSM-based smoke detector with SMS alert addresses this limitation by providing a method of communicating potential fire hazards to designated phone numbers. This advancement improves response time to smoke and fire incidents while lowering the risk of loss of life and property damage. A smoke sensor, an Arduino board, a GSM module, and a buzzer are among the hardware and software components used in the GSM-based smoke detector project. When the smoke sensor detects smoke or fire, it sends a signal to the Arduino board, which causes the GSM module to send SMS alerts to pre-specified phone numbers. When smoke or fire is detected, the buzzer sounds an audible alarm, acting as a backup alert system in the event that the SMS functionality fails.

Lastly, this Smoke Detector Project represents a significant advancement in the field of fire detection and alert systems. The primary goal of the project is to improve response time to smoke and fire incidents in buildings and premises, lowering the risk of loss of life and property damage. The project's implementation entails the integration of hardware and software components, with testing and validation critical to ensuring the system's accuracy, reliability, and effectiveness in smoke and fire detection and alerting.

1.2 Addressing Global Issue for Smoke Detector

Smoke detectors are critical safety devices that have contributed to a reduction in the number of fire-related deaths and injuries around the world. However, access to smoke detectors remains a significant global issue in many developing countries. To address these global issues, cost effective and easily accessible smoke detectors are needed. This can be accomplished by employing cutting-edge technologies such as the GSM-based smoke detector with SMS alert, which provides a dependable and quick communication method for notifying building occupants or authorities of potential fire hazards.

Other than that, in developing countries, technological advancements in smoke detector devices have been slow. There is a need for research and development into low-cost, sustainable technology solutions for developing countries. This includes the use of renewable energy to power smoke detectors. Due to a lack of maintenance, many smoke detectors that have been installed are not working properly. This is a significant issue in developing countries where smoke detectors are not checked or serviced on a regular basis. Smoke detectors should be serviced and tested on a regular basis to ensure proper operation. Additionally, there is a lack of awareness and education about the importance of smoke detectors. Educational programmes should be implemented to educate people on the benefits of smoke detectors and how to properly use them. This can include instruction on installation, maintenance, and emergency response. Furthermore, many countries do not have laws requiring smoke detectors to be installed in buildings. To improve fire safety, governments should pass regulations requiring smoke detectors in all buildings.

To summarize, addressing global issues concerning smoke detectors necessitates a multifaceted approach that includes accessibility, technology, maintenance, education, and regulation. We can improve global fire safety and reduce the number of fire-related deaths and injuries by addressing these issues.

1.3 Problem Statement

Fire incidents can cause significant damage and loss of life, particularly when they are not detected and responded to quickly. Traditional fire alarm systems are effective in alerting occupants of a building or premises, but they may not be sufficient in providing remote notification or alerts in case of smoke detection. This can be particularly challenging in situations where the building is unoccupied or where traditional alarm sounds may not be effective, such as in noisy environments or in areas with hearing-impaired individuals.

1.4 Project Objective

The project major purpose is to develop a smoke detector device with SMS alert, the system's efficiency by utilizing an Arduino Uno. Specifically, the objectives of this project are as follows:

a) To analyze the existing smoke detector device.

b) To design a smoke detector circuit using an MQ-7 smoke sensor and an Arduino board.

c) To develop the smoke detector circuit to a GSM module for SMS alert functionality.

d) To evaluate the smoke detector circuit and SMS alert functionality.

1.5 Scope of Project

The scope of this project are as follows:

i) Circuit design

- The system is designed to detect the smoke, the GSM system is used to alerting to the phone number of the smoke detection.

ii) Program development

- To use the Arduino IDE software to create a programme that will operate the system and hardware on an Arduino Uno

iii) Software development

- To create and link the circuits, use PROTEUS software, which can display the output for this design circuit

iv) Hardware

- Supply is needed to deliver power to Arduino board

LITERATURE REVIEW

2.1 Introduction

People have known since the beginning of recorded history that early response to fires had positive results in controlling those fires. When a fire was discovered, roving watchmen using hand bell-ringers or church sextons ringing church bells or factory steam whistles alerted fire brigades and fire departments. Unfortunately, these systems were lacking in detail and frequently directed the fire department to the wrong location. However, with the invention of the telegraph by Samuel F. B. Morse in the early 1840s, firefighters were given a faster and more accurate fire reporting system. The Automatic Fire Alarm Telegraph is operated by any dangerous heat, and detects the presence of fire at its commencement. The apparatus, usually set at 51.67°C, is placed on the ceiling at regular intervals in every room, office, closet, and elevator in the building. The alarm will ring when the smoke is detected and will alert to the set phone number at the device[1].

Fire and smoke spread within the building can be affected by various factors such as the geometry, dimension, layout and usage of the building. It is critical to detect fires at an early stage in order to provide fire protection in the building. The most common methods of fire and smoke detection include the use of point type detectors such as ionization smoke detectors, photoelectric detectors, and heat detectors, line type detectors, and so on. These detection methods rely on fire signatures such as smoke and heat.

Fire is caused by the chemical reaction known as combustion. It is defined by the rapid oxidation of acombustible material followed by the release of energy in the form of heat. Both a fuel and a heat energy source are required for ignition to occur. A fire occurs when the two come together in the proper proportions, either by a lack of separation or by some type of active interaction.

A low-cost fire detection and control system based on smoke and heat detection is proposed. It is made up of a variety of electrical/electronic devices/equipment that work together to detect the presence of fire and alert people via audio or visual medium after detection. These alarms may be activated by smoke detectors or heat detectors that detect fire. Then it automatically activates a relay, which can be used to send SMS messages to the registered mobile numbers.

2.2 Overview of Existing Project

This section will go over some previous project designs and implementations related to this project system. Several outstanding researchers have spent years determining the best way to optimize smoke detector systems and devices.

2.2.1 Design of GSM Based Smoke Detection and Temperature Monitoring System

This system was developed to detects smoke or its manifestations such as light, heat, etc. and delivers one or more of the following by alerting the building's residents and others around, summoning the fire extinguishing service, and managing the fire alarm detectors installed in the affected premises. The main controlling device is the AT89S52 microcontroller, which regulates and synchronizes all processes by receiving information from sensors such as the smoke sensor and the LM35 (temperature sensor). The temperature sensor detects the temperature, and the smoke sensor detects the presence of smoke. The high temperature acquired from the signal conditioning unit is displayed on an LCD monitor. A GSM modem is utilized to send the relevant alarm message to the fire station as well as the personnel responsible for the fire safety of the premises using signals from the AT89S52 microcontroller. Additionally, this system is a low-cost, dependable, and effective fire and smoke alarm system[2].

2.2.2 Microcontroller based house fire alarm system using a GSM Module

The development of this device is to protect individuals and their belongings from flames, which are a regular hazard in residential settings. This device uses an Arduino Uno board and an ATmega328 microcontroller. The ATmega328 is the primary controller for the temperature-triggered fire alarm in the ordinary home while the Arduino board serves as the main controller board for this project, and it communicates with a GSM module for communication purposes. The heat from the fire is sensed by an LM35 temperature sensor. The GSM module will transmit an alarm to the user's phone through SMS. When the temperature exceeds 400°C, an alert message appears on the LCD display and an SMS alert is sent to the user's phone. Lastly, this technology can help consumers improve their safety standards by responding quickly in the event of an accident [3].

2.2.3 Development of GSM-Based Smoke Detector and Temperature Monitoring System for Preventing Fire Outbreak

This GSM-Based Smoke detector operates using Arduino Uno Microcontroller board in conjunction with ATmega328 chip, a thermistor-based temperature sensor, flame sensor, GSM module, and LCD display. The ATmega328 is the fundamental controller chip that is used to control the household temperature notification based on the temperature sensor. The heat from the fire is measured using a thermistor-based temperature sensor. The flame sensor is made up of an electrical circuit and an electromagnetic radiation receiver. They utilize the infrared flame flicker technology. A notice message will be sent to the designated personnel through GSM module via short message service (SMS). When the system detects a temperature that is higher than the pre-set value, it immediately displays a warning signal on the LCD display and sends an SMS alert to the users. However, multiple sensors could be included on purpose to cover a larger area, or sensors with a higher reach could be built with the end goal of the study activity in mind and to avoid damage to equipment parts, the framework should be fire-sealed [4].

2.2.4 Smart Fire Alert System Using IoT

Through SMS alert, this system will warn to the varied response centers. The environmental sensors which sense a fire, high temperature, interior pollution event will pass the knowledge to the microcontroller. The microcontroller then determines whether the combination of sensor values represents a true fire event or a false alarm. If a fire occurs, the microcontroller activates the GSM module and sends an SMS alert to the various reaction centers. The microprocessor also instructs the servo to tilt a fire bucket and dowse the fireplace with flame-retardant materials in order to slow the hearth. It employs components such as temperature sensors, smoke sensors, and so on. When a fire is discovered inside the deployed area, a warning about the fire is sent to our mobile phone, and an alert email with the details of the accident site is sent to the fire station, along with the alarm buzzing, notifying the people nearby [5].

2.2.5 Wireless Smoke Detector and Fire Alarm System

This wireless smoke detector and fire alarm system was designed and implementation as remote system that can control from distant location. Fire dangers are not uncommon. Smoke detectors are installed in high-security areas to prevent injuries from fires. Throughout the system, an Arduino Uno ATmega328 is utilized as microcontroller. Wi-fi module ESP8266 functions to enables the microcontroller to connect the wi-fi. Then, this system comes up with LM35 sensor which function to sense the environmental temperature, and lastly it used smoke detector which is monoxide gas detector to detects the concentrations of CO is within the air and offers output reading within the variety of an analog voltage. However, based on the outcomes of this system, there is need the android application to regulate it either automatic or manually, and there is also can be used other different gas sensor [6].

2.2.6 Sensor based smart fire detection and fire alarm system

This system was developed to recognizes fire at an early stage, triggers an automatic alarm, and alerts the mobile user or fire control station about the incident. This, too, attempts to put out the fire. The Arduino board is used in the building of a house fire alert system. The usage of Arduino ATmega328 could be used to sense the environment for the incidence of fire using a fire and gas sensor. When the system detects a temperature of the threshold value (in this case, 104°F or more), it displays an alarm warning on the LCD display while also sending an SMS alert to mobile phone numbers recorded within the Arduino programme using the GSM module. The fire-resistant system is also activated at the same time. Simultaneously, a water sprayer producing apparatus is turned on for fire control. As a consequence, a smart wireless fire alarm system that requires less maintenance while also being safer and easier to use is required in the future in line with technology [7].

2.2.7 IoT-Based Smoke Alarm System

To address the massive smoke inhalation issue, an Internet of Things (IoT)-based smoke alarm system employing the Message Queuing Telemetry Transport (MQTT) communication protocol was created. The idea for a system is made up of three primary components: the detector, the processing unit, and the surveillance system. The detector unit combines an ESP32, a carbon monoxide sensor, an ionization smoke detector, a buzzer, a temperature and humidity sensor, and a temperature and humidity sensor. The Raspberry Pi is utilized as the processing unit to run the Node-RED application, which processes data and monitors it. A surveillance unit is a location where a camera is positioned to watch the surrounding environment. The system's response is determined by the sensor's values or the user's response. When a fire breakout is confirmed, the device quickly sounds the alarm and sends the Global Positioning device (GPS) coordinates and the lodging floor plan to the nearest fire station. As a result, where the system not only recognizes the fire in real time, but also allows the user or associated party to observe the involved scene through security camera with the help of the floor plan [8].

2.2.8 Smoke Detector Using Raspberry Pi with GPS Modem

The intention to developed this project is to raise public awareness and provide warnings regarding the impact of tobacco smoke use on the dental health of both smokers and non-smokers. In this project, raspberry pi platform was used. This smoke detector works when a smoke detector detects cigarette smoke from a person smoking in a public place (nearby school, hospital, transportation terminal, etc.), it first warns the person smoking and also if they ignore the warning (buzzer sound).Second, the camera takes an image of that person and sends it to the nearby police station. It tracks the person's closest coordinates (latitude and longitude) using a GPS modem, and the data is relayed to the nearest police station (through a wireless media such as mail or message). The system has proven to be successful at detecting smoke based on the results. This system is a conglomeration of different smoke detecting algorithms [9].

2.2.9 Combinational Smoke Detector

This combinational smoke detector project focused to design and a smoke detector which sense different fire characteristics. Smoke, carbon monoxide, and heat were found as fire signatures for the detector. This smoke detector is combined between ionization and photoelectric. For the ionization smoke detector is used to detect the presence of smoke in the air, Americium-241 radioactive material is used. The Americium-241 emits alpha particles, which ionize the air in the detector's smoke chamber. The alpha particles ionize the oxygen and nitrogen in the gadget, resulting in an electric current. When smoke enters the chamber, the amount of ionized air in the chamber decreases, reducing the amount of electric flow in the circuit. This electric flow is monitored, and if it falls below a certain level, an alert will sound. When there is a higher likelihood of a blazing fire, the ionization approach for a smoke detector is preferable. The tiny particles from a burning fire may be invisible to the naked eye, but the ionization smoke detector's properties allow it to detect a change in the chemical composition of the air. This has an advantage in the case of a burning fire, but it also causes an excessive number of false alarms because it cannot detect differences in particles in the air. However, the ionization smoke detector also can generates false alarms because it is unable to distinguish between particles in the air.

Photoelectric detectors detect the dispersion of a light source caused by particles of smoke. This is based on the Mie Scattering Theory. When smoke particles reach the path of the light source, they scatter the light in the direction of the sensor. The incident wavelength, particle diameter, and refraction index all influence the angle of refraction. These detectors work best for smouldering fires with a lot of visible smoke. They are not the best solution in the case of a raging fire with little smoke production [10].

2.2.10 Design & Implementation of Fire Alarm Circuit

This fire alarm project was implemented to provide you with adequate notice in the event of a fire in your home. Photoelectric sensors emit a light beam that is directed on a light-sensitive cell included within the alarm. The alarm is triggered if the light beam is disrupted by smoke entering the detector. Ionization sensors work by creating an electric current between two plates using a small bit of radioactive material. When smoke or heated air enters the chamber, the reaction changes and the current is disturbed, resulting in an alert. Ionization detectors function better with fast, hot fires, while photoelectric smoke detectors work best with slow, smoky fires. This project used light dependent resistor (LDR) which function to detect or measure the intensity of lights by allowing current to pass through it. Light emitting diode where it will high light when the LDR resistance are very low. Then, the speaker is function will alarm when the current flowing the collector to emitter that means there is smoke detected. However, this project used too many transistors that can make the circuit more complicated, so that, for the future design it will reduce the number of transistors [11].

2.2.11 Automatic Smoke Detection System with Favoriot Platform Using Internet of Things (IoT)

The proposed system is capable of not only monitoring the smoke state of a room, but also of alerting the user and the Fire and Rescue Department when a particular quantity of smoke is detected by a gas sensor via the Favoriot platform. The Arduino Uno is utilized as a microcontroller in this project to control all of the digital devices. Furthermore, the ESP8266 Wi-Fi shield is used to link devices to the network so that data from the smoke sensor may be updated in the Favoriot platform. If the smoke detector detects the presence of smoke, it will send a signal to the Arduino Uno, triggering the alarm. Simultaneously, the

Favoriot platform will display the updated smoke level status, and a notification will be sent to the Fire and Rescue Department if a fire is discovered. The potential of an automatic smoke detection system to use the Internet of Things (IoT) to alert the occupant as well as the Fire & Rescue Department whenever a fire is detected. This can lessen the likelihood of a fire breaking out and protect persons and property [12]

2.2.12 Smoke and Gas Detection Alarm Circuit

This project design was used two sensor which are MQ-2 and MQ-6. The MQ-2 sensor is used to detect the percentage of combustible gas and can easily detect the gas at room temperature. While MQ-6 sensor is used to detect a single gas at particular time. This sensor also can detect the gas like propane, butane, and so on. When there is a hearthplace analysis nearby. This circuit employs sensors to determine the amount of smoke (MQ2) and gas (MQ6). In this project, the gas sensor is used to see if there is any gas leakage and a smoke sensor to see if there is any smoke (hearthplace). We employ MQ2 sensors to detect smoke or a fire, and MQ6 sensors to detect gasoline/LPG leaks. This circuit activates the buzzer whenever it detects smoke and generates a matching output. However, this project circuit was built direct for the smoke and gas detector without any implementation [13].

2.2.13 Smoke Alarm

This smoke alarm project is focused on the visual and audio warning to indicate the presence of smoke. This project was implemented MQ-2 sensor as the capability of this sensor of sensing smoke and other combustible gases. This sensor choose because it has wide detecting scope, fast response and high sensitivity, stable and long life, and also a simple drive circuit. This project also used ATmega 32A because of to its comparatively substantial flash memory (32kb) as well as availability of many (32) programmable I/O lines. Then, the interfacing LCD to ATmega 32A is used to indicate the amount of smoke detected as well as the system's status. Other than that, for the visual alarm, the project choose LED as the alarm while buzzer was used as audio alarm. When the amount of smoke detected reaches the rated value, the buzzer noises, the green LED turns off, and the red LEDs turn on, in addition to the status indication of "smoke detected" on the LCD. The sensor continues to check for the presence of smoke as long as the circuit is powered. However, to ensure a longer life span, this system should be placed in a cool and dry place [14].

2.2.14 Stack Project Smoke Detector & Alarm Circuit

The development of this project is to protect lives and homes from fires. This project functionality when the smoke detector senses smoke (the detection measurement of smoke can be changed based on the size and surroundings of the room), an LCD display displays "Fire in room!" and the alarm immediately activates. So, even if a person is at home, he or she can be informed of fire catastrophes. The smoke sensor module that used in this project is MQ-2 gas sensor that will be used in gas leakage detecting. Arduino Uno R3 or also known as Arduino Uno ATmega328 will act as microcontroller. Buzzer is used for alarming purpose where it will alarm when there is smoke detected by the sensor [15].

2.2.15 Development of Fire Alarm System using Raspberry Pi and Arduino Uno

The implied fire alarm system is a real-time monitoring system that detects the existence of smoke in the air caused by a fire and takes photographs via a camera mounted within a room when a fire begins. Raspberry Pi and Arduino Uno were used to construct this fire alarm system. The capacity to remotely send an alert when a fire is detected is the system's major feature. When smoke is detected by QM-NGI gas sensor, the system will display an image of the room status on a webpage. The system will require user consent before reporting the event to the Firefighter by Short Message Service (SMS) through GSM module. Additionally, this system used of low-cost, dependable equipment that were appropriate for developing a fire alarm and were inexpensive [16].

2.2.16 Fire Detection System Based on FPGA

Fire can be recognized in its early stages, which aids in the early detection and control of fires. With its hardware features, the field programmable gate array (FPGA) may fulfil the needs of high-speed real time. SOPC technology can make designs more adaptable, software and hardware in-system programmable, and updateable. The hardware platform for the system is a Spartan 3A development board. Spartan-3A FPGAs are appropriate for a variety of consumer electronics applications such as internet access, home networking, display/projection, and digital television equipment. This system will function if there is a fire in the surrounding area, the system will transmit an alarming signal and SMS to the monitoring crew via the GSM module and buzzer. FPGA-based real-time smoke detection mainly for monitoring smoke in the environment. This system was built by SOPC system with function read and process data. As a result, this system succeeded because it can satisfy the detection requirements of real-time processing applications [17].

2.2.17 A Smart Fire Detection System using IoT Technology with Automatic Water Sprinkler

The proposed model utilizes the capabilities of many integrated detectors, such as heat, smoke, and flame. This system used a flame sensor which is programmed to detect light that falls into a specific range of wavelengths, temperature sensor (DHT-11) that to sense the surroundings temperature. It also used MQ-2 gas sensor that will detect gas leakage, and automatic water sprinkler that will function when relay switch is on, the water pump is triggered, sucking water from the tank and releasing it into the sprinkler. The signals from those detectors are processed by the system algorithm to figure out the potentiality of the fire, and the projected outcome is subsequently broadcast to various parties using the system's GSM modem. To obtain real-time data without endangering human lives, an IoT technology has been used to give the fire department with the essential data. Finally, the suggested system's major characteristic is that it minimizes false alerts, making it more trustworthy [18]

2.2.18 Raspberry Pi based Smart Fire Management System employing Sensor based Automatic Water Sprinkler

This fire detection system includes flame detectors as well as temperature sensors, which decreases the false fire detection rate. The technology also sends the user an email with a video of the fire-affected area and provides periodic room temperature updates. A gas leakage sensor was used to detect several types of gases such as ethane, methane, and LPG. When a fire or gas is detected, the suggested fire controlling system performs a variety of activities, including turning off the main power supply, turning on the exhaust fan and finally dousing the fire. Water sprinklers have been installed, which will be activated if the system's fire sensors detect a fire. If the temperature climbs beyond the defined threshold temperature, the proposed system will also send a message to the fire department together with the video and advise the user to notify the fire department manually.

The Raspberry Pi 3 is a credit card-sized single-board computer. It has been used in the proposed system to operate the different sensors via GPIO pins. The proposed system utilizes IR flame sensors to detect the infrared rays emitted by the flame. To measure the temperature of the room/hall and identify gas leakage, two temperature sensors DHT11 and one gas leakage detector MQ-5 were used. The independent of an automatic sprinkler system is determined by many aspects of a small fire. It successfully releases water onto the burning area, regulating and extinguishing the fire. Additionally, the sensor-based water sprinklers used in the proposed system are more efficient than ordinary fire sprinklers [19].

2.2.19 Design of Intelligent Fire Alarm System Based on GSM Network

This design of intelligent alarm system is developed to help solving the problem traditional fire alarm. MSP430F149 is used as the main control chip, while GSM module TC35I is used for remote alarming and data exchange. Photoelectric smoke fire detector is used that made up of infrared emission and receiving circuit. In this system, the pulse current drive mode is used by the LED driver. This mode can reduce the average power of the LEDs, increase the system's effective distance, and significantly improve interference suppression capabilities. Temperature transducer also used in this system that will measure and transmit temperature readings in various industrial and commercial applications. MSP430F149 act as main controller that realize series communication to GSM module (TC351) by its universal asynchronous receiver transmitter module that this GSM module function is to realize remote alarm via SMS that can make the system more intelligent and make the cabling simpler [20].

2.2.20 Smoke Detector

In this smoke detector with Arduino, it used MQ-2 gas sensor which is to detect preset smoke in the air. The PPM value of Smoke is displayed on a 16x2 LCD. And an LM358 integrated circuit for translating smoke sensor output to digital form (optional). A buzzer is installed as an alarm that is activated when the smoke level exceeds 1000 PPM. In this device also used NodeMCU which is an open-source electronics platform with simple hardware and software. Arduino boards can read inputs such as a light on a sensor, a finger on a button, or a Twitter tweet and convert them into outputs such as operating a motor, turning on an LED, or publishing anything online. The Arduino is used in this crystal ball project to show the message on the LCD based on the code generated in the Arduino software whenever the tilt switch senses the moment of the bread board and transmits the signals to the Arduino. As a result, the experiment of smoke detector is completed successfully utilizing MQ-2 smoke detecting sensor and is exhibited[5].

2.3 Comparison of Literature Review

Table 1 provides a comparison of the components utilized in the previously described related project. According to a review of the literature, the majority of relevant projects used MQ-2 gas sensor to detect the gas leakage from the building. Besides, the light emitting diodes (LEDs) and buzzer have also been used with function to alert the consumer. Other than that, temperature sensor also used in the most of the projects to detect the surrounding temperature.

As for the microcontroller, more of the projects used Arduino UNO but in different type of Arduino. There are also some of the project used IoT-based system and image processing techniques, and also the system used Raspberry Pi as its microcontroller.

Table 2. 1 Comparison between the component used in related existing project

Component / Existing project	LM35	Arduino Uno	AT89S52	ATmega328	MQ-2 smoke sensor	MQ-7 sensor	Flame sensor	Smoke sensor	Gas sensor	Thermo-resistive sensor	DHT 11	GSM SIM300	GSM SIM900A	GSM module	GPS module	ESP8266	ESP32	NodeMCU	Raspberry Pi	LDR	LED	Buzzer
Design of GSM Based Smoke Detection and	■		■		■							■									■	■

Temperature Monitoring System																						
Microcontroller based house fire alarm system using a GSM Module																						
Development of GSM-Based Smoke Detector and Temperature Monitoring System for Preventing Fire Outbreak																						
Smart Fire Alert System Using IoT																						
Wireless Smoke Detector and Fire Alarm System																						
Sensor based smart fire detection and fire alarm system																						
IoT-Based Smoke Alarm System																						
Smoke Detector Using Raspberry Pi with GPS Modem																						
Combinational Smoke Detector																						
Design & Implementation of Fire																						

Alarm Circuit																						
Automatic Smoke Detection System with Favoriot Platform Using Internet of Things (IoT)																						
Smoke and Gas Detection Alarm Circuit																						
Smoke Alarm																						
Stack Project Smoke Detector & Alarm Circuit																						
Development of Fire Alarm System using Raspberry Pi and Arduino Uno																						
Fire Detection System Based on FPGA																						
A Smart Fire Detection System using IoT Technology with Automatic Water Sprinkler																						
Raspberry Pi based Smart Fire Management System employing Sensor based Automatic																						

Water Sprinkler											■								■			
Design of Intelligent Fire Alarm System Based on GSM Network														■							■	
Smoke Detector		■			■													■				■

2.4 Conventional Smoke Detector System

A conventional smoke detector system is a type of fire detection system that is often used in buildings to detect the presence of smoke and inform inhabitants of a potential fire. It is sometimes referred to as a conventional system since it has a simpler architecture than more modern systems such as programmable fire alarm systems. A conventional smoke detector utilizes one or more starting circuits from the panel that are wired in parallel to identify equipment. When the ambient influence on any detection rises above a predefined threshold, these detectors are designed to reduce the circuit's resistance. A floor design with specified areas is drawn up on the mimic panel and pinned with LED lights using the mimic panel on the control panel. The LED lights display the status of the building's circuit/zone. For modest applications, conventional smoke alarm systems are cost effective. There is how the conventional smoke detector system typically works.

Multiple smoke detectors strategically positioned throughout the structure comprise the system. In most cases, these detectors are installed on the ceilings or walls of certain zones or locations. In a conventional setup, the detectors in a certain zone are connected in a parallel circuit. A network of electrical cable connects the detectors in a conventional system to a control panel. Typically, the wiring is separated into zones, with each zone has many detectors. The goal of zoning is to assist in determining the overall location of a fire within the building. The control panel is the central hub of the smoke detector system. It analyses the electrical signals from the detectors and evaluates the data to determine whether or not there is a fire condition. The panel has indication lights or an alphanumeric display to show the status and location of the activated detectors. When a smoke detector detects smoke or a fire, it transmits a signal to the control panel, which activates an auditory and visual alert notice. The alarm may contain sirens, bells, strobe lights, or any combination of these elements. The goal is to inform building inhabitants to evacuate or take necessary action as a reaction to a fire danger. Manual controls, such as manual call points or pull stations, are commonly found around conventional systems. Individuals can use these to manually activate the fire alarm system if they notice a fire or suspect an imminent danger.

It is crucial to bear in mind that the control panel in a conventional smoke detector system will only recognize the area in which an alert is triggered, but it cannot pinpoint the exact location of the activated detector. This constraint makes it not ideal for larger buildings or facilities where pinpointing the site of a fire is essential. In general, conventional smoke detector systems deliver basic smoke detection and alarm capability. They are typically found in smaller structures, residential houses, and some commercial settings that require a more cost-effective and simple smoke detection technology.

2.5 Statistics of Fire Incidents in Buildings

Building fires illustrates a serious risk to both property and human safety. In 2019, a total of 50,720 fire incidents were documented, and the number continues to rise. In fact, Malaysia loses RM5.2 billion every year due to fires, and this amount does not include the loss of life, productivity, or discomfort. A lack of awareness about fire safety increases the possibility of ignorance and harm.

According to some survey findings, some of the flames caused by sparks from maintenance work and the fundamental causes include improper cladding materials and inadequate passive fire prevention maintenance. In 2018, Dr. Mohd Zaid Abd Ghani said that in the most common reported cause of flame was electrical sources (4,558 occurrences), followed by gas-related equipment (1,328 incidents), lighters (525 incidents), and others (519 incidents)[22]. Cooking fires are the leading cause of home fires, contributing to over half of all residential fires (49%). One of the leading causes of kitchen fires is inattentive cooking. Heating and cooling devices are the second biggest cause of residential fires, contributing to about 12% of all fires. Other than that, there are many more the causes of fires. However, more research on the efficiency of the smoke detector design is required.

2.6 Microcontroller

A microcontroller is a small integrated circuit that controls a specific operation in an embedded system. A typical microcontroller consists of a CPU, memory, and input/output (I/O) peripherals all on a single chip. Microcontrollers are widely utilized in a wide range of electronic devices and systems where precise control, real-time processing, and minimal power usage are needed.

2.6.1 NodeMCU ESP8266

The NodeMCU (Node Microcontroller Unit) is an open-source software and hardware development environment based on the ESP8266, as shown in Figure 2.1, is a low-cost System-on-a-Chip (SoC). The ESP8266, developed and constructed by Espressif Systems, contains most of the essential components of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. As a result, it is an outstanding solution for Internet of Things (IoT) projects of all kinds.

The NodeMCU_ESP8266 contains 30 pins in total, 17 of which are GPIO pins. GPIO stands for General Purpose Input Output. There are 9 digital pins ranging from D0-D8 and only one analogue pin A0, which is a 10 bit ADC. The D0 pin can only read or write data and cannot perform any other functions. When the EN pin is pulled HIGH, the ESP8266 chip is turned on. When pulled LOW, the chip operates at low power. The board features a 2.4 GHz antenna for a long-range network, and the CP2102 is a USB to TTL converter. The prototype board includes the ESP-12E module, which contains an ESP8266 chip with a Tensilica Xtensa® 32-bit LX106 RISC microprocessor that works at a configurable clock frequency of 80 to 160 MHz and supports RTOS.

There's also 128 KB of RAM and 4MB of Flash memory (for programme and data storage), which is more than adequate to handle the long strings that make up web pages, JSON/XML data, and everything else we throw at IoT devices these days. The ESP8266 incorporates an 802.11b/g/n HT40 Wi-Fi transceiver, allowing it to not only connect to a WiFi network and communicate with the Internet, but also to build up its own network and allow other devices to connect directly to it. This increases the ESP8266 NodeMCU's capability.

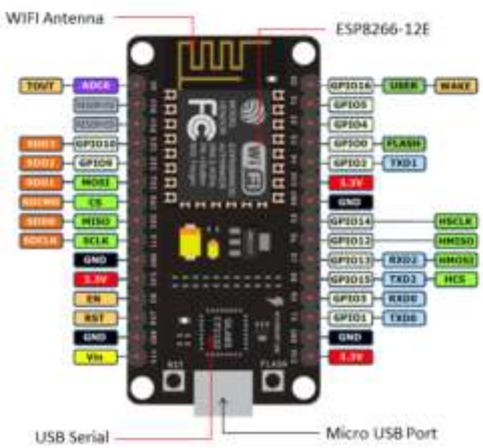

Figure 2.1 NodeMCU ESP8266

2.6.2 NodeMCU ESP32

The ESP32, as shown in Figure 2.2, is an affordable, low-power system on a chip (SoC) series that supports Wi-Fi and Bluetooth. The ESP32 has built-in antenna switches, an RF balun, a power amplifier, a low-noise receive amplifier, filters, and power management modules. ESP32 is designed for mobile devices, wearable electronics, and IoT applications, and it consumes very little power because to power-saving features such as fine resolution clock gating, numerous power modes, and dynamic power scaling.

Features of NodeMCU ESP32:

- NodeMCU based on ESP-WROOM-32 module
- 30 GPIO Version
- ESP32 is a dual-core 32-bit processor with built-in 2.4 GHz Wi-Fi and Bluetooth
- 4MByte flash memory
- 520KByte SRAM
- 2.2 to 3.6V Operating voltage range
- In breadboard-friendly breakout
- USB micro B for power and Serial communication, use to load the program and serial debugging too

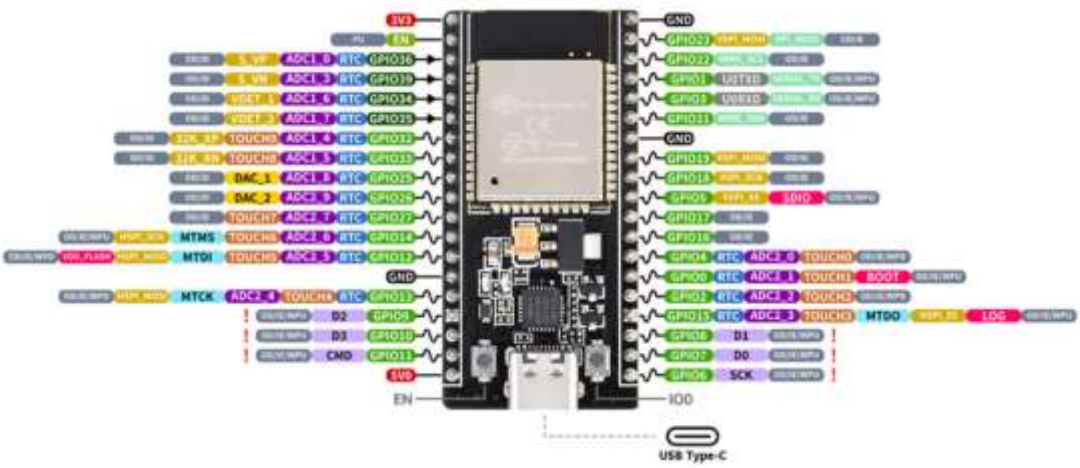

Figure 2.2 NodeMCU ESP32

2.6.3 Raspberry Pi 3 Model B

The Raspberry Pi is a credit card-sized computer that relies on the BCM2835 system-on-chip (SoC), which includes an ARM11 processor and a capable GPU, as shown in Figure 2.3. The Raspberry Pi supports a number of Linux distributions, including Debian, Fedora, and Arch Linux. This is the Raspberry Pi Model B, revision 2.0. The Raspberry Pi Foundation created the Raspberry Pi to provide a low-cost platform for computer programming exploration and teaching. The Raspberry Pi can do many of the functions of a standard desktop PC, such as word processing, Excel spreadsheets, video with high resolution, games, and programming. USB devices such as keyboards and mouse can be attached to the board's two USB ports. Due to its 0.1″-spaced GPIO header and tiny size, can also be used as a programmable controller in a wide range of robotics and electronics applications. A 5 V power source with a micro USB connector, an SD card with an operating system on it, which also serves as the main storage for the device, and input and output devices, such as a keyboard and monitor, are required to utilize the Raspberry Pi.

Figure 2.3 Raspberry Pi Model B

2.6.4 Arduino Uno

The Arduino Uno, as shown in Figure 2.4, is one of the most popular and commonly used development boards in the Arduino ecosystem. It is intended for both novices and experienced users, and it provides a versatile and user-friendly structure for developing a wide range of electronic projects.

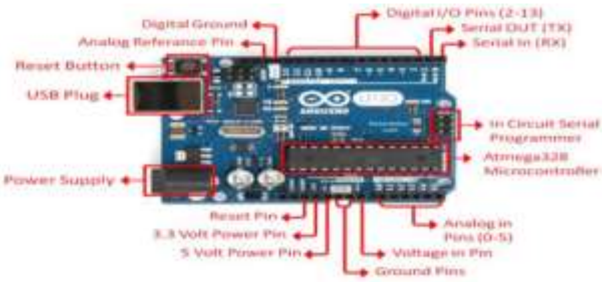

Figure 2.4 The structure of Arduino Uno

The ATmega328-based Arduino Uno is a microcontroller board. It contains 20 digital input/output (I/O) pins (6 PWM outputs and 6 analogue inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It comes with everything you need to support the microcontroller; simply connect it to a computer through USB or power it using an AC-to-DC adapter or battery to get started.

2.7 Summary

This chapter summarizes the previous work related to smoke detection system. It also highlights the research needed to complete this project's investigation. In this project research, the Arduino UNO microcontroller is chosen for controlling the entire smoke detector system since it is simple and requires less power than other microcontrollers. Additionally, the smoke sensor and temperature sensor, was chosen as main sensor to operate the smoke detector. The reason is that the detector will detect the two main parameters which are smoke and temperature. Lastly, the LEDs and buzzer act as the output or as an alarm to alert the consumer.

METHODOLOGY

3.1 Introduction

This chapter highlights the methodology of the project. This project development is divided into two parts which are hardware and software development. The developing of this project has incorporated various aspects for it to work completely via the specified research and studies into two parts which are hardware and software development. The developing of this project has incorporated various aspects for it to work completely via the specified research and studies

3.2 Methodology

This project introduces a smoke detector system that can work automatically. Different features will be combined in this improvement to complete its work. The improvement of this system is carried out step by step within the perspectives of investigating, developing program, developing equipment, and collecting the information. All the strategies, hardware, and program utilized are listed in this chapter. Figure 3.1 shows the flowchart for the project development.

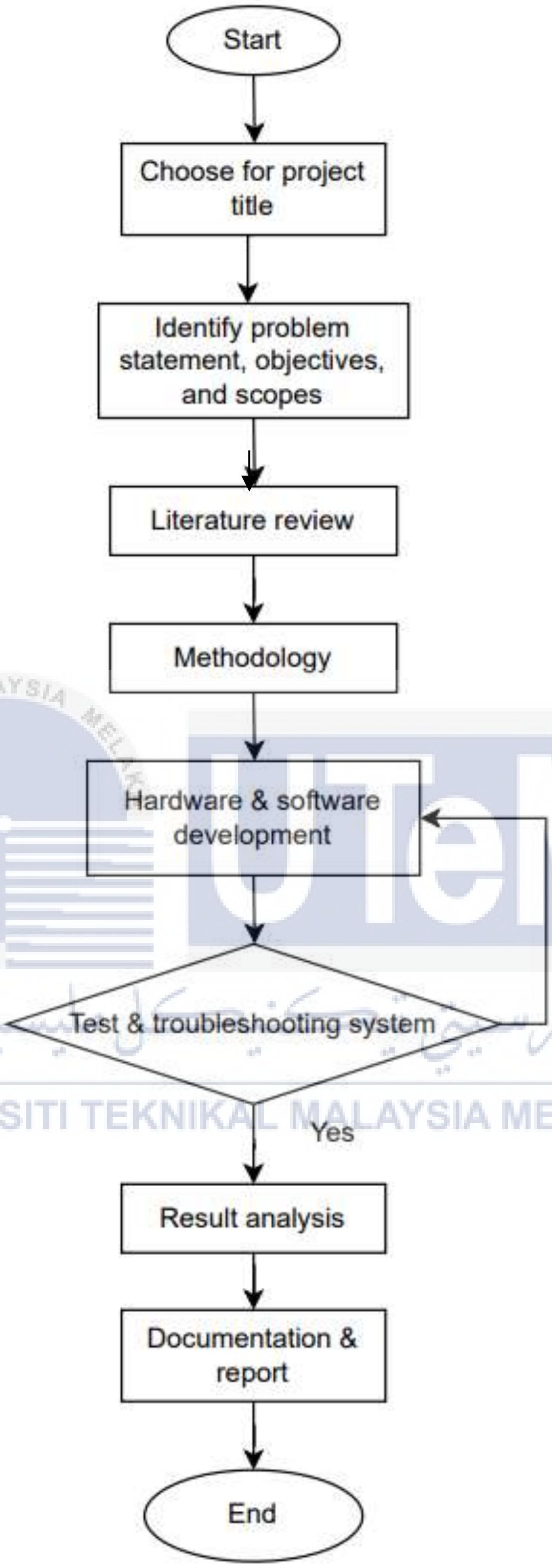

Figure 3.1 Flowchart of project development

3.2.1 Project System Flowchart

The aim of this project system flowchart as shown in Figure 3.2 is to visualize how the system operates. The first step of the operation is when the temperature sensor detects high temperature value that exceed the set value then, the MQ-2 smoke sensor detects high smoke value that exceeds the set value. After that, when both of the sensor exceeds the set value, the buzzer and LED will turn ON to give alerts to the phone number that set in GSM module.

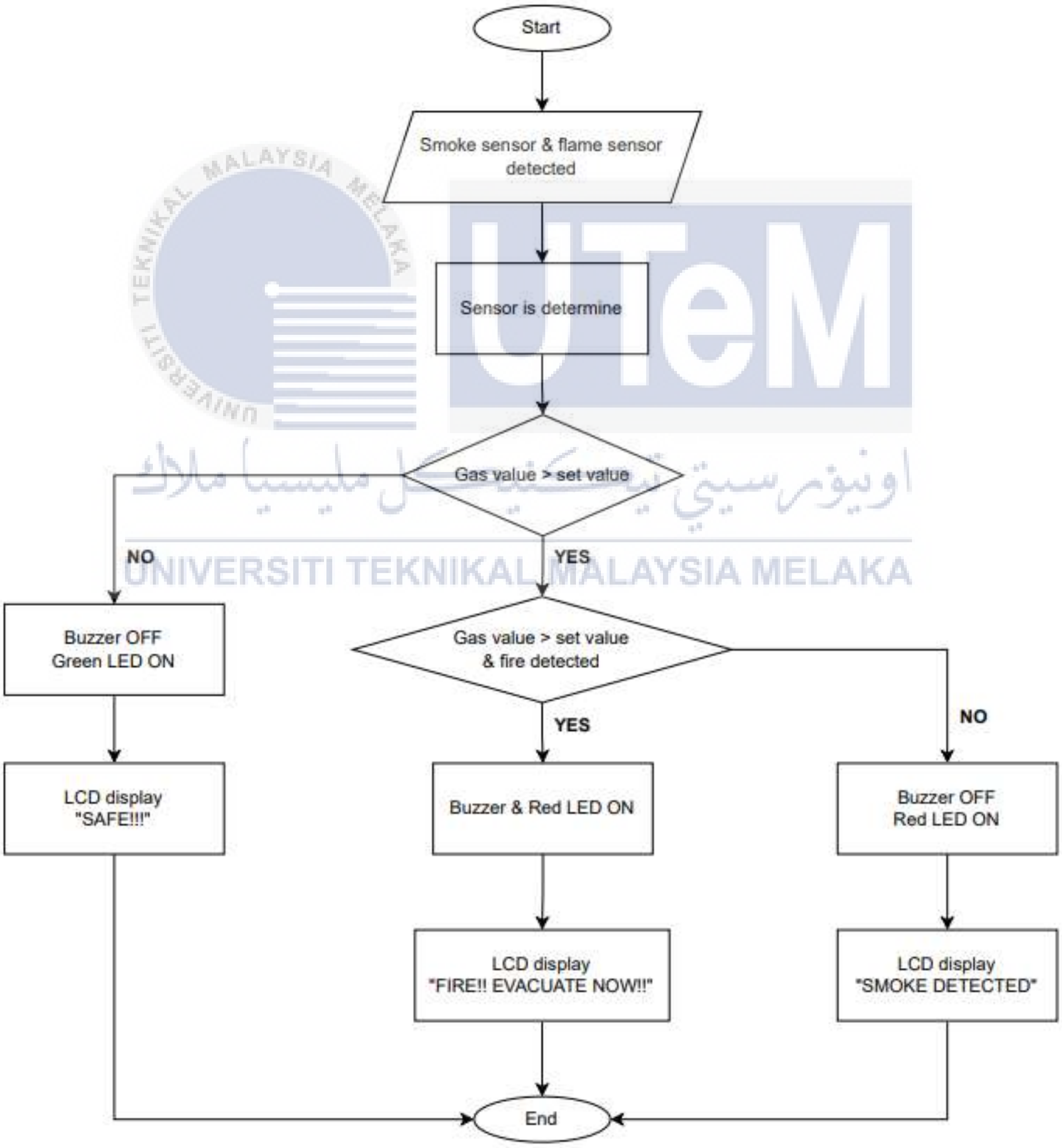

Figure 3.2 Project System Flowchart

3.3 Block Diagram of Standalone PV Solar Generation

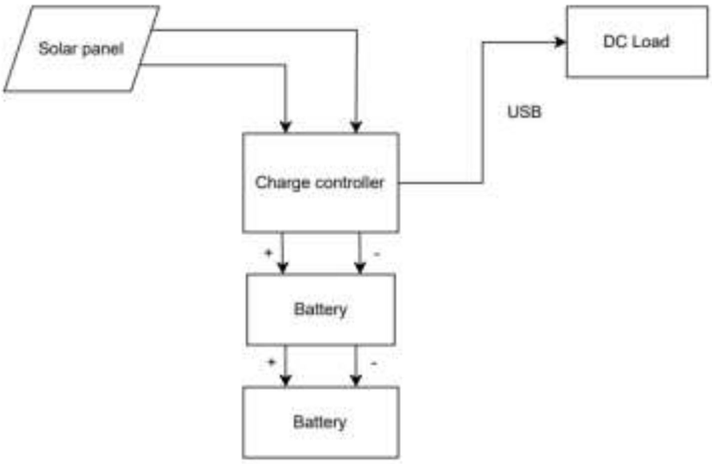

Figure 3.3 Block Diagram of Standalone PV Solar Generation

Solar energy is being used in this project because green energy should be used to conserve power. In order to charge banks of batteries for usage at night or on overcast days when the sun's energy is not accessible, photovoltaic (PV) solar panels utilize sunlight that is converted into direct current (DC) electricity using photovoltaic (PV) solar panels. The DC-DC converter is used to step up or step down the voltage if the provided voltage is either too high or too low. Figure 3.3 shows a block diagram of standalone PV solar generation.

3.4 Block Diagram of Overall System

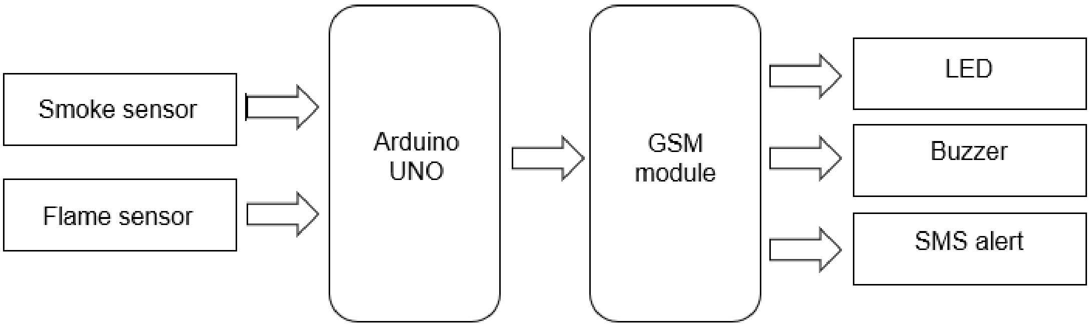

Figure 3.4 Block Diagram of GSM Based Photoelectric Smoke Detector with SMS Alert

The Arduino UNO will operate when standalone PV solar generator supplies the power. Then, when the temperature sensor detected a high temperature and the smoke sensor detected smoke, it will transmit the data to the Arduino UNO microcontroller. The Arduino UNO will process the data and transmit the output signal to the LED, buzzer, and give alert to the phone number so that the situation will be under control and also can prevent fire. Figure 3.4 shows a block diagram of GSM Based Photoelectric Smoke Detector with SMS Alert.

3.5 Software Development

This project need software development to assure the accomplishments of system functions. There are three software development which are Proteus 8, Arduino IDE, and Blynk IoT application. The software required including the sketching of circuit diagrams, simulation, the coding for Arduino UNO microcontroller, and the development of an application for controlling the system's function.

3.5.1 Proteus 8 Professional

Proteus 8 Professional or Proteus, as shown in Figure 3.5, is a software that mainly used to design circuit on PCB (print circuit board) layout, create schematic diagram, and run the simulations. By using Proteus, two-dimensional circuit can design. Proteus is made up of several libraries for various sensors and Arduino microcontroller types. Additionally, this software is compatible with the Arduino IDE, which is the programme used to code the Arduino.

Figure 3.5 Proteus 8 Professional Software

3.5.2 Arduino IDE

Arduino IDE, as shown in Figure 3.6, is an open-source platform used for building electronics projects. In order to create and upload computer code to the physical board, the Arduino system comprises of a software programme called the IDE (Integrated Development Environment) that runs on the computer. The actual programmable circuit board is sometimes referred to as a microcontroller.

The Arduino, unlike the majority of earlier programmable circuit boards, can be updated with new code using just a USB cable rather than a separate piece of hardware (called a programmer). Additionally, the Arduino IDE employs a condensed form of C++ that makes learning to programme simpler. Finally, Arduino offers a standard form factor that separates the micro-controller's functionality into a more usable packaging.

Figure 3.6 Arduino IDE Software

3.6 Component of Standalone PV Solar System

The solar photovoltaic system is the most important component of the project since it will produce the electricity needed to run the smoke detection system. The PV solar generator needs several types of components, including solar panels, a charge controller, a battery bank, and a DC-DC converter.

3.6.1 Polycrystalline Silicon Solar Panel

Solar panels made of polycrystalline silicon, sometimes referred to as polysilicon or multi-crystalline panels, use this semiconductor material. Multiple silicon shards are fused and solidified to create these panels, giving them their textured look. Polycrystalline silicon solar panels, as shown in Figure 3.7, are more affordable because of their easier production process, while having a little lower efficiency than monocrystalline panels. They may function effectively for residential, commercial, and utility-scale installations under normal sunshine circumstances and are distinguished by their characteristic blue colour. These panels have a 25 to 30 years lifespan and an excellent temperature tolerance, which allows them to tolerate extreme temperatures while maintaining a consistent output. As they employ plentiful and non-toxic silicon material to produce renewable energy while lowering greenhouse gas emissions and dependency on fossil fuels, polycrystalline silicon solar panels have a comparatively low impact on the environment.

Sunlight is converted into power by a solar panel made of polycrystalline silicon. It takes in solar energy, produces an electric current, and outputs it. You may send this electricity to the grid or utilize it to power equipment and properties. To put it simply, the panel collects sunlight and generates power.

Figure 3.7 Polycrystalline Silicon Solar Panel

3.6.2 Sealed Lead Acid Rechargeable Battery

A 12volt, 7.2 ampere-hour (Ah) sealed lead-acid (SLA) rechargeable battery, as shown in Figure 3.8, is a flexible power source that is frequently used in a range of applications. Featuring a nominal voltage of 12 volts, it caters to devices requiring this standard voltage, such as uninterruptible power supplies (UPS), emergency lighting systems, and portable gadgets. The 7.2Ah capacity shows the amount of charge the battery can retain, making it perfect for providing backup power during outages, emergency illumination, and other instances where a reliable rechargeable power source is needed. The "sealed" feature suggests that there is no need for regular water additions and that the battery is maintenance-free.

In order to offer dependable and rechargeable power, SLA batteries are employed in solar smoke detectors. The detectors use these batteries for two crucial reasons. In the beginning, they store extra energy produced by the solar panels. The extra energy generated by the solar panels that is not used by the smoke detector is saved in the SLA battery for later use. In times of low sunshine or at night when the solar panels are not producing electricity, this makes sure that the smoke detector has a backup power source. Second, SLA batteries have the benefit of being rechargeable. The solar panels may be used to charge them, enabling numerous charging and discharging cycles. They are therefore an effective and environmentally friendly power source for solar smoke detectors. SLA batteries enable solar smoke detectors to function regardless of external power sources, enabling continuous smoke detection capabilities and improving dependability, particularly in off-grid or remote places where access to standard power outlets may be restricted.

Figure 3.8 Sealed Lead Acid Rechargeable bttery

3.6.3 Solar Charge Controller

A photovoltaic system's charge controller is an essential component. Its major responsibility is to ensure that the batteries are sufficiently charged utilizing power from the solar panels. To avoid charging excessively and damage, the controller controls the voltage and current going to the batteries. Additionally, it guards the batteries against short circuits, excessive voltage, and over discharging. Various recharge modes are available on certain controllers for various battery types. They have the ability to manage the power supplied to linked devices. We can view significant system performance data via displays or interfaces. Solar charge controllers, as shown in Figure 3.9, come in a variety of forms, but they all work to ensure that the batteries are charged effectively and securely.

Figure 3.9 Solar Charge Controller

3.7 Component of Smoke Detector Device

This section will explain the component used in developing the smoke detector device. The main components used are Arduino Uno, LM35 temperature sensor, MQ-2 smoke sensor, buzzer, and LED.

3.7.1 Arduino Uno R3 ATmega328P

Known microcontroller boards like the Arduino Uno, as shown in Figure 3.10, are frequently utilized in electronics projects and prototyping. At its heart is a powerful ATmega328P microprocessor with a 16 MHz clock speed. The Arduino Uno provides a wide variety of connectivity possibilities for sensors, actuators, and other electrical components with its 14 digitals input/output pins and 6 analogue input pins. The Arduino IDE, a user-friendly software environment that facilitates code writing, compilation, and uploading to the board, makes programming the Arduino Uno simple. Shields, which are extra modules that offer certain features like Wi-Fi connectivity, motor control, or sensor integration, allow the board to be expanded. The Arduino Uno is a great option for both novice and seasoned makers for a variety of purposes includes robotics, home automation, and interactive art displays because to its open-source design, low cost, and sizable user community.

Figure 3.10 Arduino Uno R3 ATmega328P

3.7.2 SIM900A GSM Module

The tiny SIM900A GSM module, as illustrated in Figure 3.11, is used to link electrical devices to mobile networks. It enables users to utilize the GSM network to send text messages, make phone calls, and access the internet. Projects like tracking, home automation, and remote monitoring frequently employ it. It is compatible with single-board computers like the Raspberry Pi and Arduino microcontrollers. Power must be supplied, and AT instructions must be used to interact with it. It offers functions including internet access, a call audio interface, and GPIO ports for attaching other devices. Overall, it facilitates GSM network-based wireless communication between devices.

Figure 3.11 SIM900A GSM Module

3.7.3 MQ-7 Sensor

The MQ-7 sensor, as shown in Figure 3.12 is a gas sensor module intended to measure airborne quantities of methane (CH4) and carbon monoxide (CO). It has a high sensitivity to these gases and outputs an analog voltage that is proportionate to the concentration that is detected. Since the sensor has a heater element to control temperature, it must first preheat in order for results to be reliable. The analog output of the MQ-7 sensor, which is widely utilized in applications including home and industrial safety, can be interfaced with microcontrollers for additional analysis. While handling potentially dangerous gases, users should be aware of the sensor's limitations and take the necessary precautions to assure precision. Regular calibration is also advised.

Figure 3.12 MQ-7 Sensor

3.7.4 Flame Sensor

The detection of a flame or fire is done with a flame sensor. Figure 3.13 shows a flame sensor that generates an electrical signal by detecting the infrared light that the flame emits. By activating alarms or other safety precautions in response to this signal, fire emergencies can be handled quickly. Flame sensors are extremely reliable for detecting fires while minimizing false alarms because they are made to be sensitive to the particular wavelength of IR radiation released by flames.

Figure 3.13 Flame Sensor

3.7.5 Liquid Crystal Display (LCD) module 16x2

A smoke detectors' 16x2 LCD module acts as a display for messages and essential data. It displays information such as battery life, sensor functionality, alert status, temperature value, gas value, and so on. The LCD module offers a visual interface that, all things considered, makes it easier for me to engage and monitor the smoke detector. In this project, the LCD as shown in Figure 3.15, is used for displaying the temperature sensor and gas value of the residence.

Figure 3.14 Liquid Crystal Display (LCD) module 16x2

3.7.6 Resistor

Smoke detectors' resistors, as shown in Figure 3.16, serve crucial purposes. Resistor aid in voltage level management, component protection, and setting smoke detection sensitivity. It also capable of calibrating, controlling time, and limiting current. In general, resistors are essential to the precise and dependable operation of smoke detectors.

Figure 3.15 Resistor

3.7.7 Buzzer

Buzzer in smoke detector, which emits a loud noise when smoke or a possible fire is present, is an essential component. Its responsibility is to attract attention and warn others about the threat. The buzzer as shown in Figure 3.17, which emits a loud, audible noise when the smoke detector detects smoke, is activated when smoke is present. This makes it easier for people to be aware that a fire could be there and that they should take precautions, such as fleeing the area or calling for assistance. The buzzer's distinctive and conspicuous loud noise is intended to draw attention so that people may react swiftly and stay safe.

Figure 3.16 Buzzer

3.7.8 Light-Emitting Diode (LED)

The LED in a smoke detector serves the straightforward purpose of giving visual indicators. Normally, when everything is normal and the smoke detector is operating properly, it will continuously produce a green light. The LED, as shown in Figure 3.18, may flash or change colour in the presence of smoke or a potential fire to draw your attention to the situation and alert you to the alarm. It may also signal that the battery needs to be changed since it is running low. Overall, the LED enables you to quickly determine the smoke detector's state and take necessary action.

Figure 3.17 Light-Emitting Diode (LED)

3.8 Size of Solar Panel

Load details:

1 no's of 800mW MQ-7 smoke sensor use for 24 hour/day

2 no's of 0.044W LED use for 1 hour/day

1 no's of 1W buzzer use for 1 hour/day

2 no's of 0.25W resistor for 1 hour/day

1 no's of 0.48W Arduino UNO use for 1 hour/day

Total load = (1 x 800mW x 24) + (2 x 0.044W x 24) + (1 x 1W) + (2 x 0.25W) + (1 x 0.48W)

= 23.292W

System specific requirement:

Energy usage (per day) = 23.292Wh

Depth of Discharge (DoD) = 50%

Days of Autonomy (DoA) = 2 day

Battery Bank Temperature Multiplier (BBTM) = 1

Peak Sun Hour (PSH) = 4 hours

Solar panel size:

The output power of solar panel

= Energy usage (per day) ÷ PSH ÷ system efficiency

= 23.292W ÷ 4 ÷ 0.85

= 6.85W

Polycrystalline silicon panel size = 12V, 10W

Therefore, 6.85W ÷ 10W ≈ 1 solar panel

Hence, 1 polycrystalline silicon solar panel is needed for the system to operate.

3.9 Size of Battery Bank

Average daily:

Energy usage (per day) = 23.292W

Battery bank capacity (Wh):

= (Daily average usage x DoA x BBTM) ÷ DoD

= (23.292Wh x 2 days x 1) ÷ 0.5

= 93.168Wh

Battery bank capacity (Ah):

= Battery bank capacity (Wh) ÷ system voltage

= 93.168Wh ÷ 12V

= 7.764Ah, 12V

Sealed lead acid battery size = 7.2Ah, 12V

Therefore, 7.764Ah ÷ 7.2Ah ≈ 1 battery

Hence, this project need 1 battery sealed lead acid battery.

Summary of system sizing:

i) Energy usage: 20.292W, 1 day

ii) Solar panel size: 12V, 10W x 1 solar panel

iii) Battery size: 7.2Ah, 12V

iv) Depth of Discharge: 50%

v) Days of Autonomy: 2 days

3.10 Sustainable Development

Several technologies and procedures will be used to construct a GSM-based solar smoke detector with SMS alert while keeping sustainability in mind. First, prioritize energy efficiency by utilizing low-power components and technology. Sleep modes or power management strategies to reduce power usage during idle periods will be utilized. A solar panel to capture renewable energy, with optimum location and orientation to ensure maximum sunlight intake will be incorporated. In order to optimize battery management, high-efficiency solar panels and a smart charging system will be used. Low-power GSM and energy-saving communication methods will also be used. To decrease errors in detection, smoke detectors that satisfy energy efficiency criteria and optimize detecting algorithms will be chosen. Eco-friendly and recyclable resources for the device's housing and components will be examined, while harmful compounds will be avoided. The equipment with end-of-life concerns in mind, emphasizing recyclability and offering explicit instructions for its disposal will be designed. Users need to be educated on energy efficiency, eco-friendly practice, and the benefits of sustainable technology through user guides and awareness campaigns. By adopting these techniques, a GSM-based solar smoke detector with SMS warning may be designed in accordance with sustainable development principles, reducing energy consumption and environmental effect.

3.11 Cost and Bill of Materials

The total expected to purchase all the hardware components for this project is about RM191.52. Table 2 shows the cost and bill of materials which will be purchased for this project.

Table 3.1 Cost and Bill of Materials for Overall Project

No.	Material	Description	Quantity	Price (RM)
1.	12V, 5W Polycrystalline Solar Panel	1 unit = RM20.00	1	20.00
2.	12V, 6.0Ah Li-Ion battery	1 unit = RM40.00	2	80.00
3.	Arduino UNO	1 unit = RM30.00	1	30.00
4.	LM35 Temperature Sensor	1 unit = RM4.50	1	4.50
5.	SIM900A GSM Module	1 unit = RM30.00	1	30.00
6.	MQ-2 Smoke Sensor	1 unit = RM5.40	1	5.40
7.	Flame Sensor	1 unit = RM1.50	1	1.50
8.	Liquid Crystal Display (LCD) module 16x2	1 unit = RM8.40	1	8.40
9.	Resistor	1 unit = RM0.10	2	0.20
10.	Buzzer	1 unit = RM1.38	1	1.38
11.	Light-Emitting Diode (LED)	1 unit = RM0.12	2	0.24
12.	Jumper Wire Female-to-Male	1 unit = RM3.70	1	3.70
13.	Jumper Wire Male-to-Female	1 unit = RM3.70	1	3.70
14.	Breadboard	1 unit = RM2.50	1	2.50
Total (RM)				**191.52**

3.12 Gantt Chart

Table 3.2 Gantt Chart

No.	Task	PSM1														PSM2													
	Weeks	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Work on the Software/Hardware	■																											
2	Project Title Conformation and Registration		■																										
3	Briefing with Supervisor			■																									
4	Study the Project Background			■																									
5	Drafting Chapter 1: Introduction			■	■																								
6	Task progress evaluation 1						■																						
7	Drafting Chapter 2: Literature Review							■	■																				
8	Table of Summary Literature Review								■																				
9	Drafting Chapter 3: Methodology										■	■																	
10	Work on the Software/Hardware									■	■																		
11	First Draft submission to Supervisor										■																		
12	Task progress evaluation 2											■	■	■															
13	Submission Report to the Panel													■															
14	Presentation of BDP1														■														
15	Drafting Chapter 4: Analyze Data and Result												■																
16	Data Analyze and Result												■	■			■	■											
17	Record the Result																		■	■									
18	Drafting Chapter 5: Conclusion and Recommendation															■					■	■	■			■			
19	Compiling Chapter 4 and Chapter 5																							■	■	■			
20	Submit Latest Report to Supervisor																										■		
21	Finalize the Report																										■	■	
22	Presentation of BDP2																												■

Table 3.2 shows the task or activities which have been planned towards the successful of this project.

3.13 Summary

This chapter outlines the suggested process for starting a new system development project. Each of the proposed improvements from the chapter must be successfully executed if the project is to meet its ultimate goal. Each system component hardware and software is described in detail in this chapter. A flowchart and a block diagram are also used to show how the processing system functions by breaking down each steps in detail. This chapter went into further detail on the hardware and software used for this project as well as the reasoning behind its execution.

RESULTS AND DISCUSSIONS

4.1 Introduction

The troubleshooting procedure and findings, derived from the project's output data, are presented in this chapter. The expected outcome is centered on two aspects: the power generated by the independent photovoltaic system and the sensitivity and efficacy of the detector's sensors. In this chapter, the tabulated project result will be examined and described.

All of the chosen parts and tools have been used to produce the project prototype, which is based on the study conducted in Chapter 2. The components that were used were selected based on the computations completed in Chapter 3. Furthermore, the standalone PV solar system and smart smoke detector hardware have been built using the circuit design simulation from Chapter 3. The project's design, simulation, assembly, and troubleshooting processes all make use of the software and tools listed in Chapter 3. Many tests and modifications are made to the system coding in order to achieve the intended outcome.

4.2 Prototype Development

In this project, a standalone photovoltaic solar system and a smart smoke detector are linked systems.

First, the solar panel serves as the main power source when the system first powers up. The solar panel is linked to a solar charge controller, which plays a vital function in guarding against the 10A battery being overcharged. In addition to protecting the battery, this controller oversees the process of charging it and reintegrates it into the system to produce power. Furthermore, the system effectively uses the USB port on the solar charge controller to turn on the Arduino, demonstrating how solar energy may be used to power the system's essential components.

Then, the second system which is smoke detector system that necessitates a microcontroller for system control. This microcontroller operates an LCD for display purposes and a GSM module 900A. A microcontroller from Arduino has the necessary code uploaded to it. Communication functionalities are enabled by the GSM 900A module, most likely enabling the system to send or receive messages via a GSM network. The LCD is also utilized to show the surrounding situation either there is smoke or fire or safe. The method effectively utilizes the USB port that the solar charge controller provides to power up the microcontroller. The microcontroller is powered by this USB port, which also serves as an activation point. In addition, the solar charge controller's output is designated to power the GSM module 900A, guaranteeing that it gets the necessary power source to function properly.

Precautions are taken to make sure that the connections, particularly the component terminals, are connected adequately to avoid the circuit blowing up and destroying the hardware.

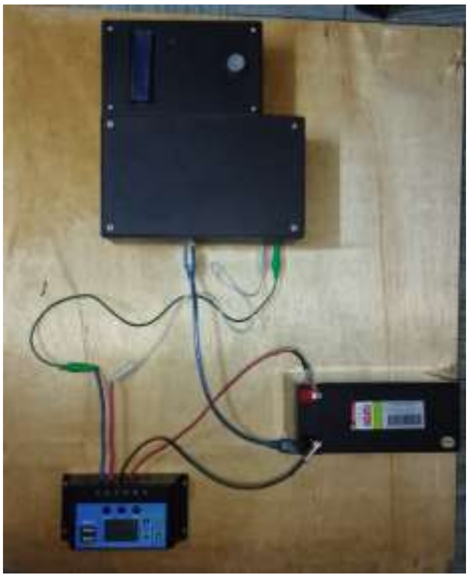

Figure 4. 1 Complete project prototype without solar panel

4.3 Project Testing Result

As part of the data gathering approach, experiments were carried out for two days on 04/01/2024 and 05/01/2024, and for a further two days on 08/01/2024, and 09/01/2024, in order to assess the system's functionality and obtain more precise data. Additionally, the data collection process is carried out for four hours a day, from 11 a.m. to 2 p.m., for every 30 minutes. This process has been carried out to guarantee that the solar panel will get the maximum amount of sunshine and function as intended. A load has also been linked to the output side of the battery bank in order to guarantee its efficiency based on the calculation.

During data collection, the power generated by the solar panel is calculated using the electrical power formula. The link between the solar panel power, voltage and current is indicated in Equation 4.1. In the meanwhile, Equation 4.2 has been used to get data regarding battery charging times.

$$\boldsymbol{P = VI}$$

Where P = Solar panel power (mW)

V = Solar panel voltage (V)

I = Solar panel current (mA)

$$\boldsymbol{T = \frac{C}{R}}$$

Where T = Battery bank charging time (Hours)

C = Battery bank capacity (mAh)

R = Charging current (mA)

4.3.1 PV Solar System Data Day 1

Table 4.1 presents the statistics acquired from the solo PV solar system on 4/1/2024. While there was some sunshine in the afternoon, the weather that day was gloomy in the morning while the data was being collected. In the evening, the clouds begin to gather once more.

Table 4.1 The result of data collection for day 1

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
11.30 am	6.67	0.140	0.835	12	50.00
12.00 pm	6.32	0.125	0.737	12	56.00
12.30 pm	7.78	0.175	1.235	12	40.00
1.00 pm	7.67	0.152	1.126	12	46.05
1.30 pm	7.35	0.135	1.039	12	51.85
2.00 pm	6.25	0.115	0.980	12	60.87

Table 4.1 shows that around 11.30 am, the solar panel's output power is 0.835 W since there is ample sunshine and a clear sky. The solar panel's power output keeps rising until it reaches its maximum power of 1.235W at 12.30 p.m. The power starts to decrease about 1 p.m. as clouds begin to blanket the sky.

4.3.2 PV Solar System Data Day 2

Table 4.2 presents the statistics acquired from the solo PV solar system on 5/1/2024. The day's weather was sunny and bright during the data gathering period.

Table 4.2 The result of data collection for day 2

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
11.30 am	7.16	0.139	0.789	12	50.36
12.00 pm	7.87	0.145	0.895	12	48.28
12.30 pm	7.78	0.186	1.167	12	37.63
1.00 pm	7.67	0.179	1.097	12	39.11
1.30 pm	7.35	0.164	1.039	12	42.68
2.00 pm	7.26	0.161	0.980	12	43.48

Table 4.2 shows that around 11.30 a.m., the solar panel's output power is 0.789 W since there is ample sunshine and a clear sky. At 12.30 p.m., the solar panel's power output increased to 1.167W. At 1 p.m., 1.097 W of power begins to decrease as a result of clouds obscuring the sky.

4.3.3 PV Solar System Data Day 3

Table 4.3 presents the statistics acquired from the solo PV solar system on 8/1/2024. Cloudy conditions prevailed throughout the whole day of data gathering that day.

Table 4.3 The result of data collection for day 3

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
11.30 am	6.17	0.154	0.652	12	45.45
12.00 pm	7.68	0.186	1.135	12	37.63
12.30 pm	7.41	0.171	0.982	12	40.94
1.00 pm	7.79	0.189	1.134	12	37.04
1.30 pm	7.97	0.199	1.159	12	35.18
2.00 pm	7.13	0.163	0.837	12	42.94

Table 4.3 shows that around 11.30 a.m., the solar panel's output power is 0.652 W since the sky is covered in clouds. The solar panel produces the most power at 1.30 p.m., generating 1.159 W. The power was down about 2:00 p.m. because of the overcast sky.

4.3.4 PV Solar System Data Day 4

Table 4.4 presents the statistics acquired from the solo PV solar system on 9/1/2024. Clouds dominated the sky throughout the entire day of the data collection period that day.

Table 4.4 The result of data collection for day 4

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
11.30 am	6.53	0.155	0.783	12	45.16
12.00 pm	7.08	0.159	0.874	12	44.03
12.30 pm	7.56	0.196	1.179	12	35.71
1.00 pm	7.34	0.174	1.148	12	40.23
1.30 pm	7.29	0.170	1.134	12	41.18
2.00 pm	7.26	0.165	0.989	12	42.42

Table 4.4 shows that around 11.30 a.m., the solar panel's output power is 0.783W since clouds are obscuring the sky. The electricity generated by solar panel at 12.30 p.m is the highest with the value of 1.179W. Because of the overcast weather, the power continued to decrease about 1 p.m.

4.4 Standalone PV Solar System Average Data Analysis

Table 4.5 Average Data Analysis For 5 Days

Day	Average				
	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
1	7.01	0.140	0.992	12	50.80
2	7.52	0.162	0.995	12	43.59
3	7.36	0.177	0.983	12	39.86
4	7.18	0.170	1.018	12	41.46

The average solar panel power and average solar panel current are plotted on a graph, as shown in Figure 4.3. The graph presented in Figure 4.5 indicates that there will be a positive correlation between average solar panel power and average solar panel current.

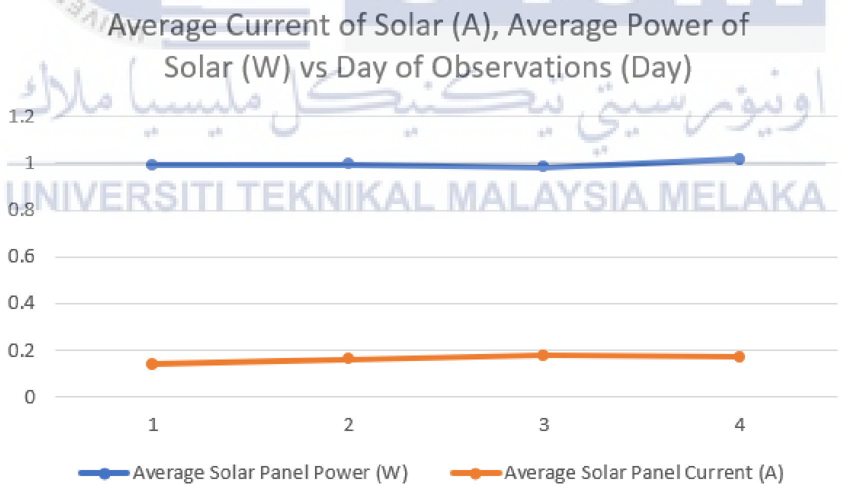

Figure 4. 2 Graph of the relationship between average solar panel power and average solar panel current

The solar panel's exposure to sunlight was not optimal during the early-year prototype testing, which took place during Malaysia's rainy season. Because the weather was primarily overcast and rainy, the 4-day average solar radiation intensity was low. The daily data that was gathered dramatically changed as a result of this.

Its low output current was also influenced by the solar panel's suggested size for this particular project. On a bright, sunny day, a peak sun hour of 4 hours was assumed in the calculations for the size of the solar panel. But the weather was constantly overcast during the actual testing week, which reduced the output of the solar panel. The suggested 10W, 12V PV solar panel has a maximum current output of 550mA on a sunny day. Regrettably, the panel's full output was not achieved during testing due to the cloudy weather, resulting in a minimal current. The incompatibility of the panel's requirements resulted in a reduced capacity to convert solar radiation into electrical energy. 0.1623A of average output current and a maximum of 997 mW of average output power were recorded during the testing.

Adding on, the charge controller is an essential part of charging Sealed Lead Acid (SLA) batteries because it controls the charging current and guards against overcharging and over-discharging. The battery bank, however, required more than 24 hours to fully charge, according to the experimental results in Table 4.6. The low output current from the solar panel led the charge controller module to work erroneously.

The average charging time exhibits a negative correlation with a rise in average solar panel output current, as demonstrated in Figure 4.6, which depicts the link between the two variables. This indicates that a faster battery bank full charge is the outcome of a higher solar panel output current.

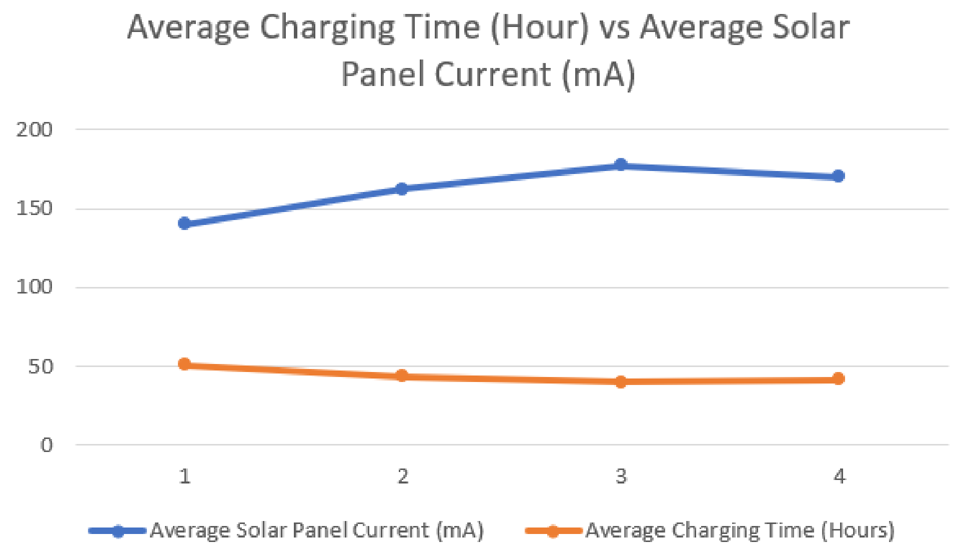

Figure 4. 3 Graph of the relationship between average charging time and averager solar panel current

4.5 Battery Bank Performance

The data for electricity generated by solar panels and battery charging time is recorded based on data obtained over the course of 4 days, with 2 to 3 hours of power every day. The average power produced by the solar panel, when exposed to sunshine for 2 to 3 hours each day for 4 days, is 0.997W, and the average charging time for the battery bank is 43.93 hours. The battery bank will be charged with a load during the day when the system is operational for approximately 24 hours per day. When the battery bank is fully charged throughout the day, the system will function at maximum capacity at night, contingent upon the battery bank.

In order to ensure that the battery bank can provide the load with the maximum amount of power, the battery's endurance has also been examined and assessed. The longest period of time a battery bank can support a load without assistance is known as its battery endurance. The battery bank endurance is calculated using the formula (4.3) below.

$$Battery\ bank\ endurance = \frac{Vdc\ x\ Ah}{Load}$$

As a result, the battery endurance can be determined by inputting the specifications of the battery bank employed for this project.

$$Battery\ bank\ endurance = \frac{12\ x\ 7}{1}$$

$$Battery\ bank\ endurance = 84\ hours$$

According to the calculation, the system may operate entirely on the battery bank for up to 84 hours without needing to be charged. But each battery bank only performs at about 90% of its declared capacity, hence the actual working hours should be

$$Battery\ bank\ endurance = \frac{12\ x\ 7}{1} x\ 90\%$$

$$Battery\ bank\ endurance = 75.6\ hours$$

4.6 Smoke Detector Performance Analysis

The smoke detector is an improvised fire safety system that uses solar power as its primary energy source to detecting possible fire. This device consists of 6 essential elements such as Arduino Uno, MQ-7 gas sensor, flame sensor, I2C LCD, buzzer, and LED . The sensors, strategically located at an elevated location, interfaces with the Arduino Uno to detect any possible fire.

When the system first starts up, it makes sure that only the green LED, which denotes a normal or safe status, is turned on. False alarms and unnecessary alerts are prevented by implementing this preventive measure. The gas sensor's starting setting is 250 ppm, and the flame sensor will identify any potential fires. The LCD will display, as seen in Figure 4.4, the value of the particle found in the air as well as any possible fire.

Figure 4. 4 Green LED turn on in normal condition

As seen in Figures 4.5 and 4.6, the green LED will remain on whenever the gas sensor value exceeds the predetermined value but the flame sensor does not detect a fire. The LCD will then display “SMOKE DETECTED,” along with a warning sent to the first user via SMS.

Figure 4. 5 LCD display “SMOKE DETECTED”

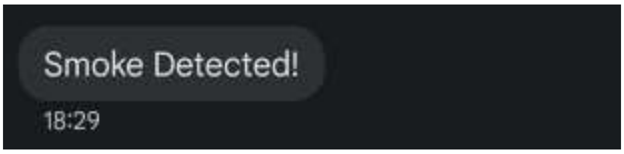

Figure 4. 6 Notifications from SMS

When the flame sensor detects a possible fire or the gas sensor value above the predetermined threshold, the red LED will light up, the LCD will say "FIRE!! EVACUATE IMMEDIATELY!!," and both users will receive an SMS alert. Figures 4.7 and 4.8 illustrate this procedure. This gives an accurate visual depiction of the smoke particle in the air that is being detected.

Figure 4. 7 LCD display and red LED light ON

Figure 4. 8 Notification from SMS

Furthermore, the sensors have been positioned at a significant angle to identify any possible fire or smoke. The time response of the gas sensor in detecting smoke take only in

1 second and this is repeated time to observe the device responses to the environment. Three attempts at detecting any smoke present have been made with the sensor in order to assess the device's response time in that regard. The sensor responds to the smoke particle in one second on each of the three trials. Testing has been done on the flame sensor to guarantee that it will work well.

4.7 Summary

To sum up, this chapter describes the experimental data collection and analysis that was done for this project in order to assess system performance. Using the recommended standalone PV solar system on a bright, sunny day will allow the panels to produce their maximum output power and charge the battery more quickly. According to the experiment, testing on a cloudy day is not effective with the recommended system sizing. The sun doesn't shine for long enough during the rainy season to fully charge the battery bank needed to power the load. The main goal of this study is to ascertain whether the sensor, charge controller, battery, and solar panel are suitable for usage with smart smoke detectors. The recommended specs for the battery bank, charge controller, and PV solar panel are generally insufficient to power the smart smoke detector as anticipated, which suggests that the standalone PV solar system is under designed. Nonetheless, the smart smoke detector has proven useful in spotting any potential smoke or fire. The recommended specs for the battery bank, charge controller, and PV solar panel are generally insufficient to power the smart smoke detector as anticipated, which suggests that the standalone PV solar system is under designed. Nonetheless, the smart smoke detector has proven useful in spotting any potential smoke or fire.

CONCLUSION

5.1 Conclusion

This chapter summarizes the development of smoke detector device, utilizing a self-sufficient solar-powered Photovoltaic (PV) system. The project aims to assess the viability of standalone PV solar elements in independently powering the smoke detector device. The system comprises two integral components: the PV solar system, which converts solar energy into electricity to power the flood monitoring device and charge the battery bank during sunlight, and the smoke detector device, equipped with two sensors which are flame sensor and smoke sensor for early smoke and fire detection. This intelligent system ensures continuous functionality by seamlessly transitioning to stored battery power when sunlight is unavailable. Ultimately, this project represents a significant stride in enhancing user safety through sustainable and monitoring the surrounding conditions with the level of smoke and existence of fire, providing timely warnings in hazardous conditions, and contributing to community resilience.

Finally, a system that is independently powered by solar energy and a battery bank is the GSM-based Photoelectric smoke detector. The GSM-based smoke detector and the PV solar system are the two components that make up this system. When there is enough sunlight, the PV solar system produces electricity from the sun's energy to run the smoke detectors and recharge the battery bank. Smoke detectors use stored energy from the battery bank to function when sunlight is not available. Essentially an update to the traditional smoke detector system, the smoke detector system. The temperature and smoke values are considered when the system is operating, and both values are considered. As a result, this project will help alert everyone when the fire is about to spread.

5.2 Project Objectives

The project's four primary goals are reviewed and explained in brief below.

5.2.1 To analyze the existing smoke detector device

A thorough review of pertinent papers, journals, and other research works was done in order to examine a number of pre-existing smoke detector devices in the second chapter. With a focus on comprehending their designs and functions, this study reviewed the functionality and procedures used in various project systems. In order to determine which parts would work best for developing a smoke detector that is powered by a freestanding photovoltaic system, the literature review made it easier to compare various components.

5.2.2 To design a smoke detector circuit using an MQ-7 smoke sensor and an Arduino board

The creation of a smoke detector and a stand-alone PV solar generator was necessary to successfully complete the second objective. Both systems were built with great care to ensure maximum performance. A thorough assessment of the requirements provided in Chapter 2 served as the basis for choosing the parts for the smoke detector and PV solar generator. The battery, charge controller, and solar panel sizes were determined in Chapter 3 while taking the system's power consumption into account. The successful creation of the prototype was made possible in large part by the project's strategic design. The suggested concept was successfully followed in the creation of the intelligent smoke detector system and freestanding PV solar system.

5.2.3 To develop the smoke detector circuit to a GSM module for SMS alert functionality

Chapter 4 shows how the attempts to update the smoke detector circuit have been effective in incorporating a GSM module for SMS alert capability. This achievement constitutes a noteworthy advancement in safety protocols, since it not only enables the system to identify smoke but also creates a reliable channel of communication for prompt action via SMS warnings. By adding a real-time communication layer to the traditional smoke detector setup, this integration offers a more sophisticated and preventive method of fire safety. Through the integration of the GSM module and smoke detector circuit, we have developed a system that not only detects possible threats but also guarantees the quick and efficient distribution of vital information. The previous advancement highlights the project's dedication to employing modern technology for pragmatic purposes, giving precedence to the identification and prompt notification of safety issues, thus augmenting security in residential and commercial settings.

5.2.4 To evaluate the smoke detector circuit and SMS alert functionality

The system's hardware choices need to cooperate in order for the project to produce a standalone system. A comparative examination of several components was done in Chapter 2 to ascertain which equipment is most appropriate for the project. The perfect measurements for batteries, charge controllers, and solar panels have been determined through investigation and calculation. The battery bank and solar panel must have sufficient energy storage capacity in order for the system to operate when the sun isn't shining. The solar panel must produce enough energy to meet the needs of the smoke detecting gadget. A proper solar charge controller is necessary to charge a battery bank without overcharging or overdischarging.

Additionally, an appropriate smoke-detection sensor has been chosen for this system. The examination of the experimental data gathered to determine if the components selected to build the standalone PV solar system and smoke detector system were appropriate is covered in detail in Chapter 4. The size of the suggested solar panel, charge controller, and battery bank is insufficient to generate the required output, leading to the conclusion that the standalone PV solar system is under-designed.

5.3 Project Limitation

Numerous restrictions and difficulties that were experienced during the project's prototype development and testing data collection had an impact on the experimental output data. The average intensity of solar radiation was relatively low, and the peak sun hours were shorter, because the project testing took place at the end of the year during Malaysia's rainy season. The recommended sizing of the PV solar system was initially intended for execution on a sunny day, as per the sizing calculation specifying a peak sun hour of 4 hours. Because of this, installing the suggested PV solar system on a cloudy day is not feasible because solar energy is not converted as effectively to electricity by the solar panels. A number of charge controller modules are required to speed up the battery bank charging process when sealed lead-acid batteries are used as battery banks, adding to the complexity of the charging system.

5.4 Recommendations

Investigating component compatibility between the flood monitoring device and standalone PV solar system is the aim of this study. To guarantee that the smoke detector device can be effectively powered by the standalone PV solar system on both bright and overcast days, the most critical component is the size of the solar panel, charge controller, and battery bank.

A few elements, including the performance of the solar panel, the charge controller, and the endurance of the battery bank, have been investigated. There are thus several ways in which this project can be enhanced. These are the recommendations that were made which are expand the size of the PV solar panel to generate more electricity from solar radiation, even on overcast days, by automatically aligning the panels with the movement of the sun to maximize sunlight exposure and improve electrical conversion, a solar panel tracker can increase energy output, and make the charging circuit simpler and charge the battery more quickly by utilizing an intelligent charge controller.

5.5 Project Potential

Creating a solar-powered smoke detector has a lot of potential advantages that go hand in hand with better safety protocols and environmental sustainability. First off, using solar energy makes a solution less dependent on conventional energy sources, which makes it more environmentally and energy-efficiently designed. This not only reduces the device's carbon footprint but also encourages environmentally friendly safety technology practices.

The solar-powered smoke detector can improve installation locations' adaptability and flexibility. The gadget can operate independently of conventional power sources by utilizing solar energy, which makes it appropriate for off-grid or isolated locations where connecting to electrical networks may be difficult. As a result, smoke detection equipment can now be used in a wider variety of settings, such as outdoor areas, recreational places, and transient installations.

Furthermore, since solar power requires less continuous operating costs after the original investment is made, it is clearly cost-effective in the long run. Over the course of their useful lives, solar-powered smoke detectors can operate effectively in areas with plenty of sunshine and little to no ongoing energy expenditures. This makes them a financially viable option.

The incorporation of solar technology is consistent with the current trend of building sustainable and intelligent homes. A dedication to responsible living is demonstrated by the use of solar-powered smoke detectors in the construction of eco-friendly, energy-efficient homes. This is in line with larger campaigns that support the incorporation of renewable energy sources into commonplace electronics.

In conclusion, the potential of a solar-powered smoke detector resides in its ability to integrate cutting-edge safety features with eco-friendly technology, providing a flexible, affordable, and long-lasting option for improved fire detection and prevention.

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