Real-Time Fire Detection and Monitoring System Using IoT Case Study on: Chemical Industry Corporation Awash Melkassa Chemical Factory (CICAMCF)

Negash Abera Dadi

A Thesis Submitted to

The Department of Electrical Power and Control Engineering

School of Electrical Engineering and Computing

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Electrical Power and Control Engineering (control Engineering)

Office of Graduate Studies

Adama Science and Technology University

August 2022

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DECLARATION

I hereby declare that this Master Thesis entitled "Real-Time Fire Detection and Monitoring System Using IoT in Chemical Factory (Case Study on Awash Melkassa Chemical Factory)" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

Negash Abera	________________	________________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that, I have read the revised version of the thesis entitled "Real-Time Fire Detection and Monitoring System Using IoT in Chemical Factory (Case Study on Awash Melkassa Chemical Factory)". Prepared under my guidance by Negash Abera submitted in partial fulfillment of the requirements for the degree of Masters of Science in Electrical and Computer Engineering (Specialization in Control Engineering).Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

________________	________________	________________
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APPROVAL SHEET

I, the advisors of the thesis entitled “Real-Time Fire Detection and Monitoring System Using IoT in Chemical Factory (Case Study on Awash Melkassa Chemical Factory)” and developed by Negash Abera, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

________________	________________	________________
Major Advisor	Signature	Date

We, the undersigned, members of the Board of the Examiners of the final open defense by Negash Abera have read and evaluated his thesis entitled “Real-Time Fire Detection and Monitoring System Using IoT in Chemical Factory (Case Study on Awash Melkassa Chemical Factory)” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Electrical and Computer Engineering (Specialization in Control Engineering).

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TABLE OF CONTENTS

LIST OF TABLES

TABLES **PAGES**

LIST OF FIGURES

FIGURES **PAGES**

LIST OF ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ADC	Analogue to Digital Conversion
AMCF	Awash Melkassa Chemical Factory
AWG	American Wire Gage
CB	Circuit breaker
CICAMCF	Chemical Industry Corporation Awash Melkassa Chemical Factory
DC	Direct Current
DCS	Distributed Control System
EOLR	End of Line Resistor
FACP	Fire Alarm Control Panel
GND	Ground
IC	Integrated Circuit
ICS	Industrial Control Systems
IOT	Internet of Things
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro Controller Unit
NI	National Instrument
PC	Personal Computer
PCB	Printed Circuit Board
PIC	Programmable Interface Controller
PPM	Parts Per Million
RL	Relay
SCADA	Supervisory Control and Data Acquisition
SLC	Signaling Line Circuit
SMS	Short Message Service
VI	Virtual Instrument

ABSTRACT

The paper describes real-time fire alarm detection and monitoring system using Internet of Things (IoT). The Awash Melkassa Chemical Factory (AMCF) is used as a case study to show that the proposed technique the effectiveness of the proposed technique. The plant had a conventional (analog) fire alarm system that had been out of service for almost 15 years. The system was out of operation due to a lack of replacement components and technological obsolescence. The essential data is acquired from the factory through direct involvement, and the outcome indicates that false alarms will occur frequently as a result of the system being disconnected. In this work, we suggest a quick detection and reaction from buildings (ground floor,1st floor & 2nd floor), a gas station, and a Sulphur melting area in the event of a smoke/fire without manual call for help in real time monitoring and analysis of the environment using Internet of Things (IoT). Three fire scenarios, three temperature scenarios, and two manual call point scenarios are included in the real simulation test at AMCF's buildings (ground floor, 1st floor & 2nd floor), gas station, and Sulphur melting area. Various results were recorded during the studies, including smoke detector, temperature sensor, and MCP. In our system, monitoring and event detection are performed automatically in the event of an abnormal scenario, based on real-time data capture. As part of the response, the system turns off the main power system and activity output devices, and LabVIEW software sends insurance and fire department notifications. For further study, all data, including time and date, can be exported as an excel sheet. A Signaling Line Circuit (SLC) is used in addressable fire alarm systems to connect with sensors and complete the system. When compared to traditional systems, these systems offer more versatility and functions. Furthermore, if a problem with the addressable fire alarm system arises, the information from the panel will assist the operator in determining the source of the problem. As a result, addressable fire alarm systems are the most crucial issue in the industrial sector, particularly for fire and insurance companies. The performance analysis of the study is based on the design and modeling of the system. using Micro C Pro, Proutse, and Lab VIEW software.

KEY WORDS: *- Real Time fire, detection, Monitoring, Internet of Things, SCADA, Fire detectors, PIC16F84550 microcontroller, MCP, Lab VIEW, fire alarm system.*

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

At present, the recent technologies developed strongly and the industries are increasing to achieve maximum production fire-safety has been a major worry because fire threats can be fatal and dangerous for companies, as well as a requirement for human life to identify and report fires quickly. The Real-time fire alarm monitoring and protection system are considered one of the basic infrastructure for the growth of chemical industries (Bransby & Jenkinson, 1998). For efficient operation of chemical industries and to meet the final chemical products, this real-time early detection of fire alarm systems has an efficient and effective manner by avoiding fire accidents by monitoring the status of fire alarm system using Internet of Things (IoT) technology. Real-time fire alarm detection and monitoring system using SCADA is designed specifically for chemical companies to monitor the properties and human life in said a company and detect pre-fire alarms. The suggested benefits of IoT include increased application quality and ease of use, cost reduction, enhance functionality, automation, and increase access to resources as well as optimize real-time operations in daily life (Cheminod et al., 2013). In industrial applications, the Internet of Things (IoT) can help with process optimization and factory management (Bloom et al., 2018). Despite the many advantages of IoT devices, they are nevertheless subject to existing Internet-enabled attacks and privacy issues. Because of the reduced processing capability on devices, IoT adds a new layer of vulnerability that is potentially more difficult to harden against attacks(Xi & Ling, 2017). Moreover, bringing IoT technology to the industrial environment could increase security concerns because, in the industrial setting, security is often related to safety. For example, a breach in security in a factory could damage the machines and cause injury to the human operators (Bloom et al., 2018). IoT is a natural extension of Supervisory Control and Data Acquisition (SCADA) systems in the industrial sector (Hunzinger, 2017).SCADA offers real-time data on industrial activities to management and monitoring, enables more efficient control, increases plant and employee safety, and lowers operating costs. The use of standard hardware and software in SCADA systems, as well as enhanced communication protocols and increased access to outside networks, such as the internet, enable these benefits(Yu et al., 2005). It is also a software package installed on networked computing platforms, like personal computers (PCs) or Desktop, which are helpful graphical control for industries. In this work, all data is delivered to a PC and shown on a SCADA designed user interface. The data is also saved as an Excel file on a computer. This allows users and operators to keep a real-time eye on the status of the fire alarm system. Modern industry relies on the supervisory control and data acquisition (SCADA) system. Most popular SCADA systems applications founded in water treatments, chemical plants, and power networks. SCADA (Supervisory Control and Data Acquisition) systems were popular in the 1960s as a way to more efficiently monitor and control the status of remote equipment.

1.1.1 Description of the Study area

Awash Melkassa Chemical Factory (AMCF), which is, located at Misrak Shewa Zone, Oromiya Region Awash Melkassa town about 17kms from Adama town towards the south east, on the route to Assela, which sits at an altitude of 1600 meters above sea level, 100 kilometers from the capital city. AMCF is a newly developed basic chemical industry in the country. AMCF is Ethiopia's only chemical company, producing sulfuric acid, aluminum sulfate, and oleum (currently blocked), and Hydrogen peroxide. Awash Melkassa Chemical Factory (AMCF) is the biggest chemical factory in a country as well as in east Africa so all the demands of our country are fulfilled by the products of this factory the country also exports the product to neighboring countries to some extent. It was built at the end of the Dergue Regime in July 1984 E.C by Poland government in aid form to part of the strong military purpose for the production of bombs and gun bullets and on a total area of 14 hectares; an initial investment of roughly 108 million Birr was made. Figure 1.1. Up to Figure 1.6 shows the proposed study area of AMCF's.

FIGURE 1. 1. Overhead picture of a smoke detector on the ground floor

FIGURE 1.2. Overhead picture of a smoke detector on the First Floor

FIGURE 1.3. Overhead picture of a smoke detector on the Second Floor

FIGURE 1.4. Overhead picture of a smoke detector on the Third Floor

FIGURE 1.5. A gas station Point of view: Manuel Call point

FIGURE 1.6. Area of Sulphur Melting Point of view: Manuel Call point

1.2 Statement of the Problem

The existing analog conventional type fire alarm controlling system of Awash Melkassa Chemical Factory (AMCF) was not functional and the system is phased out from the market this makes me motivated and brings a solution based on SCADA System. During fire accident time Operator, call their colleague orally to extinguish the fire. Therefore, the need for having a SCADA-based fire alarm system is for identifying the fire zone/location problem easily for giving feedback within a real-time detection and taking action before the damage.

This study, therefore, seeks to design and simulate a real-time fire alarm detection and monitoring system based on Lab VIEW software that will continuously monitor the existence of a large amount of smoke and sound an alert if a considerable volume of smoke is detected, automatic extinguishing fire, and open the main circuit breaker in case of fire. Therefore, the need of having SCADA systems used to collect updated data, and remotely controls the system's status-using internet. Because IoT features such as processing, storage, interfaces, sensing, actuating, and software usage & administration complement SCADA and hence Internet-connected control systems, they are complementary to SCADA.

When we specifically see the fires that occur in Awash Melkassa Chemical Factory (AMCF), it may be due to the melting of sulfur, overloading, and friction. These, incidental fires of chemical factories have a wider impact on environmental pollution not only for this but also on the country and its economy. In truth, there is a mechanism in place in chemical plants to check fire alarms, but there is no system in place to notify the appropriate authorities if something goes wrong. This means that the technician or operator must visually evaluate each working area using a visual inspection manual. This takes time, and if no one checks within the allotted period, the devices may be destroyed. For example, a fire may surpass the allowed smoke value, resulting in the factory being burned. Therefore, the goal of this study is to come up with a cost-effective, modern, and intelligent solution to announce incidental fire before damaging the properties and human beings' life.

1.3 Objectives of the Study

1.3.1 General Objective

The study's overall goal is to design and simulate real-time fire alarm detection and monitoring system using Internet of Things for Awash Melkassa Chemical Factory (AMCF).

1.3.2 Specific Objectives

The following specific objectives have been developed to achieve the above-mentioned general objective:-

- To indicate areas/locations at risk of fire and design a preferable method to detect incidental fire smoke.
- To pass fire information to appropriate departments e.g. fire brigade and insurance Companies.
- To monitoring real time event alarming for smoke sensor and temperature sensor
- To automatically turn off the main power circuit breaker and extinguished fire automatically.
- To display a computerized based fire alarm system for sulfuric acid factory using Lab VIEW software and monitor the status of a fire alarm system using an IoT device such as a personal computer, laptop, or mobile phone, you can access the Favorite platform.
- To record real-time events for smoke & Temperature sensors once the fire catastrophe has occurred, for future investigation

1.4 Significance of the Study

Chemical industries are expanding at a rapid pace; a real-time early detection fire alarm system is very useful. The SCADA based fire alarm detection system avoids a delayed fire accident that damages the properties of factories as well enables quick control actions to be taken. Therefore, the developed programming can display the status of the fire alarm system and fast in taking action. Fire detection and alarm systems are critical for avoiding serious fire-related accidents. Any property, home, company, warehouse, or mall may suffer significant loss or destruction as a result of a fire. It also causes serious harm to people's lives. As a result, fire detection systems are extremely significant in today's society. As a result, to send update information automatically to the control room and to notify for immediate action and for continuously supervise the detector connecting line. The study should concentrate on some of the strategies to improve the chemical company's competitiveness. Furthermore, the study will act as a springboard for other academics to pursue significant and intensive research in this sector. The PIC18F4550 microcontroller has been used together with smoke sensors and manual call points/break the glass to measure and activate the fire alarm system. Automatic fire alarm systems have been established by managing this quantity with the PIC18F4550 microcontroller.

1.5 Methodology

1.5.1 Block diagram of the system development process

The system consists of hardware and software. The hardware part includes a PIC18F4550 microcontroller, PCB, sensors, Relay, DC motor pump, and power supply. The software components are Mikro C PRO for programming PIC18F4550 microcontroller to interface with hardware proteus 7.7 professional and Lab VIEW software for graphical display. The author must complete a number of procedural duties in order to reach the study's principal goal. Furthermore, the following formal approaches will be followed and, if necessary, changed during the course of the project.

- **Literature Review:** The work of the paper must inevitably be dependent on previous work done by others researchers related to this selected topic. So, to look into the works of this researcher and get necessary and important information related to the topic; different kinds of literature will be referred from different available sources such as books, papers, journals, and articles, etc. Therefore, the literature review includes reading books, articles, papers, journals, simulation tools, and searching the internet related to IoT SCADA based real-time fire alarm and detection systems.
- **Data Collection:** Because the outcome of this study is influenced on the data that is collected, various data will be the data is collected from the Chemical Industry Corporation Awash Melkassa Chemical Factory (CICAMCF) and verified. This is followed by studying the major problems. In addition, methods of avoiding this problem based on the system have been revised and then control and parameter setting undertaking.
- Based on the parameter system design using software taking place.
- The system will then be simulated using Lab VIEW software. After that, the entire work will be completed.

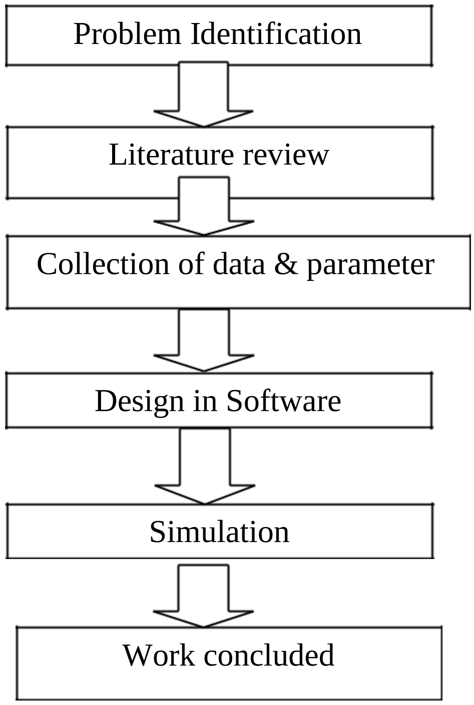


FIGURE 1.7. System development methodology block diagram

1.5.2 Hardware requirement list

The development tools used for this paper are a PIC18F4550 microcontroller, smoke sensors, manual call points, LCD, Battery source, LED, Relay, and a driver circuit.

1.5.3 Software requirement list

- Simulator used: Proteus 7.7 professional software
- Languages used: Mikro C PRO, Lab VIEW and
- Windows XP, Windows 7, Windows 8, and Windows 10 are the operating systems available.

1.5.4 Description of Lab VIEW

Lab VIEW stands for Laboratory Virtual Instrument Engineering Workbench, which was created by NI Company founders Doctor James Truchard and Jeff Kodosky, as well as a buddy named Jack McRiessen. It was first used on the original Macintosh computer in May 1986, even before Microsoft released their graphic operating system Windows. The NI Company's Lab VIEW application has three key functional parts: virtual instrument operation and graphic presentation; design and edit of background programs; and selection and connection of subprograms (Margush, 2012).

1.6 Scope and Limitations of the Study

1.6.1 Scope of the Study

The Scope of this paper is to create continuous real-time fire alarm detection and monitoring system from a different location to the central mentoring station for Awash Melkassa Chemical Factory (AMCF) based on IoT. The performance analysis in this work has been carried out based on the design and simulation of the proposed work using Lab VIEW software. All the smoke sensors and Manuel call points were installed at the field to collect data from the buildings (ground floor, 1st floor & 2nd floor), a gas station, and a Sulphur melting area and pass the data to the PIC18F4550 microcontroller. Between the two devices, a serial port is utilized for communication SCADA graphical computer and PIC18F4550 microcontroller. Finally, the software design is given top importance in order to construct an appropriate algorithm that would interface quickly with the PIC18F4550 microcontroller and SCADA graphical computer.

1.6.2 Limitations of the Study

- When there is no internet, the system does not display the status on the remotely.
- Only working on the same network.

1.7 Outline of the Study

The paper is divided into six chapters, each of which is explored briefly below.

The introduction (background), explanation of the topic, general and specific objectives, and significance of the study are all described in Chapter 1, as well as the methodology, scope, and limitations, and outline. The theoretical basis and literature of the study areas are covered in Chapter 2. Chapter 3 shows the overall block diagram for fire system, the software design flow chart of the study, the working principle of a block diagram of the study have been also explained. We'll talk about the description of the object hardware and software. Chapter 4 briefly discussed result analysis and discussion of the work. Finally, a conclusion and recommendation have been made in Chapter 5. Appendices and references are also included in this chapter.

CHAPTER TWO

2 THEORETICAL BACKGROUND AND REVIEW OF LITERATURE

2.1 Theoretical Background

Sulphuric acid is one of the most commercially important of all chemicals. Sulphuric acid is a highly strong acid made industrially by reacting water with sulphur trioxide, which is made by combining sulphur dioxide and oxygen in a chemical reaction using either the contact or chamber technique. The acid is employed in the production of fertilizers, pigments, dyes, medicines, explosives, detergents, and inorganic salts and acids, as well as in petroleum refining and metallurgical processes, at varying concentrations (93-98 percent). Sulphuric acid is used as the electrolyte in lead–acid storage batteries, which is one of its most well-known applications. Sulphuric acid is made using clean, dry sulphur dioxide (SO_2) gas as a starting material. This can be created by burning molten sulphur, metallurgical off-gases, or decomposing wasted sulphuric acid.

2.2 MQ2 Sensor

MQ2 is a general-purpose smoke/gas sensor, which can detect a wide range of gases and smoke, including LPG, Butane, Methane (CH_4), smoke, and Hydrogen. Sensor MQ2 is also sensitive to smoke in addition to these. A tiny heater and an electro-chemical sensor are used inside the MQ 2 series of smoke/gas sensors. They are sensitive to a variety of gases and are utilized at room temperature inside (Debnath et al., 2020). The output is an analog signal that may be read using the Microcontroller's PORT A analog input. Most sensors can be used with both AC and DC voltages because there are no electronic components inside. Connecting both 'A' and 'B' pins together is the preferred wiring method. It is safer, and it is assumed that the output results are more dependable. Despite the fact that many schematics and datasheets state contrary, it is recommended to both 'B' pins. Smoke is detected when the resistance of the sensing material is varying in the presence of smoke. The concentration of smoke sensed is determined using a voltage divider rule.

FIGURE 2.1. Smoke Sensor

Figure.2.2 (Configuration A or B) shows the structure and configuration of the MQ-2 gas sensor, which is made up of a crust made of plastic and stainless steel net and a micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode, and heater. The heater creates the ideal working environment for sensitive components. The wrapped MQ-2 has six pins, four of which are used to fetch signals and two of which provide heating current.

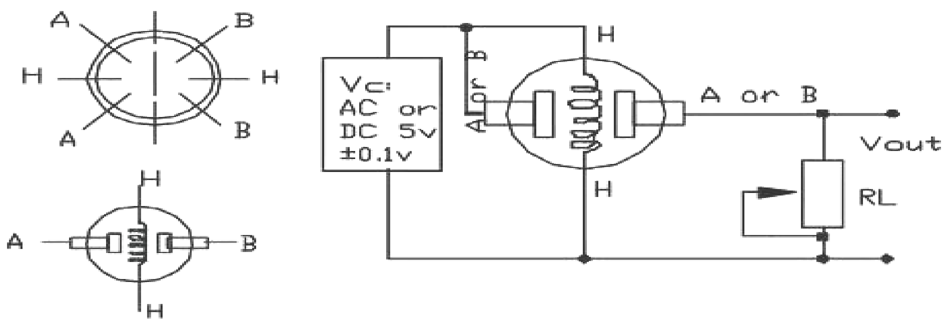


FIGURE 2.2. Structure and configuration, basic measuring circuit

Table 2.1. MQ2 Gas sensor specifications

Quantity	Value & Unit
Operating voltage	$\leq$ 24V DC
Heating Voltage	5V$\pm$0.2V AC/DC
Load resistance	Adjustable
Heater resistance	33Ω ± 5%
Heating consumption	$\leq$ 900mW
Sensing Resistance	2 KΩ – 20 KΩ
Concentration Scope	200 – 10000ppm
Preheat Time	More than 24 hour

In Figure 2.2, the heater is attached to both 'A' pins and is for +5V. Only if the heater requires a constant +5V voltage is this conceivable. The load-resistor is the variable resistor shown in the diagram, and it can be used to establish a good value. In most applications, the load resistor is adjustable resistor. The MQ2 sensor has both analog and digital output. (Digital for combustion gas and analog for gas concentration). The analog output is oriented toward the smoke/gas concentration. This is connected to the PORT A of the microcontroller. MQ2 varying concentration levels (200 to 10000ppm). The sensitivity of sensor can be calibrated with the help of blue nob as shown in figure 2.3 and figure 2.4 is the picture of the pin out of the MQ2 sensor.

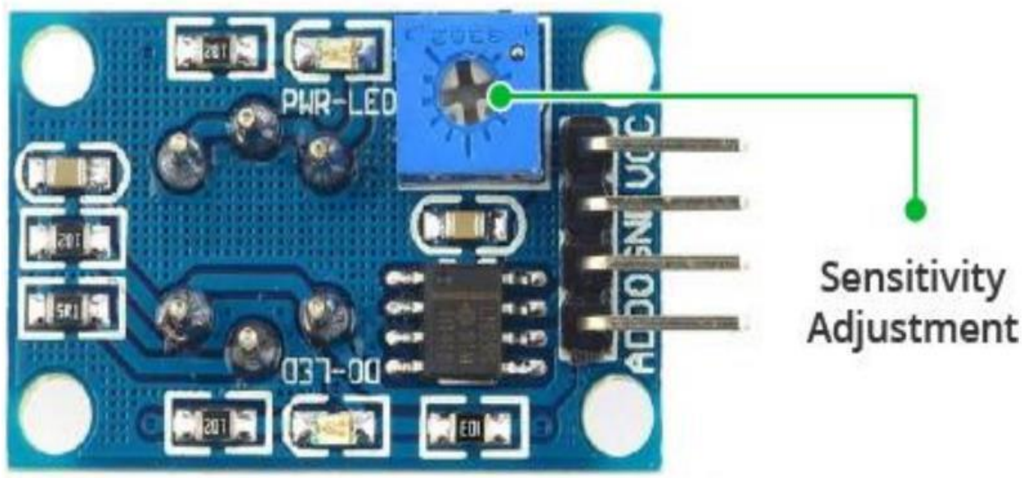


FIGURE 2.3. MQ2 sensors sensitivity adjustment

VCC 5 V.

GND Ground Pin.

D0 Digital data of detected Combustible gases.

A0 Analog voltage proportional detected gas concentration.

FIGURE 2.4. MQ2 sensors pin out circuit

2.3 Temperature Sensor

The temperature sensor used for this paper is LM35. As it gives the simplicity of connection and required a range of temperature measurement. The problems like oxidation do not occur due to proper packaging. Compared with thermistor, LM35 is giving more accurate and linear in measuring temperature. The operating temperature range is from -55^{O}C to 150^{O}C. It also has the property of low self-heating and do not cause a change of more than 0.1^{O}C temperature rise in still air (Chen et al., 2019).

2.4 Review of other works

Several works have been done for fire alarm automation system design using Microcontroller technology in many countries. SCADA system is implemented in power, railway, fire alarm, and water supply. However, to cover all the research that was worked by different researchers is very difficult. Therefore, we compiled the most important research by categorizing them into two such as Lab VIEW-based IoT SCADA system for fire alarm automation method, which is related to my work here.

According to (Bransby & Jenkinson, 1998), the researchers proposed, that "Alarming performance" the fire alarm controlling systems to check the plant's safety. If a fault develops and the plant is on the verge of becoming unsafe, one or more alarms should sound. The operator should be aware of this, respond to determine the cause, and take corrective action to return the plant to a safe state. Besides, to implement their system accurately they use different equipment and the overall system is connected with the DCS system. They didn't say how they link the controller to the computer, though.

According to (Schulz et al., 2008), the researchers proposed, that "Case Study Special Design of Smoke Detection System in Mental Health Facility in New Zealand". The performance-based design of an aspirated recessed point type smoke detection system in the bedrooms of a secure wing in a mental health hospital run by one of New Zealand's largest district health boards is described in this case study. The system was created specifically to meet the clinical needs of the health board. Besides, to implement their system accurately they use different equipment's such as Raspberry Pi, automatic sprinkler suppression system, automatic smoke detection system, manual call points, emergency lighting and building hydrants. The researchers use the MX4428 I SMART SENSE algorithm with the detectors. There is no information regarding the sensor values or state at the time of the fire that may be used in a future investigation after the fire catastrophe.

According to (Zhang & Yue, 2013), the researcher deliberates that" the design of multi-zone wireless burglar alarm system in Huang he science and technology collage, in china". This proposed paper was tested in eight regional wireless burglar alarm systems using the AT89C51 microcontroller. This burglar alarm is made up of an infrared sensor chip BISS0001 that allows them to execute their system precisely. The AT89C51 microcontroller serves as the detector, with the LX2262/LX2272 data encoder/decoder serving as the controller. The design is centred on remote alarming with a 25m range.

According to (Aldmour et al., 2019), the researchers proposed, that" RISK ASSESSMENT METHODS FOR CONVERGEDIOT AND SCADA SYSTEMS: REVIEW AND RECOMMENDATIONS in a University of Cardiff and Wales in UK". This proposed paper, Special concerns for risk assessment methods in the context of merged IoT and SCADA systems are identified in this suggested article, and the researcher presents recommendations for the inclusion of the special considerations alongside standard methods for managing risks. The benefits of the proposed paper using an IoT system are to improve and facilitate application quality, cost reduction, enhance functionality and automation, increase access to resources as well as optimize real-time. The researcher proposes that a hybrid risk assessment method for converged ICS/SCADA operations in daily life and IoT systems could be followed, and point out areas where the usual risk assessment and management procedure could be improved. According to (Chen et al., 2019), the researcher deliberates. "Design and Implementation of Fire Alarm Device Based on Single chip". The paper uses an MQ-2 smoke sensor and DS18B20 temperature sensor when a fire occurs, there will be a lot of smoke and the temperature will be greater. A smoke sensor detection module and a temperature sensor detection module, respectively, allow the device to detect smoke and temperature signals and send them to STC89C52 single chip to decide whether to alarm. In the specific implementation process, the hardware design, which include a single chip module, sensor module, display module, alarm module, and key module, as well as the software design, which employs the C programming language to create the alarm system via Keil u Vision 4 software. In the event of a fire, the system does not interrupt the electric circuit before releasing extinguishing gas. According to (A. et al., 2016), the researcher deliberates "a GSM Enabled Smart Fire Alarm Controlling System with SMS Alert". The main controller of the system is Pentium 300MHz (or higher) processor with at least 128 MB of RAM and 500 MB of free hard disk space. The hardware devices consist of Sierra Wireless Development kit along with required power supplies and adaptors, SIM cards with the following features enabled according to usage: Basic GSM features such as SMS and voice call, PIN1, PIN2, PUK1, and PUK2 code. The Smart Phone and RS-232 Serial Cables are used in the system. The software Languages used: Windows XP or Windows 7 Operating System, Embedded C, Android, Simulator. According to (Makandar, 2021), the authors designed an "SMS Based Fire Alarm and Detection System". The main controller of the system use Microcontroller Arduino Pro Mini ATMEGA328It has 1 hardware serial port, 6 ADC inputs, 14 digital I/O pins, and works on 5 volt power and runs at 16 MHz. The SIM800L is a 2G module that works on all GSM frequencies. According to (Imteaj et al., 2017), the authors designed an "An IoT based Fire alarming and authentication system for workhouse". Proposed a fire alarming system for garment factories where the growth of the industry is challenged by frequent fire outbreaks and uses a master-slave approach where a single Raspberry Pi controls several Arduino microcontrollers coupled with temperature and light intensity sensors. The sensors gather information and transfer it to the Arduino microcontrollers, which process it. Raspberry Pi will be in charge of all of the microcontrollers.

According to (Tanwar et al., 2017), the authors designed an" An Advanced Internet of Thing based Security Alert System for Smart Home ".They proposed a low-cost home security system that allows monitoring of the house from a remote location. Several home security systems exist but it has issues like delay in the transfer of alert by phone, text, or email during unfavourable situations. As a result, a sophisticated system is developed that can detect an intruder or any unexpected incident when no one is at home. This system includes a PIR sensor that detects intruders and a camera that records the intruder's image. The Raspberry Pi is used for minimizing the delay in the processing of email alerts along with the captured image of the intruder. This allows the user to more effectively and efficiently monitor the home from afar. The paper demonstrates the Raspberry Pi's versatility as well as the breadth of its potential applications.

2.5 Proposed System

The proposed system which includes a block diagram of the entire system shows on Figure 3.1 and a system front panel graphical monitoring display shows on Figure 3.2. It includes a smoke sensor (MQ-2), a temperature sensor (LM35), and manual call points. The environmental condition is sensed by each smoke sensor and temperature sensor, which is then relayed to central processors, where the parameters for varied smoke/temperature are sent to the fire and insurance departments via IoT. When a fire occurs, the operator receives a notification on both the FACP and the local graphical SCADA computer, and the authorities are notified of the fires at the precise location via the IoT in the system. The chosen language and software are superior for practical implementation and have many advantages, such as sending data collected from sensors and storing it in a database that can be used for future investigation after a fire accident has occurred, similarly, website and android application make them available to users remotely, and in the event of a fire, the system automatically turns off the main power circuit breaker, therefore addressable (digital) and automatic fire alarm system are used to protect people/property at all times specially at night. The present awash melkassa chemical factory fire alarm system is of the analog (nonaddressable) kind. The system makes extensive use of transistors and relays. During a fire, the system simply shows the most recent information. The existing system has the following limitations: it gives a general idea of where the fire or smoke is rather than an exact location; the circuit is disabled when one of the devices in the circuit becomes detached; in the event of a fire, the system will not turn off the main power circuit breaker; there is no system data base; and it is not a redundancy system.

2.6 The Internet of Things (IoT) for Proposed System

Internet of Things was employed for the proposed system, which included four smoke sensors (MQ2), one temperature sensor (LM35), and two manual call points, all of which were integrated in a network using LabVIEW software. The use of IoT in chemical plants makes the systems more efficient and dynamic. A smoke and temperature sensor detects the presence of smoke/temperature in the surroundings and sends the information to the central processor (microcontroller). The central processor is the brain of the system, analyzing data and making decisions that are linked to an alarm system. It also delivers real-time data to a SCADA computer via serial communication and uses an IoT Platform to continuously monitor the presence of environmental conditions remotely(Sayed & Gabbar, 2017). As a result, the planned IoT ecosystem is made up of web-enabled devices.

CHAPTER THREE

3 SYSTEM DESIGN AND DESCRIPTION

3.1 Block diagram of overall system

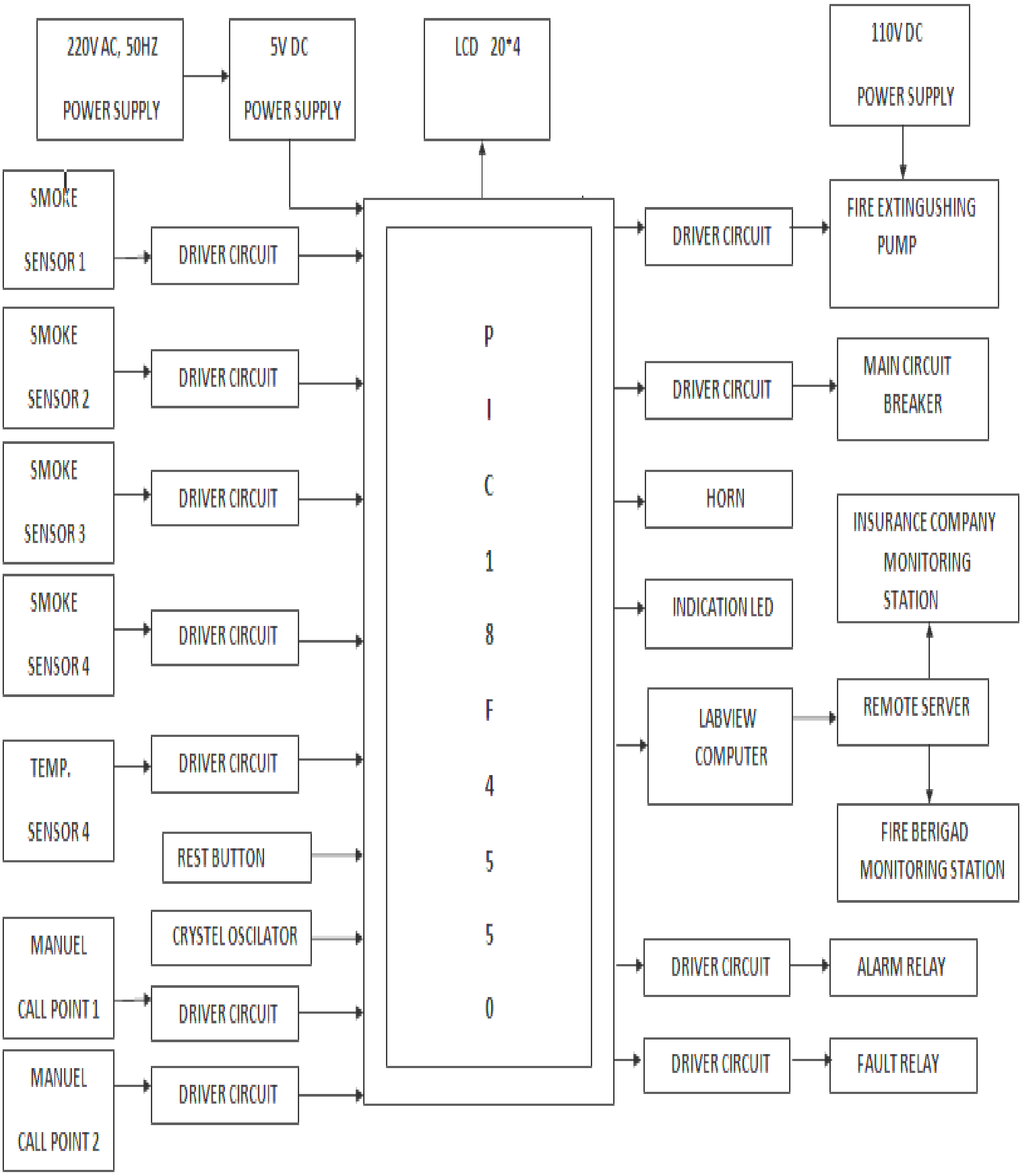


FIGURE 3. 1. Block diagram of overall system

3.2 Fire alarm system algorithm

Smoke sensors, temperature sensors, and manual call points are all part of the fire alarm system's algorithm. The sensors detect changes in the environment and send data to a central processor, in this case a microcontroller, which collects and processes the data before making a decision. Serial communication connects the local server to the central processor. It is located in the factor and communicates the status of each sensor to the insurance and fire departments by using IoT technology. Figure 3.2 shows the algorithm.

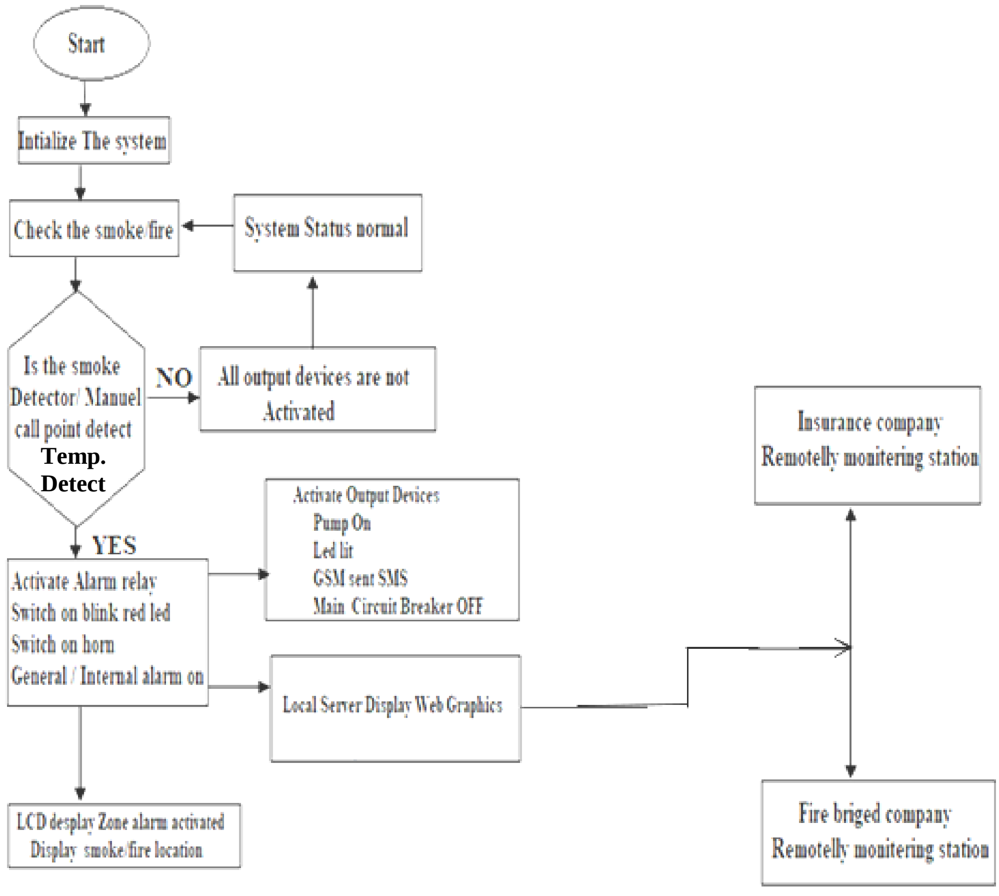


FIGURE 3.2. Fire alarm system algorithm

3.3 Working principle of the overall system

The system has worked through the form of figure 3.1 and figure 3.2. The overall system consists of hardware and software. The hardware architecture is made up of the following components: sensors, PIC18F4550 microcontroller, SCADA graphical computer, driving circuits, power supply, indication led, buzzer and LCD. PORT A of PIC18F4550 microcontroller interfaced with smoke and temperature sensors, PORT B interface with

LCD; PORT C interface with alarm led indication, and PORT D interface with horn, buzzers, internal alarm, and general alarm.

Control and Indication Equipment

Each sensor must be terminated with an EOLR (End Of Line Resistor) which Short and open circuit conditions can be detected by the panel. The EOLR (End Of Line Resistor) is to be located with the last device on each zone/object. There are six area in the system and a maximum load of 720mA (0.72A) per zone. Each zone/object can be independently configured to FACP. The FACP monitors each area continually for fire and fault conditions, which are only presented on the affected zone. When a fire condition is detected on the panel activates the Fire indications for that area of places. Other fires or fault states will be monitored by all remaining places.

The System's Front Panel Main Graphical Design

The Figure 3.3 shows the System front panel graphical monitoring display developed in the LabVIEW 2018, which monitors all the sensor parameters and gives indication on the panel and alert signal by operating through the micro-controller. It displays smoke concentration/ppm values, smoke concentration/ppm waveform chart, Temperature values, Temperature waveform chart, history table, time and date. The interfacing of PIC18F4550 micro-controller with the smoke sensor, temperature sensor and manual call points is shown in figure 3.1. The LabVIEW software then checks for the critical conditions and acquire the real-time data. When sensor values exceed the predefined threshold values in the LabVIEW front panel it gives an indication by turning LED ON. On SCADA graphical display each LED comprises of 3 indicators: one for normal operation (Green circle), for warning alarm (Yellow circle) and for trip (Red circle). As shown on figure 4.48 and 4.49 also, through a webpage, the LabVIEW computer sends real-time data to the fire and insurance departments. In parallel to this figure 4.50 shows LabVIEW acquires all the real-time data collected by sensors in the form of excel sheet.

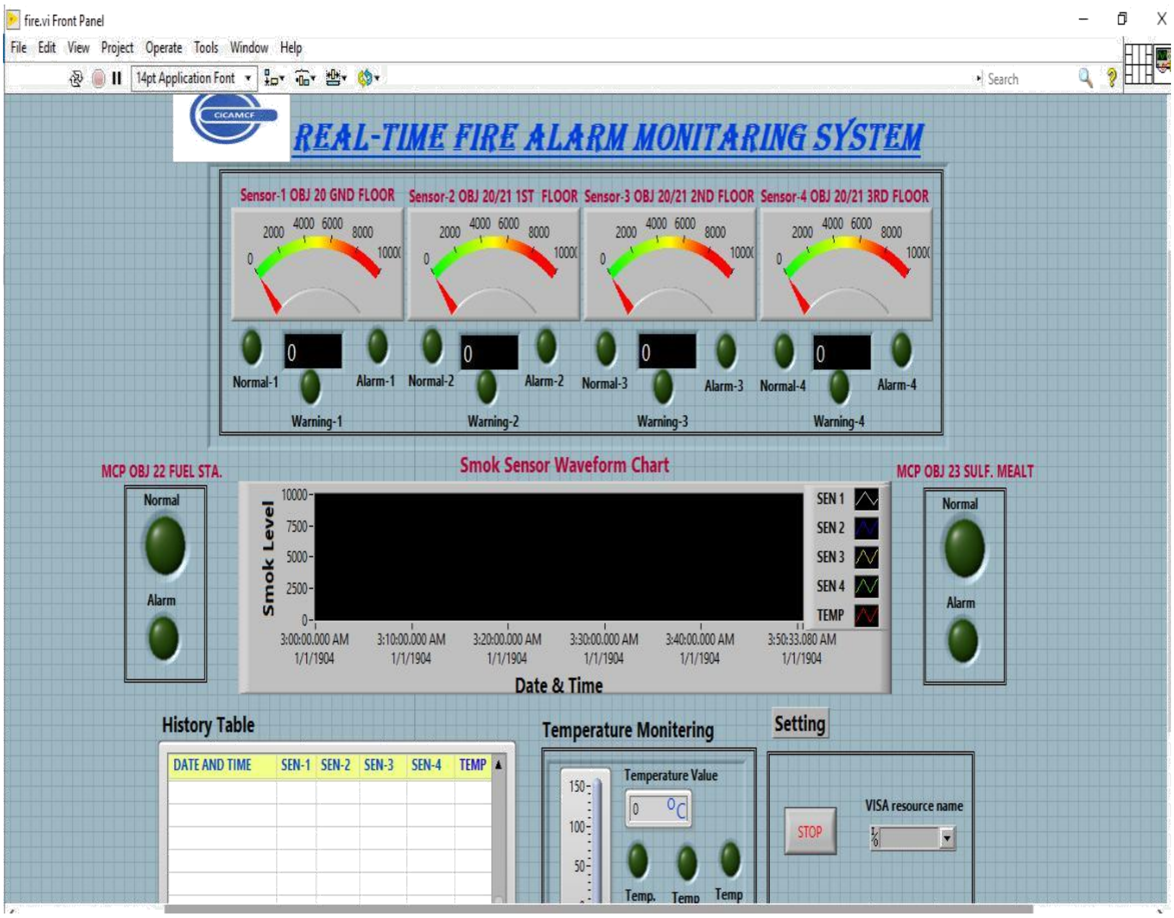


FIGURE 3.3. System front panel graphical monitoring display

Fire Alarm Control Panel (FACP)

A fire alarm control panel is designed to save life and property from the risk of fire methods of protection. The FACP is a central element of the system and it is equipped with MCU, LCD 20*4, relays, and driving circuits. The LCD can operate in 4-bit mode. The 4-bit mode was selected due to the advantage of the greater economy of I/O pins. As a result, ground is connected to pins D0, D1, D2, and D3. Furthermore, because data is always written into the LCD, the R/W line is connected to the ground.

Fire Alarm Control Panel (FACP)

- Signaling sources of fire detected by automatic fire warning devices
- Indicating areas at risk of fire
- Actuating alarm devices
- Passing fire information to appropriate service e.g Insurance company and fire brigade department
- Activating fire protection devices

Signaling device (LEDs)

- Fire Alarm
- Fault Alarm
- Test led
- Power status

The proposed Fire alarm controls Panel (FACP) have a feature of:-

- Power status indication both for DC and AC
- Internal alarm indication from detectors
- General alarm indication from MCP
- Fire alarm condition (RED led blink and lit also LCD fair zone)
- MCU health status indication
- Fault indication for each object (Short/Open circuit & cable loop)
- Lamp test
- External horn sound and rest button

The design has the capability of indicating several statuses

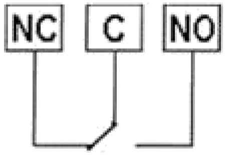
A. The Quiescent (stand by) Condition /Supervising mode

This is the panel's normal state. There are no defects or alarms, and the panel appears to be in good working order. The LCD shows that the system is normal and all LEDs are turned off, apart from Power indicates. In the quiescent condition, the Fault relay shows GREEN LED ON which indicates no short circuit, no open circuit, and cable loop status is ok.

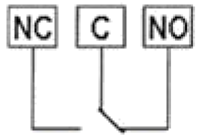
B. During The Alarm Condition

On the panel, a fire alarm is indicated by a RED LED blinking and a area alarm red LED lighted. The panel on the LCD screen reads: Display of the fire location text. The alarm relay operates in the event of a fire condition. The outputs of the fire relay can be Fire Alarm Routing Equipment or Fire Protection Equipment. Also, SCADA system displays the status and display on remote computers.

Alarm Relay: - Alarm signaling relay is located in the FACP and the operating power supply is DC12V DC. Normally closed (NC) contact of relay used for no alarm system normal condition and normally open (NO) contact of relay used for alarm condition.



NORMAL CONDITION



ALARM CONDITION

Alarms are classified as - INTERNAL ALARM and GENERAL ALARM INTERNAL ALARM: - Alarm from smoke detectors GENERAL ALARM: - Alarm from MCP (Manuel call point)

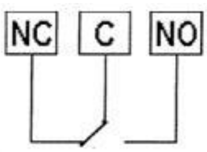
C. During The Fault Condition

Amber/yellow LED indicates faults and faults for each zone/object are indicated individually. Fault conditions are reported by fault control devices. During system health conditions GREEN LED will light. The fault relay operates in the event of a fault condition. This relay has been set to fail-safe mode, which means that if there is a malfunction, the relay contacts will remain active.

When the following faults occur, the Fault Relay will activate:

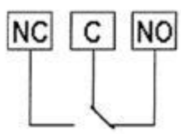
- Impedance faults
- Open circuit
- Short circuit

Fault Relay: - Fault signaling relay is located in the FACP and the operating power supply is DC12v.Normally closed (NC) contact of relay is used for system health conditions and normally open(NO) contact of relay is used for Fault indication.



OPERATING CONDITION

SYSTEM HEALTH CONDITION



FAULT CONDITION = NO VOLTAGE STATUS

(FAIL SAFE)

Lamp testing state: - operating status in which the control signals that applicable functions are being checked.

3.4 Tools for System Development

- PIC18F4550 microcontroller
- Smoke sensor (MQ2) and Break the glass (Button)
- Relays (24vdc,12vdc and 5vdc)
- LEDs (Green, Yellow, RED, and amber)
- LCD (20*4)
- Buttons,Transistor, Crystal oscillator, Diodes, Resistance, Capacitors & regulator
- Buzzer and horn
- PCB for a driving circuit

3.5 Data collection

3.5.1 Primary Data

Primary data was gathered with the help of the participants. Awash Melkassa Chemical Factory. The following data was collected during the site survey for this study: collected through interview of operators what are the major fire faults happened at the factory, how to get faulted places/areas/location, the length of the smoke detectors and MCP, rating, each sensor's type, system topology and layout, conductor type, and climatic variables are all factors to consider.

How to find Alarm/faulted object/areas

When one of the smoke sensors or MCP was on alarm/ faulted condition there is no option to announce that condition remotely. Due to manual work sometimes they will forget to inform responsible persons.

3.5.2 Secondary Data

Data collected

Table 3.1. Distances from FACP to Smoke detectors & Manuel call points

	Place/area	Length of Sensors from FACP
1	The smoke detector at Ground Floor	8 M
2	The smoke detector at First Floor	15 M
3	The smoke detector at Second Floor	22 M
4	The smoke detector at Third Floor	30 M
5	Manual Call point at Gas station	100 M
6	Manual Call point at Sulfur melting area	40 M

3.6 Mathematical Modeling

3.6.1 Fire Alarm system

For Fire Alarm Systems, there are numerous fire alarm calculations we must understand to properly design a code for a system. These calculations can break down exact requirements for voltage drop on a circuit and back up battery sizes.

Step One

Find the total current from all smoke detector and MCPs. Each device's current draw can be seen on the specification page. There for in the case of AMCF there are four smoke detectors and two manual call points they each draw 720mA or (0.72A). If we add all six appliances together (6 x 0.72) we have a total current draw of 4.2A.Ideally we want 10 present above this amount therefore 4.2 * 0.1 = 0.42 + 4.2 = 4.62A total current.

Step Two

Determine the detector's distance from the FACP. For the case of AMCF the distance of each sensor far from FACP as describe in Table 1.We have to double this distance to account for both conductors. Therefore for each detector the distance describes like:-

1. 8M (26.246 feet x 2 conductor) = 16M (52.492 feet total)
2. 15M (49.2126 feet x 2 conductor) = 30M (98.4252 feet total)
3. 22M (72.1785 feet x 2 conductor) = 44M (144.357 feet total)
4. 30M (98.4252 feet x 2 conductor) = 60M (196.8504 feet total)
5. 50M (164.042 feet x 2 conductor) = 100M (328.084 feet total)
6. 40M (131.232 feet x 2 conductor) = 200M (262.464 feet total)

Step Three

Now that we know the distance, we need to know what type of conductor we are using for the circuit. We'll use a 16 AWG conductor, which has a resistance of 4.016 Ω for 1000 feet. To calculate the actual resistance, divide by the distance and multiply by 4.016 Ω.

For Ground Floor

52.492/1000 = 0.052492 * 4.016 = 0.211 Ω

The resistance of a 4 AWG conductor is listed as 0.2485 Ω at 1000 feet.

Do the math once more by multiplying 0.2485 by 0.052492 = 0.013 Ω.

For First Floor

98.4252 /1000 = 0.09843 * 4.016 = 0.3953 Ω

The resistance of a 7 AWG conductor is listed as 0.4982 Ω at 1000 feet.

Do the math once more by multiplying 0.2485 by 0.09843 = 0.005 Ω.

For Second Floor

144.357 /1000 = 0.144357 * 4.016 = 0.5797 Ω

The resistance of a 8 AWG conductor is listed as 0.6282 Ω at 1000 feet.

Do the math once more by multiplying 0.6282 by 0.144357 = 0.09 Ω.

For Third Floor

196.8504 /1000 = 0.1968 * 4.016 = 0.791 Ω

The resistance of a 10 AWG conductor is listed as 0.9989 Ω at 1000 feet.

Do the math once more by multiplying 0.9989 by 0.1968 = 0.1965 Ω.

For Gas station

328.084 /1000 = 0.3281 * 4.016 = 1.317 Ω

The resistance of a 12 AWG conductor is listed as 1.588 Ω at 1000 feet.

Do the math once more by multiplying 1.588 by 0.3281 = 0.521 Ω.

For Sulfur melting area

262.464 /1000 = 0.2625 * 4.016 = 1.054 Ω

The resistance of a 12 AWG conductor is listed as 1.588 Ω at 1000 feet.

Do the math once more by multiplying 1.588 by 0.2625 = 0.42 Ω.

Step Four

Calculate the voltage at the end of the FACP. We use the simple Ohms Law I*R=E to accomplish this. We know our circuit's total current is 4.62A (see Step 2), and we know our circuit's real resistance is 4.016 (using 16 AWG conductors and applying the math):

4.62A * 4.016 Ω = 18.564 V.

For Ground Floor

0.013 Ohms using 4 AWG conductors

Using 4 AWG conductor doing the math: 4.62A * 0.013 Ω = 0.06 V

For First Floor

0.005 Ohms using 7 AWG conductors

Using 7 AWG conductor doing the math: 4.62A * 0.005 Ω = 0.0231 V

For Second Floor

0.09 Ohms using 8 AWG conductors

Using 8 AWG conductor doing the math: 4.62A * 0.09 Ω = 0.4158 V

For Third Floor

0.1965 Ohms using 10 AWG conductors

Using 10 AWG conductor doing the math: 4.62A * 0.1965 Ω = 0.90783 V

For Gas station

0.521 Ohms using 12 AWG conductors

Using 12 AWG conductor doing the math: 4.62A * 0.521 Ω = 2.41 V

For Sulfur melting area

0.42 Ohms using 12 AWG conductors

Using 12 AWG conductor doing the math: 4.62A * 0.42 Ω = 1.924 V

Step Five

Determine the actual voltage drop at towards the end of the FACP, the real voltage To do this, start by subtracting the voltage in step four from the operational voltage at the FACP's head.

For Ground Floor

24V - 0.06 V = 23.94 V

For Second Floor

24V - 0.0231 V = 23.9769 V

For Second Floor

24V - 0.4158 V = 23.5842 V

For Third Floor

24V - 0.90783 V = 23.09217 V

For Gas station

24V - 2.41 V = 21.59 V

For Sulfur melting area

24V - 1.924 V = 22.0759 V

Step Six

Based on the actual voltage at the circuit's end, choose the cable size to employ. Calculate the minimum voltage drop required for successful operation. The operational voltage range for our visible audible signalling device is 18.564V DC to 24V DC. Using the voltage obtained from the preceding procedures, it is evident that 16 AWG is the best choice.

3.6.2 Concentration of Smoke

To calculate the concentration of smoke in PPM, we need to choose two points from the curve of a specific smoke from the graph given in figure 3.4. In our example, we chose locations from the graph curve (10000, 0.6) and the smoke line (800, 2) as our starting points. Because these points are on a logarithmic scale, compute the slope using the formula Slope = (y2-y1)/(x2-x1) One point from the top, and the slope is used in the format (x, y, slope) in a program.

Let's look at the graph now.

1. The graph's scale is log-log. This means that the behaviour of the smoke concentration in terms of the resistance ratio is exponential on a linear scale.

$$\log(y) = m * \log(x) + b \tag{3.1}$$

2. The data on smoke concentrations only goes from 200 to 10,000 parts per million.
3. Despite the fact that the relationship between resistance ratio and smoke concentration appears to be linear, it is not.

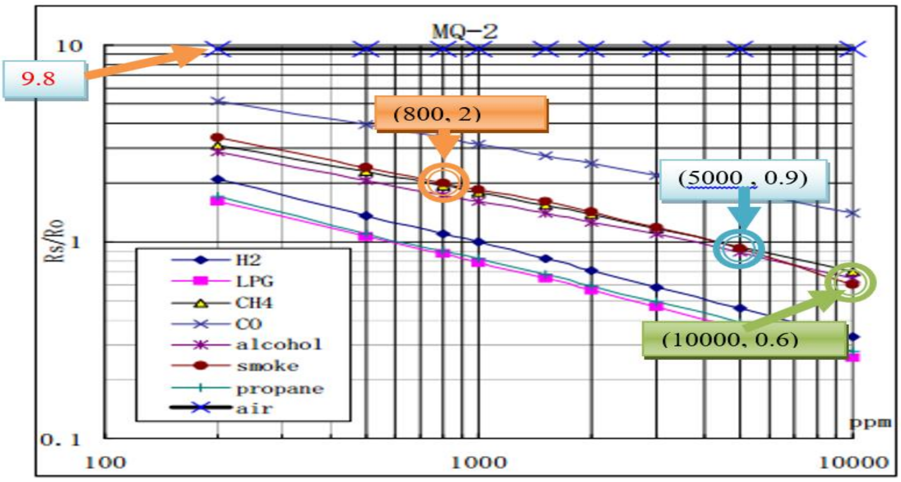


FIGURE 3. 4. MQ-2 Sensitivity Characteristics graph

The x-axis of a graph is the Rs/R0 ratio, while the y-axis is the ppm concentration of smoke. We must locate the spot (Smoke concentration, RS/R0 ratio). We will receive a Rs/R0 ratio in pure air. Now, using the above slope, Rs/R0 ratio, and the first point described above, the concentration of smoke may be calculated using the formula below. Because it is a logarithmic coordinate, it is multiplied by ten to get a non-logarithmic value.

To Measure PPM from MQ2 Smoke Sensors

The datasheet suggests that the optimal number for RL is 5K thus that is what we shall use. As you can see from figure 3.5 the resistor RL is connected between the Analog output pin and the ground. To find the value of ppm we can use again Figure 3.4.

To calculate the value of Rs/Ro, we must first calculate the value of Rs and the value of Ro.

The sensor resistance at a high concentration of smoke is Rs, whereas the sensor resistance in pure air is Ro.

The value of Vc in this formula is our supply voltage (+5V), and the value of RL is 5K, which we acquire from the datasheet. We could also get the value of VRL and lastly calculate the value of Rs using the Micro C PRO application. I've included a Micro C PRO program that reads the sensor's analog voltage (VRL) and uses this formula to calculate the value of Rs.

Calculating the Ro Value at a Clean Air

Because the value of Rs/Ro in Figure 3.4 is constant for air (thick black line), we can utilize these numbers, Rs/Ro = 9.8.

$$Rs/Ro \tag{3.2}$$

$$\text{Therefore} \quad Rs/Ro = 9.8 \qquad \text{and } Ro = Rs/9.8$$

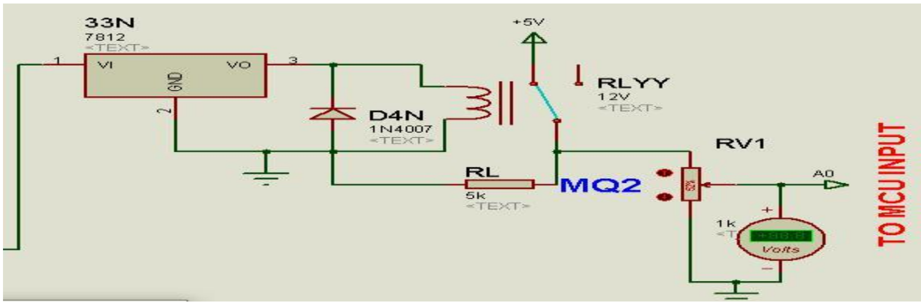


FIGURE 3. 5. MQ-2 smoke sensor output pin configuration with MCU

We can deduce I from Ohm's Law as follows:

$$I=V/R \tag{3.3}$$

In our circuit, this equals

$$I = VC / (RS+RL) \tag{3.4}$$

Using the value obtained, we can calculate the output voltage at the load resistor.

$$V = I \times R \tag{3.5}$$

$$VRL = [VC / (RS + RL)] \times RL \tag{3.6}$$

$$VRL = (VC \times RL) / (RS + RL) \tag{3.7}$$

So now we have to figure out what RS is.

$$VRL \times (RS + RL) = VC \times RL \tag{3.8}$$

$$(VRL \times RS) + (VRL \times RL) = VC \times RL$$

$$(VRL \times RS) = (VC \times RL) - (VRL \times RL)$$

$$RS = [(VC \times RL) - (VRL \times RL)] / VRL$$

$$RS = [(VC \times RL) / VRL] - RL \tag{3.9}$$

The analog average data from the sensor will be converted to voltage in order to calculate R0. Then we'll utilize the RS formula to figure out what R0 is. In the Micro C PRO code, we'll teach you how to achieve it.

The Rs/Ro and PPM Relationship

We can calculate the ratio (Rs/Ro) if we know how to calculate the value of Rs and Ro. Despite the fact that the smoke line (burgundy) looks to be linear, it is not. The appearance is due to the scale being divided unevenly for aesthetic purposes. As a result, the relationship between Rs/Ro and PPM is logarithmic, as seen in the equation below. The datasheet chart is utilized once more to translate the digital signal to concentration units. The MQ-2 smoke sensor is not linear, thus $y = mx + b$ is a simple calibration line. It uses a log-log scale, which necessitates a little extra math. As a result, the equation $y = mx + b$ can be changed to $\log(y) = m*\log(x) + b$. Using the chart, calculate the slope and intercept can be:-

$$\log (y) = m*\log(x) + b$$

Where,

y = ratio (Rs/Ro) m = slope of the line

x = PPM b = intersection point

Use the formulae to calculate slope value

$$m = [\log(y) - \log(y0)] / [\log(x) - \log(x0)]$$

The logarithmic quotient rule yields the following results.

$$m = \log(y/y0) / \log(x/x0)$$

The values for x, x0, y, and y0 are now substituted.

$$m = \log (0.6/2) / \log (10000/800)$$

$$m = -0.476$$

As for (b), let's get the graph's midpoint value (x, y), which is (5000, 0.9), as illustrated in figure 3.4.

$$\text{Log} (y) = m*\log(x) + b$$

$$b = \log (0.9) - m*\log(x)$$

$$b = \log (0.9) - (-0.476)*\log (5000)$$

$$b = 1.714$$

Once when we get the calculated values of We can calculate the smoke concentration using the variables m and b.

$$x (ppm) = 10[\log10(y)-b]/m \quad (3.10)$$

Using the MQ2 Smoke Sensor, create a program to calculate PPM.

Below is the complete program for calculating PPM using a MQ2 smoke sensor. A few key lines are described further down. We must first declare the values of load resistance (RL), slope (m), intercept (b), and resistance in fresh air before continue with the program (Ro). We've already discussed how to obtain all of these figures; now it's time to construct a program.

Performance Evaluation

Industry safety is a serious concern. With real-time notifications, the system should be accurate and dependable. The PIC18F4550 microcontroller used features an inbuilt EEPROM and USART, which aids in providing an immediate notice to the industry in the event of a fire. This gives you a breakdown of how well the system is performing. The Microcontroller PIC18F4550 in the system has a high-performance Quad timer's core processor that outperforms the processors in the Microcontroller PIC18F4450 and Microcontroller PIC18F2455.

Table 3.2. Comparison between different models of Microcontroller

Feature	Microcontroller PIC18F4550	Microcontroller PIC18F4455	Microcontroller PIC18F2455
Program Memory			
Memory (Flash bytes)	32K	24K	24K
Data Memory			
Single Word instruction	16384	12288	12288
SRAM (bytes)	2048	2048	2048
EEPROM (bytes)	256	256	256
Input Output	35	35	24
10bit Analog to Digital (channel)	13	13	10
Streaming Parallel Port (SPP)	Yes	Yes	No
Interface With I^2C	Yes	Yes	Yes
Comparator	Yes	Yes	Yes
Timer8/16-bit	1/3	1/3	1/3
Pin	40	40	40

The Microcontroller PIC18F4550 offers superior features and can give higher performance under challenging settings, according to this analysis. Because industrial safety is a major concern, great performance is required. The fire alarm should sound and the sprinkler motor should turn on in response to the fire. The SCADA computer records real-time data and sends status using IoT technology to the fire department and insurance company(Thomas & McDonald, 2017).

CHAPTER FOUR

4 RESULT ANALYSIS AND DISCUSSION

4.1 Simulation Result

Automated smoke detector and temperature monitoring system using IoT allows the employers to monitor the room's smoke condition whenever they are far away from their workplace through the Favorite platform by using a personal computer, a laptop, or a smart phone. The smoke value is considered to be 5000ppm equated to 0.005 grams per cubic centimeter (g/cm3) considering working in smoke or 5000ppm equated to 0.5%. The detection of values beyond the threshold is recorded and a notification alert is sent to the control room and fire department using IoT technology. The implementation of the Internet of Things (IoT) in the product system gives advantages in terms of safety, ability to react, and cost-effective. Besides that Internet of Things is able to operate anytime with the network connection to record all the data on the Favorite platform. The analog port of microcontrollers is coupled to a sensor system. The MQ2 sensor has a sensitivity of 10000ppm and can detect DC voltage up to 5V. The simulation is done using four smoke sensors, one temperature sensor, and two manual brakes the glass. The sensor receives the input signal and displays the amount of smoke detected on the LCD, FACP and SCADA monitoring computer. The simulation result has been obtained using Proteus 7.7, Micro C Pro version 6.6.3 software, and Lab VIEW 2018 software. In normal conditions, the relay will not get a driving signal from the microcontroller. The output-driving load is connected to the relay's normally open contact.

There are three scenarios for the indicated threshold value for smoke detectors.

- Scenario 1:-There is no smoke presence (0 ppm / system Normal).
- Scenario 2:-Smoldering fire (non-flame) greater than 4273ppm is set to alert.
- Scenario 3:-Fire with a concentration of more than 5000ppm is set to alarm/trip.

For manual call points (brake the glass) we used scenarios.

- Scenario 1:- Normal situation (no fire, no broken glass)
- Scenario 2:- Fire situation (fire/ broken glass)

For the temperature sensor we used 3 scenarios.

- Scenario 1:- System at normal state is set to 0 ^{o}C up <57^{o}C
- Scenario 2:- System alert is set to >57^{o}C & goes up to < 90^{o}C
- Scenario 3:- System alarm(trip) temperature is set to > 90^{o}C

For simulation

- Instead of Smoke detectors we are using variable resistor. To vary the concentration/ppm increments (+) and decrements (-) buttons are used.
- For Temperature we are using LM35 sensor. To vary the temperature increments (+) and decrements (-) buttons are used.
- For Manuel's call points, we are using a normal push button.

4.1.1 Ground floor Smoke sensor monitoring simulation result

Ground floor: Scenario one (There is no smoke presence (0 ppm / system Normal).

The simulation result (figure 4.1) shows that the smoke level in a room in normal conditions (without smoke) is 0 ppm, which is dependent on the MQ-2 sensor sensitivity in clean air factor resistance. Table 4.1 shows that no devices have been reached, and a real-time monitoring result (figure 4.2) shows data being transmitted to a graphical SCADA computer, as well as a real-time notification being sent to the Fire and Insurance Department via the IoT system.

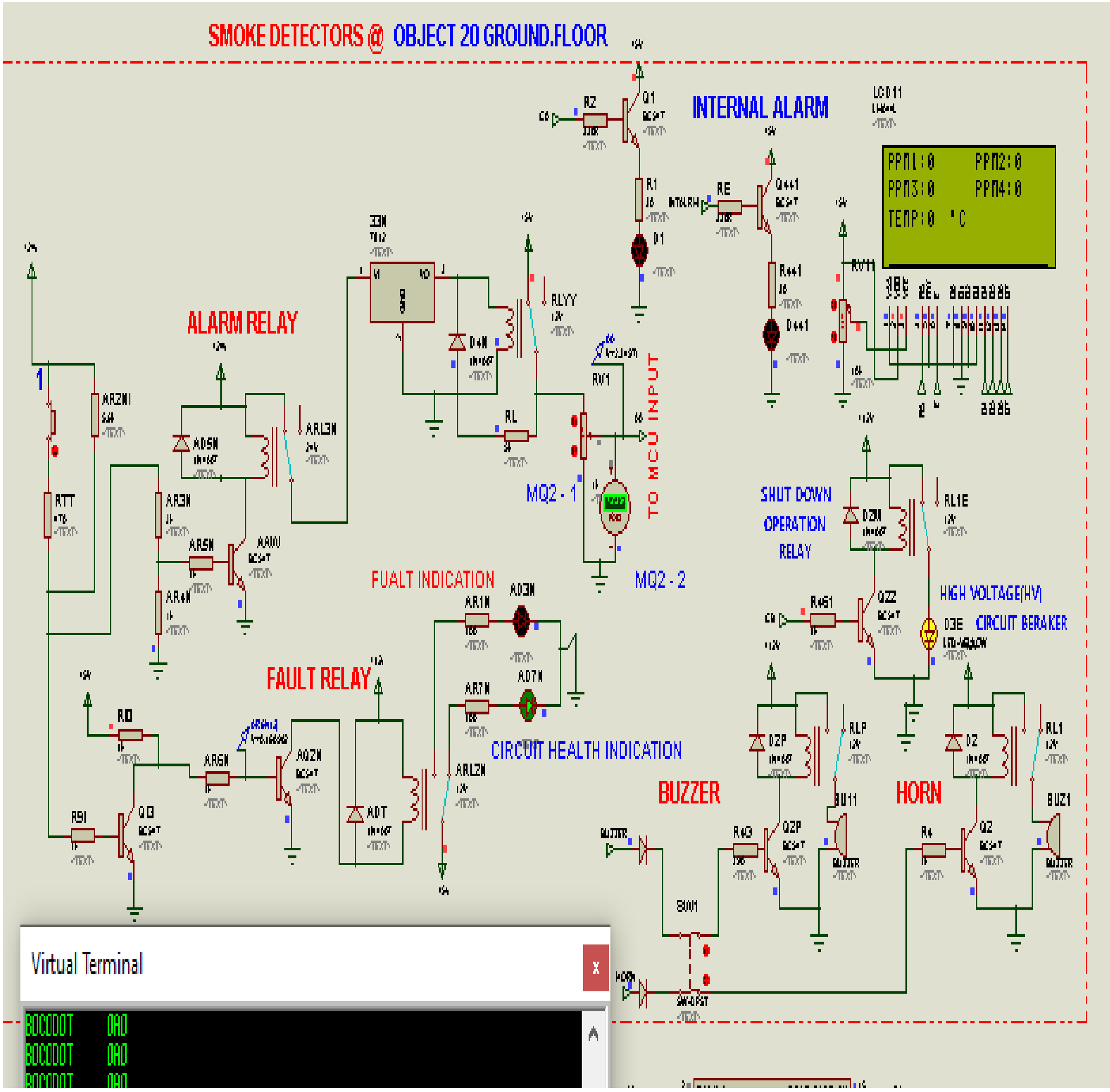


FIGURE 4.1. Ground floor Scenario on Smoke concentration/ppm simulation result

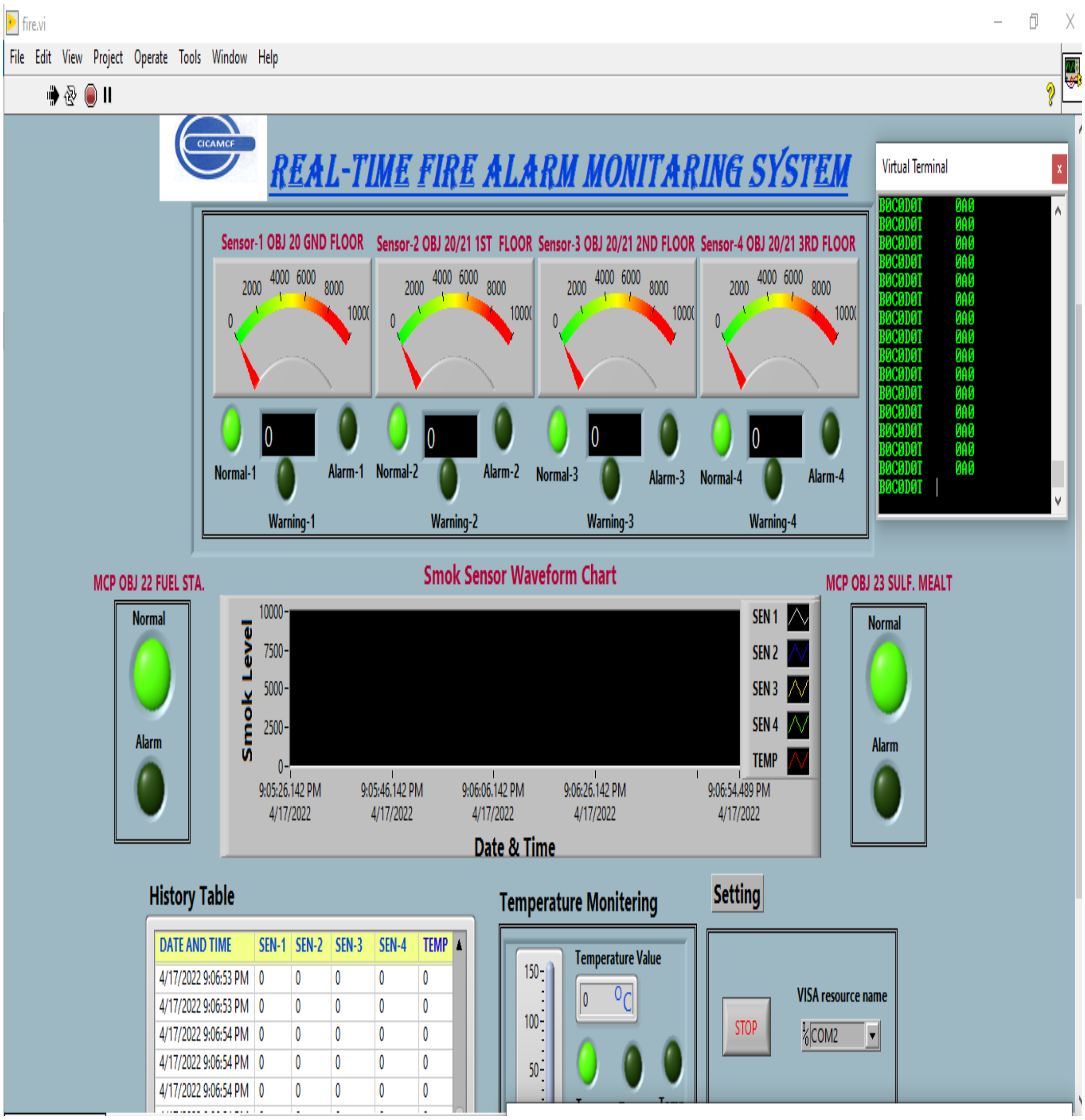


FIGURE 4.2. Ground floor Scenario one Smoke concentration graphical simulation result

Scenario one: Test Result

Table 4.1. Ground floor Smoke sensor Scenario one: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
0 PPM	without Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Ground floor: Scenario Two: (Smoldering fire (non-flame) greater than 4273ppm)

The simulation result (figure 4.3) shows that the smoke level in a room in a warning condition (with smoke present) ranges from 4237 ppm to < 5000 ppm, depending on the MQ-2 sensor sensitivity in the clean air factor resistance. There are no achieved devices, according to Table 4.2, but a warning Yellow light indication enabled on the SCADA computer (figure 4.4) shows data to graphics SCADA computer, as well as a real-time message sent to the Fire and Insurance department utilizing IoT system. Based on the results of the experiments, the smoke level warning was utilized to notify the employer via a preferred platform and the Fire Department to take preventative action before the system broke down.

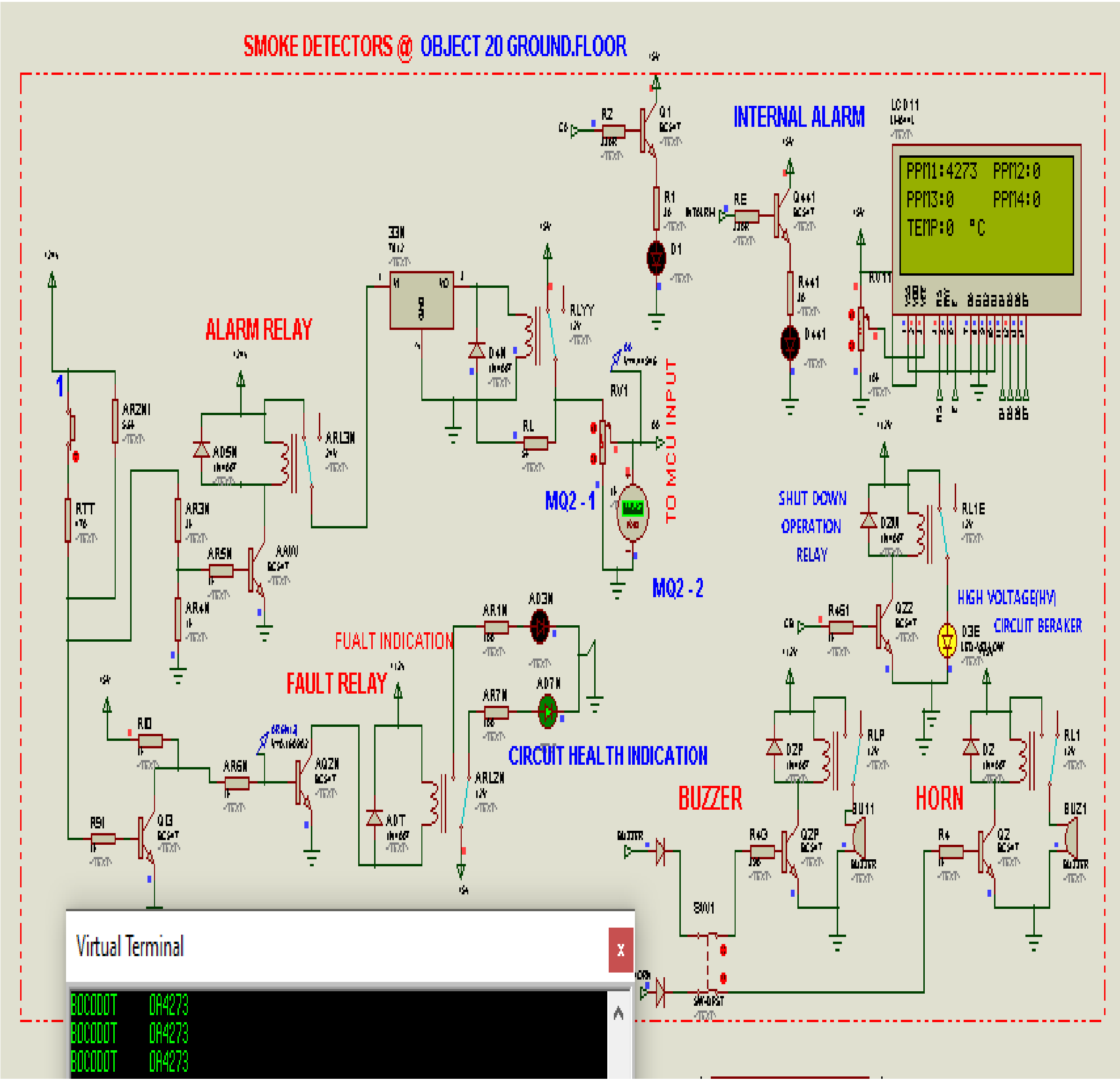


FIGURE 4.3. Ground floor Scenario two Smoke concentration/ppm simulation result

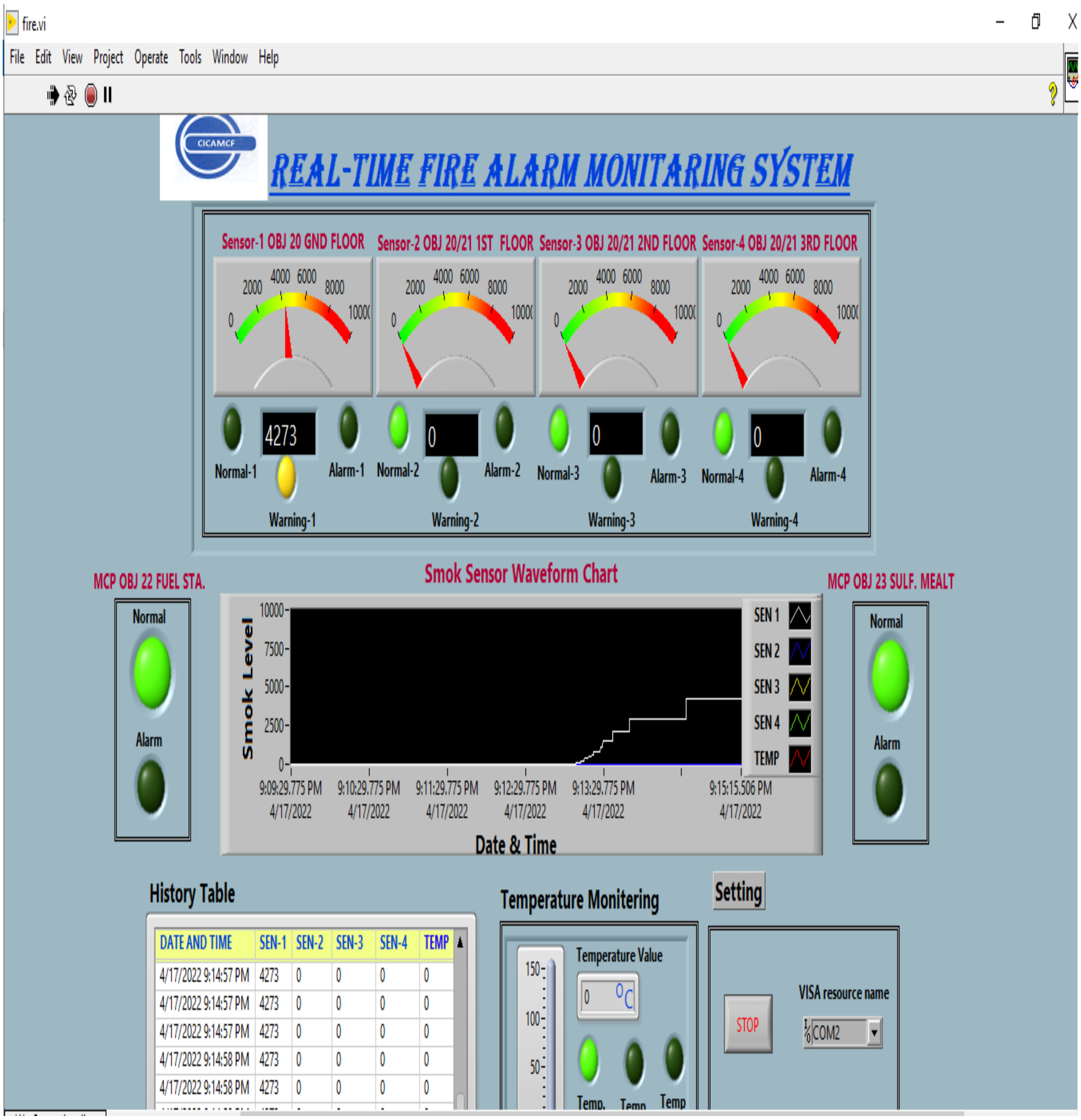


FIGURE 4.4. Ground floor Scenario two Smoke concentration graphical simulation result

Scenario Two: Test Result

Table 4.2. Ground floor Smoke sensor Scenario Two: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
1PPM–4273PPM	Thin Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Ground floor: Scenario Three: (Fire with a concentration of more than 5000ppm)

The simulation result (figure 4.5) shows that in a room in Alarm condition (with a high level of smoke), the smoke level is between 5001 ppm and 6602 ppm, depending on the MQ-2 sensor sensitivity in clean air factor resistance. According Table 4.3 shows that the buzzer and horn devices were successfully installed, and the Red alarm led indicator on the SCADA computer (figure 4.6) was enabled, as well as a real-time notification to the Fire and Insurance Department via the IoT system. According to the experiment, the Fire Department will get an alarm message via IoT if the smoke level surpasses the threshold amount, as illustrated in Figure 4.48. The notification message to the fire department contains all of the pertinent information, including the name of the factory, recorded data, data, and time.

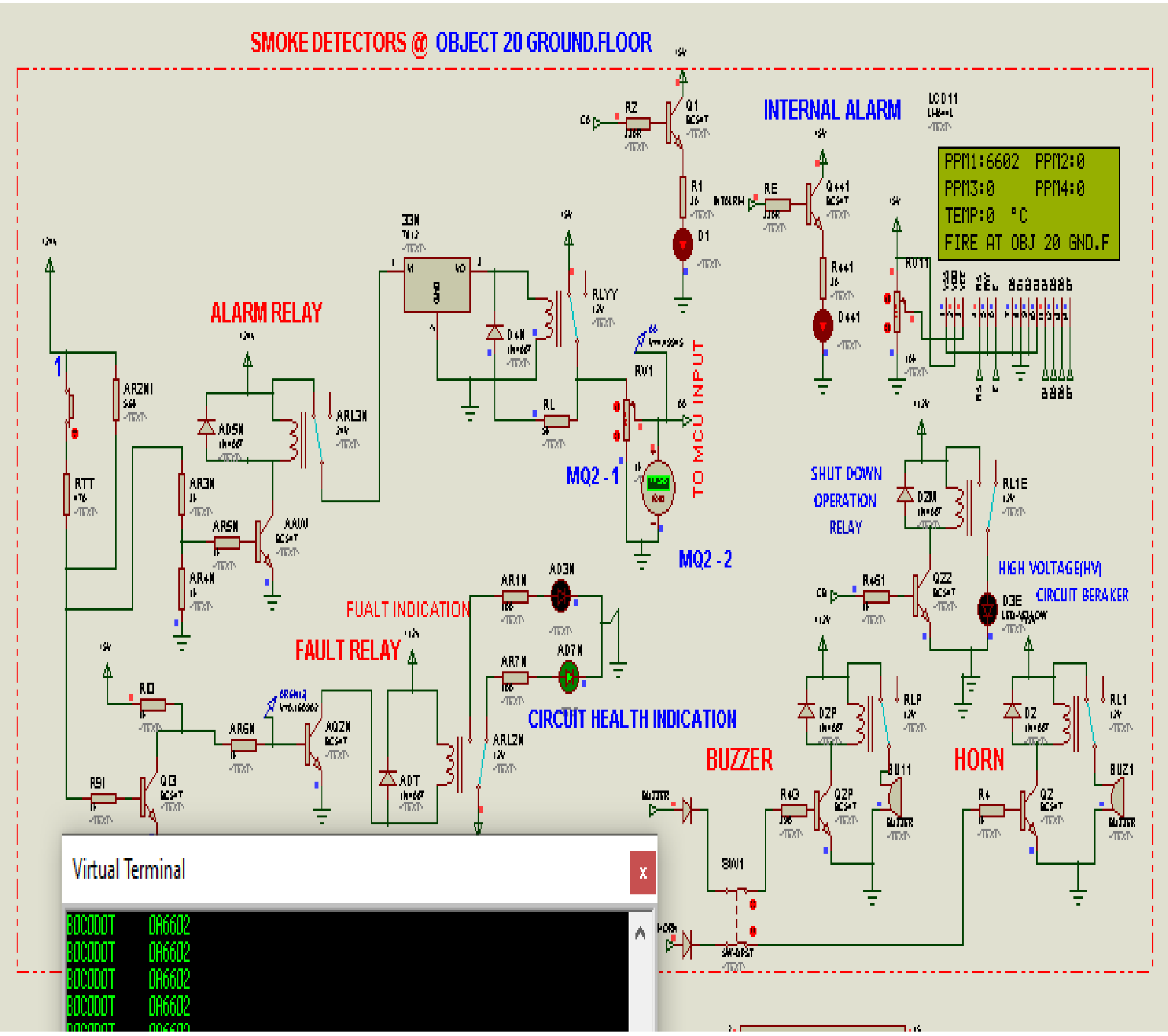


FIGURE 4.5. Ground floor Scenario three Smoke concentration/ppm simulation result

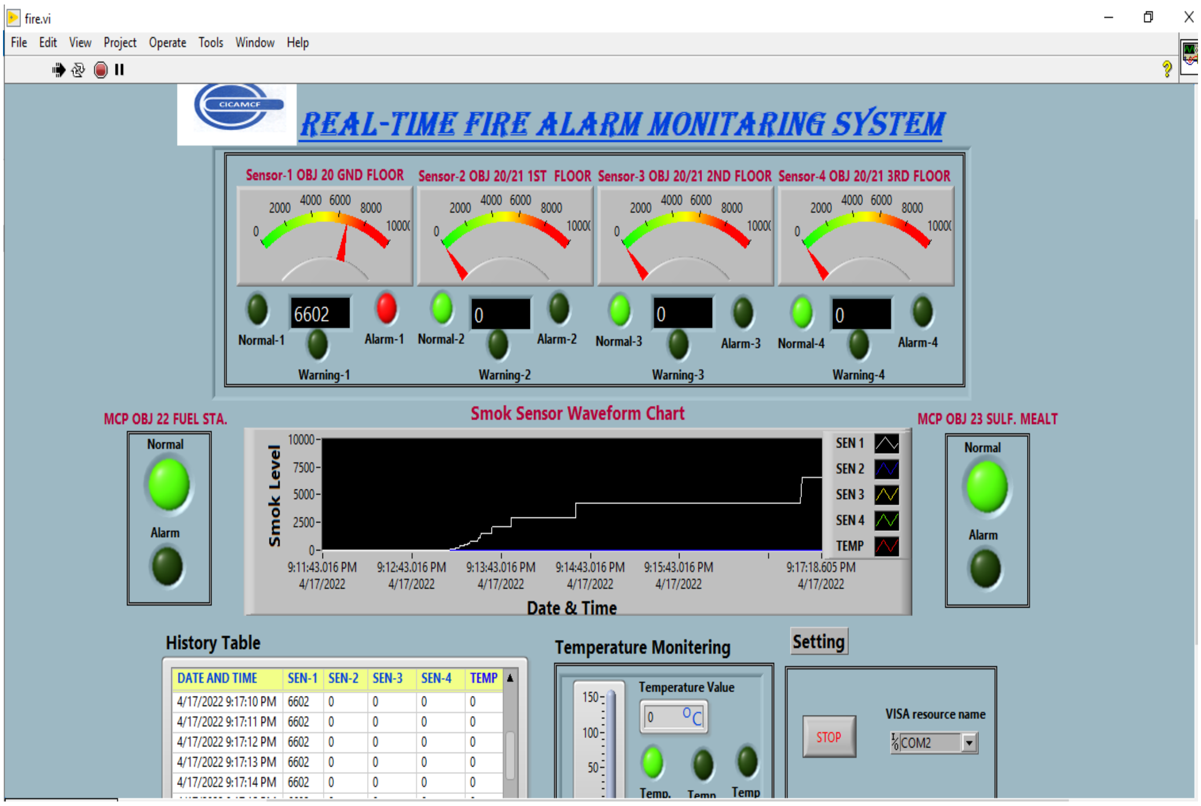


FIGURE 4.6. Ground floor Scenario three Smoke concentration graphical simulation result

Scenario Three: Test Result

Table 4.3. Ground floor Smoke sensor Scenario Three: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
5000PPM — 6602PPM	Thick Smoke	ON	ON	ON	ON	OFF	OFF	OFF

Experimental Data Visualization

Figure 4.7 show how smoke levels varied over time for several of the combustible materials used in these studies, as well as the periods when visible smoke and flame appeared and the times when the relevant sensor alarms were activated. Sensor one

(SEN1) is recognized by white horizontal lines, followed by sensor symbols that denote the sensor's alert times. The x-axis shows the time and date it took for the material to ignite, while the y-axis shows how the sensor responded to the smouldering and PPM settings.

Lower smoke present is defined as a smoke value ranging from 0 to 4273 ppm. When a room smoke level is greater than 4273 ppm the microcontroller gets an input signal from the MQ-2 sensor and the microcontroller sent Warning output signal to the SCADA graphics computer as the same time real-time data will be sent to the monitoring station using internet. Therefore, the alarm smoke level chosen for this experiment is larger than 5000 parts per million. The smoke sensor MQ-2 detects smoke and activates the buzzer, and horn, switch off the main circuit breaker and display the status in real-time.

The visualization of smoke concentration (ppm) in the room from 11:03 to 11:06 on April 17 is shown in Figure 4.7. Because the collected data is updated every second, a system of automated updating every second is used to ensure the data's timeliness and proper display function.

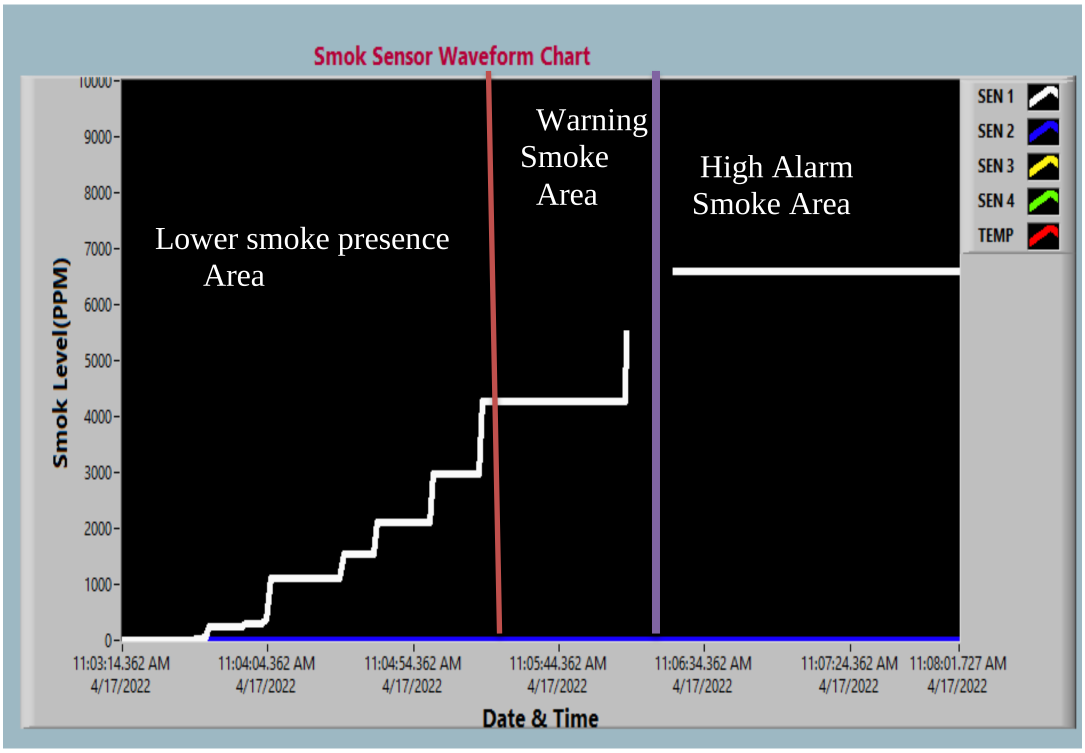


FIGURE 4.7. Ground floor Smoke sensor smoke concentration/ppm waveform chart

4.1.2 First floor Smoke sensor monitoring simulation result

First floor: Scenario one: (There is no smoke presence (0 ppm / system Normal).

The simulation result (figure 4.8) shows that the smoke level in a room in normal conditions (without smoke) is 0 ppm, which is dependent on the MQ-2 sensor sensitivity in clean air factor resistance. Table 4.4 shows that no devices have been reached, and a real-time monitoring result (figure 4.9) shows data being transmitted to a graphical SCADA computer, as well as a real-time notification being sent to the Fire and Insurance Department via the IoT system.

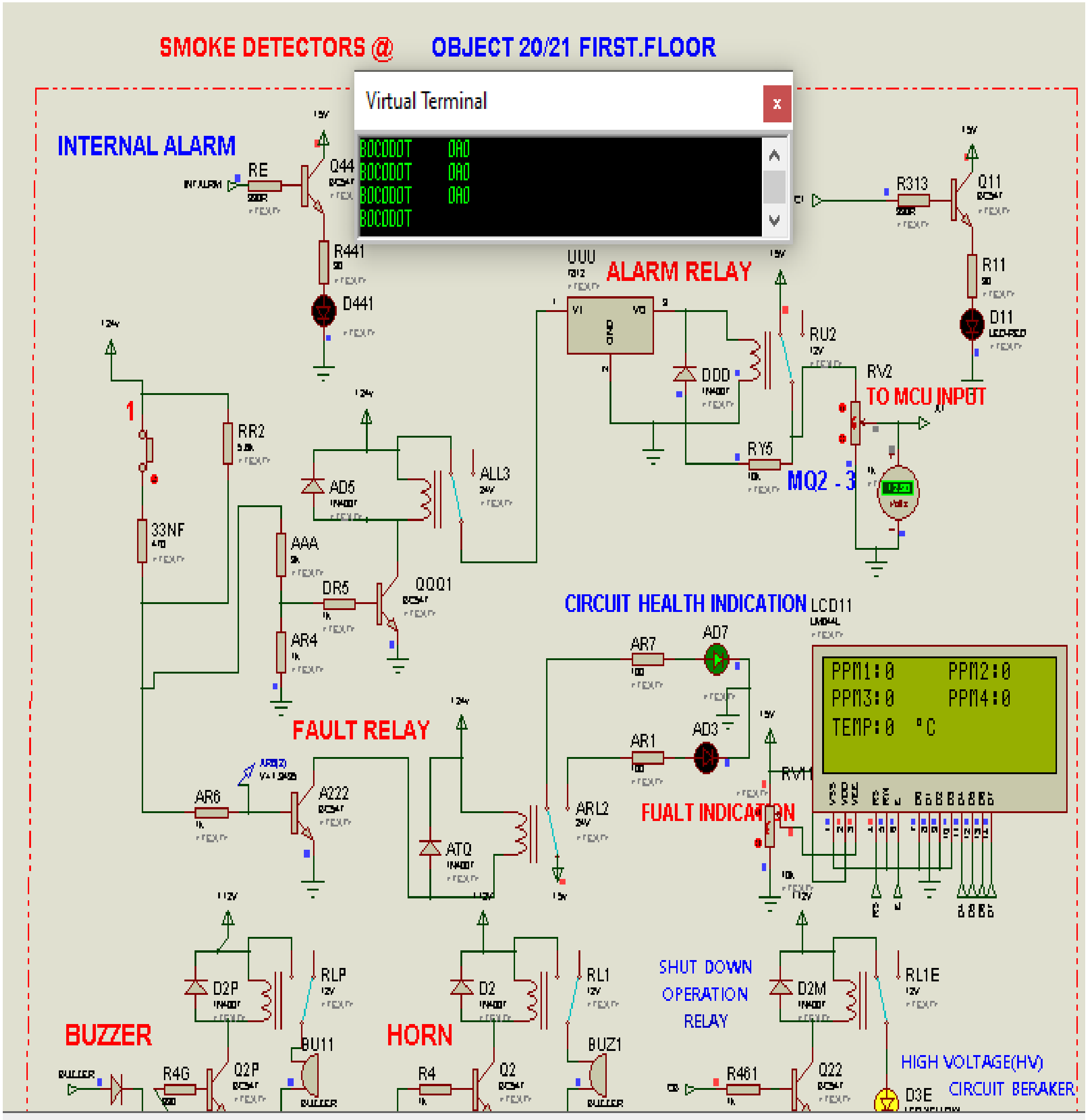


FIGURE 4.8. First floor Scenario one Smoke concentration/ppm simulation result

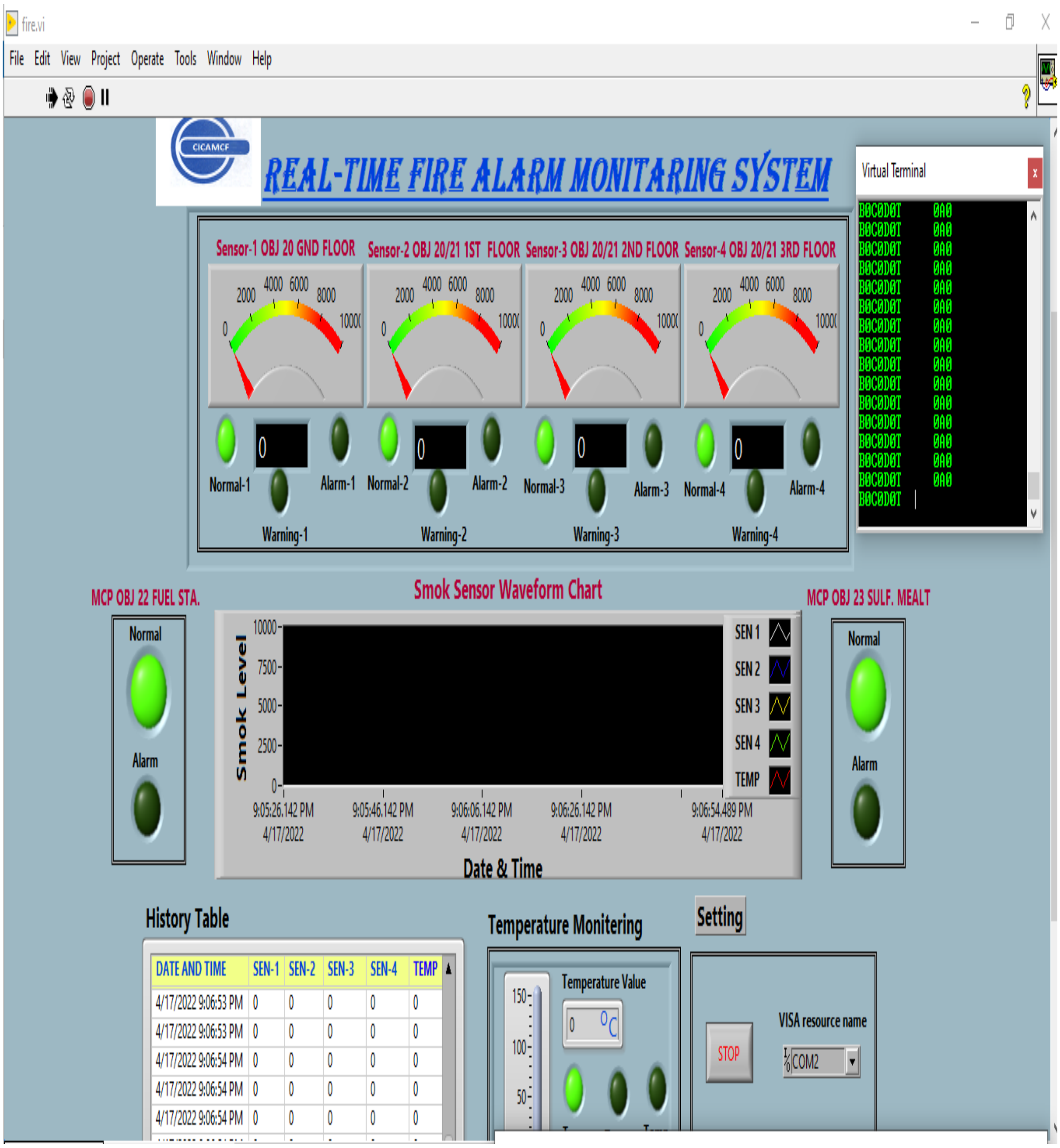


FIGURE 4.9. First floor Scenario one Smoke concentration graphical simulation result

Scenario one: Test Result

Table 4.4. First floor Smoke sensor Scenario one: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
0 PPM	without Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

First floor: Scenario Two: (Smoldering fire (non-flame) greater than 4273ppm)

The simulation result (figure 4.10) shows that the smoke level in a room in a warning condition (with smoke present) ranges from 4237 ppm to < 5000 ppm, depending on the MQ-2 sensor sensitivity in the clean air factor resistance. There are no achieved devices, according to Table 4.5, but a warning Yellow light indication enabled on the SCADA computer (figure 4.11) shows data to graphics SCADA computer, as well as a real-time message sent to the Fire and Insurance department utilizing IoT system. Based on the results of the experiments, the smoke level warning was utilized to notify the employer via a preferred platform and the Fire Department to take preventative action before the system broke down.

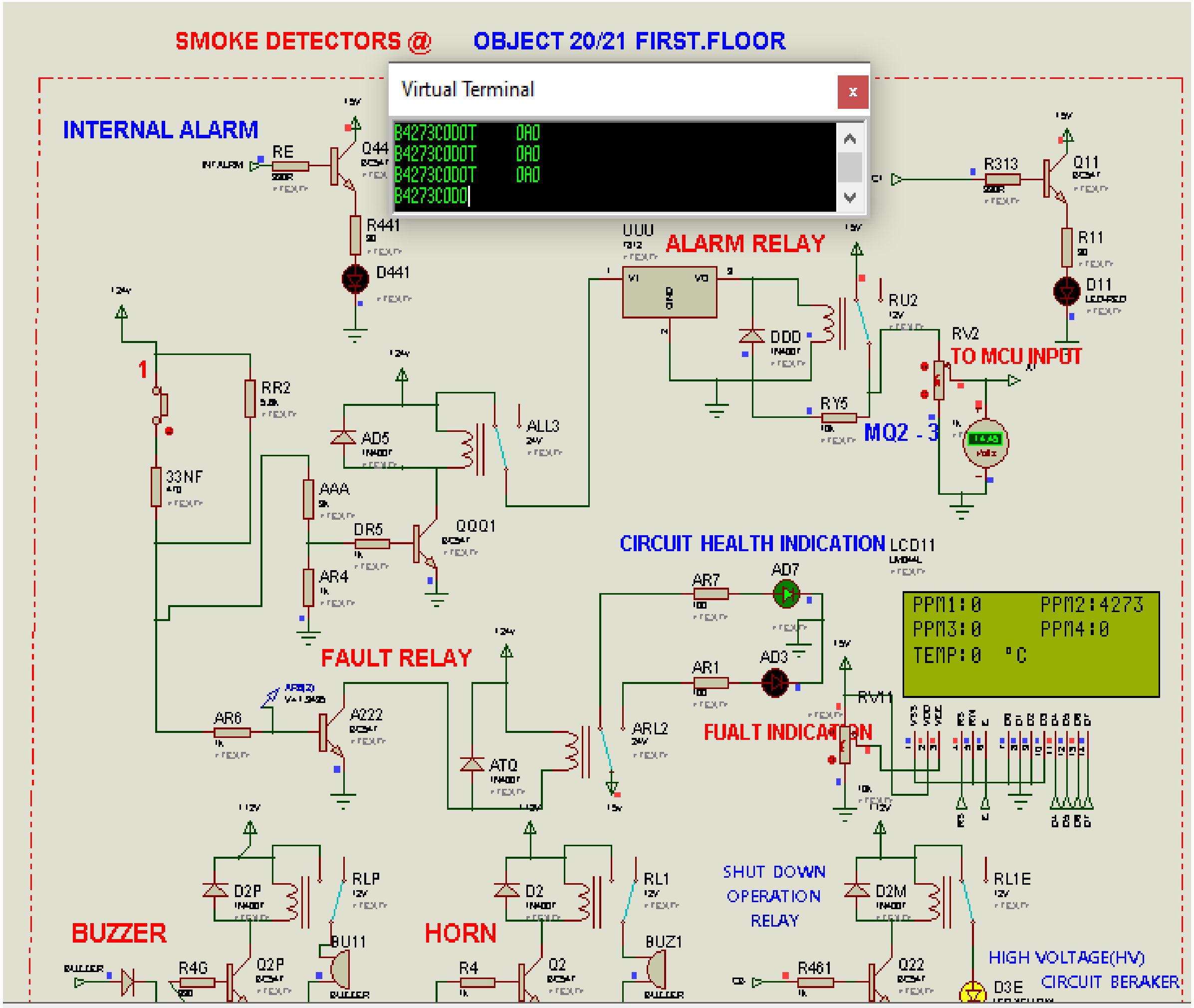


FIGURE 4.10. First floor Scenario two Smoke concentration/ppm simulation result

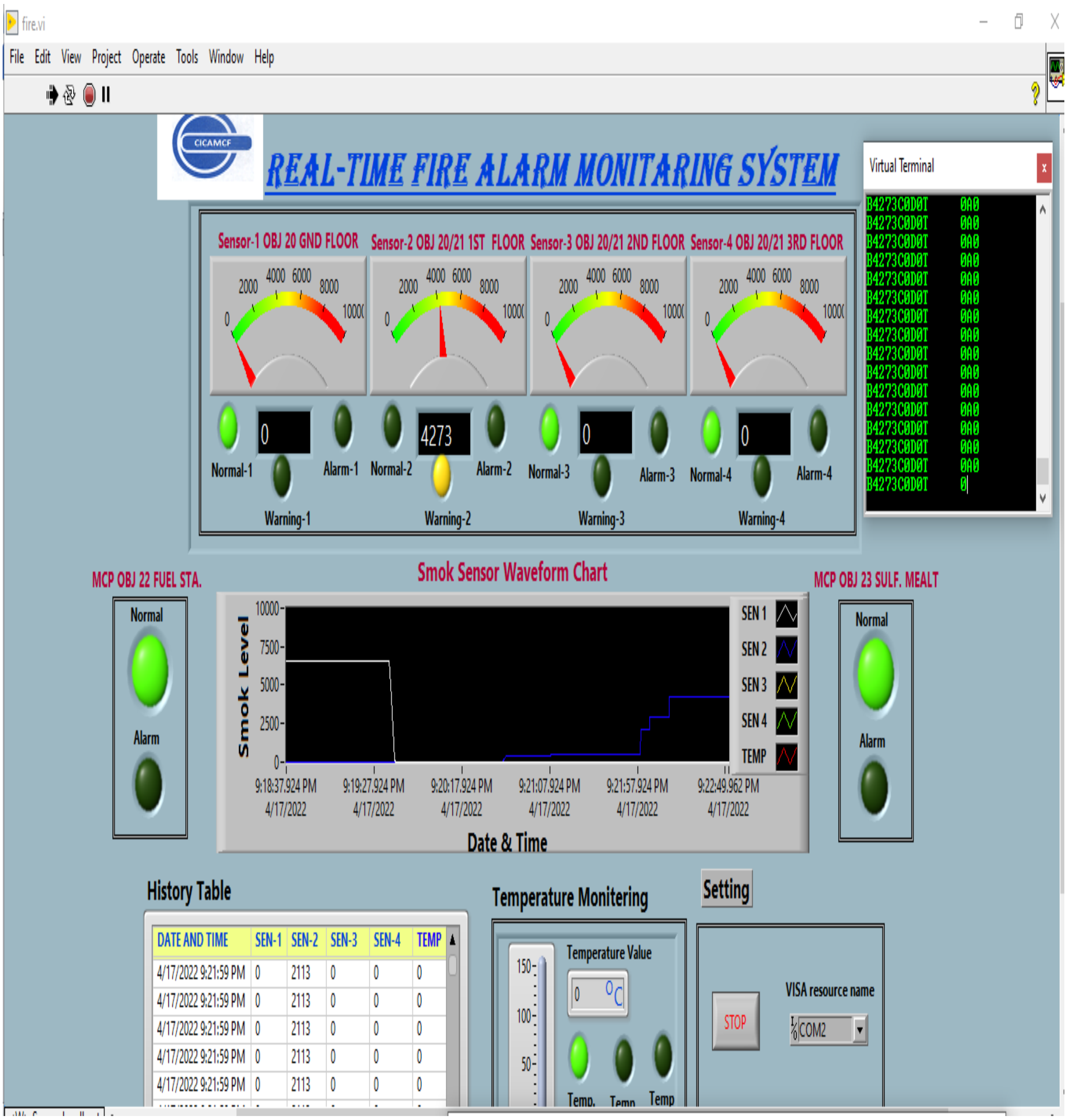


FIGURE 4.11. First floor Scenario two smoke concentration graphical simulation result

Scenario two: Test Result

Table 4.5. First floor Smoke sensor Scenario two: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
1PPM–4273PPM	Thin Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

First floor: Scenario Three: (Fire with a concentration of more than 5000ppm)

The simulation result (figure 4.12) shows that in a room in Alarm condition (with a high level of smoke), the smoke level is between 5001 ppm and 6602 ppm, depending on the MQ-2 sensor sensitivity in clean air factor resistance. According Table 4.6 shows that the buzzer and horn devices were successfully installed, and the Red alarm led indicator on the SCADA computer (figure 4.13) was enabled, as well as a real-time notification to the Fire and Insurance Department via the IoT system. According to the experiment, the Fire Department will get an alarm message via IoT if the smoke level surpasses the threshold amount, as illustrated in Figure 4.48. The notification message to the fire department contains all of the pertinent information, including the name of the factory, recorded data, data, and time.

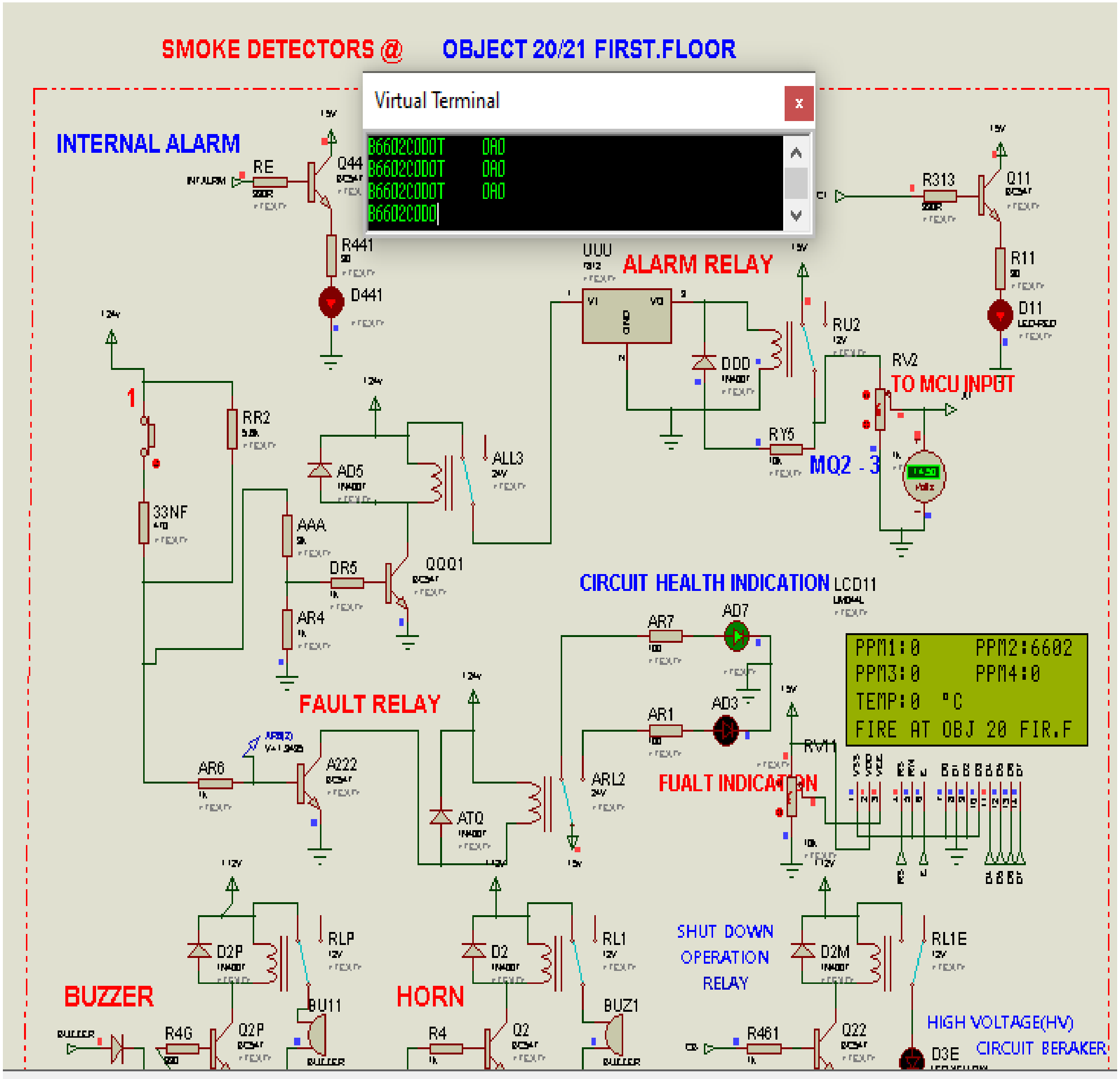


FIGURE 4.12. First floor Scenario Three Smoke concentration/ppm simulation result

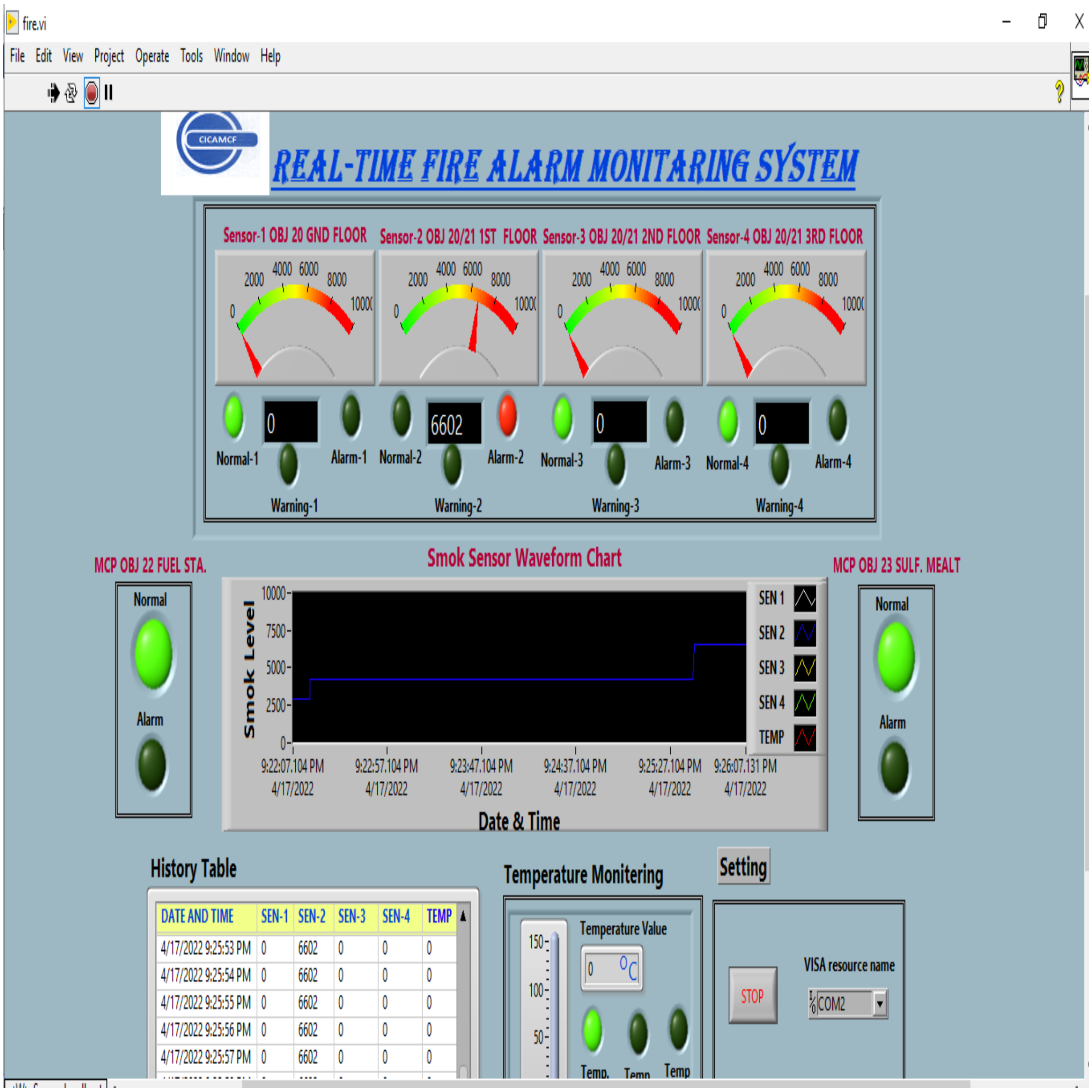


FIGURE 4.13. First floor Scenario Three Smoke concentration graphical simulation result

Scenario Three: Test Result

Table 4.6. First floor Smoke sensor Scenario Three: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
5000PPM __ 6602PPM	Thick Smoke	ON	ON	ON	ON	OFF	OFF	OFF

Visualization of Experimental Data

Figure 4.14 show how smoke levels varied over time for several of the combustible materials used in these studies, as well as the periods when visible smoke and flame appeared and the times when the relevant sensor alarms were activated. Sensor one (SEN2) is recognized by blue horizontal lines, followed by sensor symbols that denote the sensor's alert times. The x-axis shows the time and date it took for the material to ignite, while the y-axis shows how the sensor responded to the smouldering and PPM settings.

Lower smoke present is defined as a smoke value ranging from 0 to 4273 ppm. When a room smoke level is greater than 4273 ppm the microcontroller gets an input signal from the MQ-2 sensor and the microcontroller sent Warning output signal to the SCADA graphics computer as the same time real-time data will be sent to the monitoring station using internet. Therefore, the alarm smoke level chosen for this experiment is larger than 5000 parts per million. The smoke sensor MQ-2 detects smoke and activates the buzzer, and horn, switch off the main circuit breaker and display the status in real-time.

The visualization of smoke concentration (ppm) in the room from 11:14 to 11:18 on April 17 is shown in Figure 4.14. Because the collected data is updated every second, a system of automated updating every second is used to ensure the data's timeliness and proper display function.

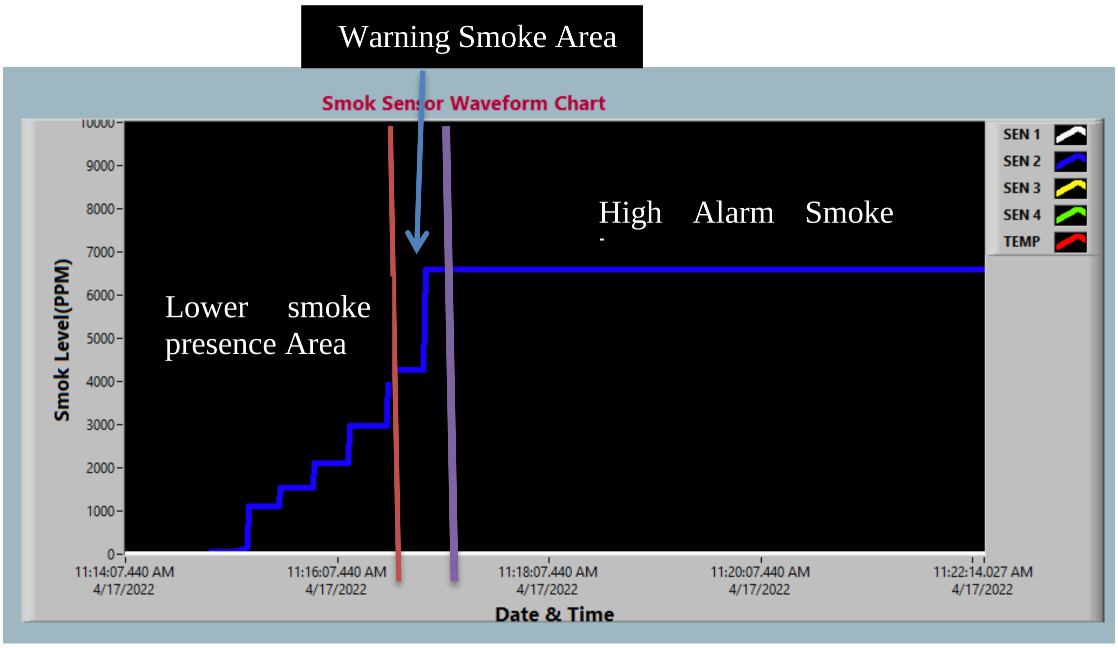


FIGURE 4.14. First floor smoke sensor concentration/ppm waveform chart

4.1.3 Second floor Smoke sensor monitoring simulation result

Second floor: Scenario one: (There is no smoke presence (0 ppm / system Normal).

The simulation result (figure 4.15) shows that the smoke level in a room in normal conditions (without smoke) is 0 ppm, which is dependent on the MQ-2 sensor sensitivity in clean air factor resistance. Table 4.7 shows that no devices have been reached, and a real-time monitoring result (figure 4.16) shows data being transmitted to a graphical SCADA computer, as well as a real-time notification being sent to the Fire and Insurance Department via the IoT system.

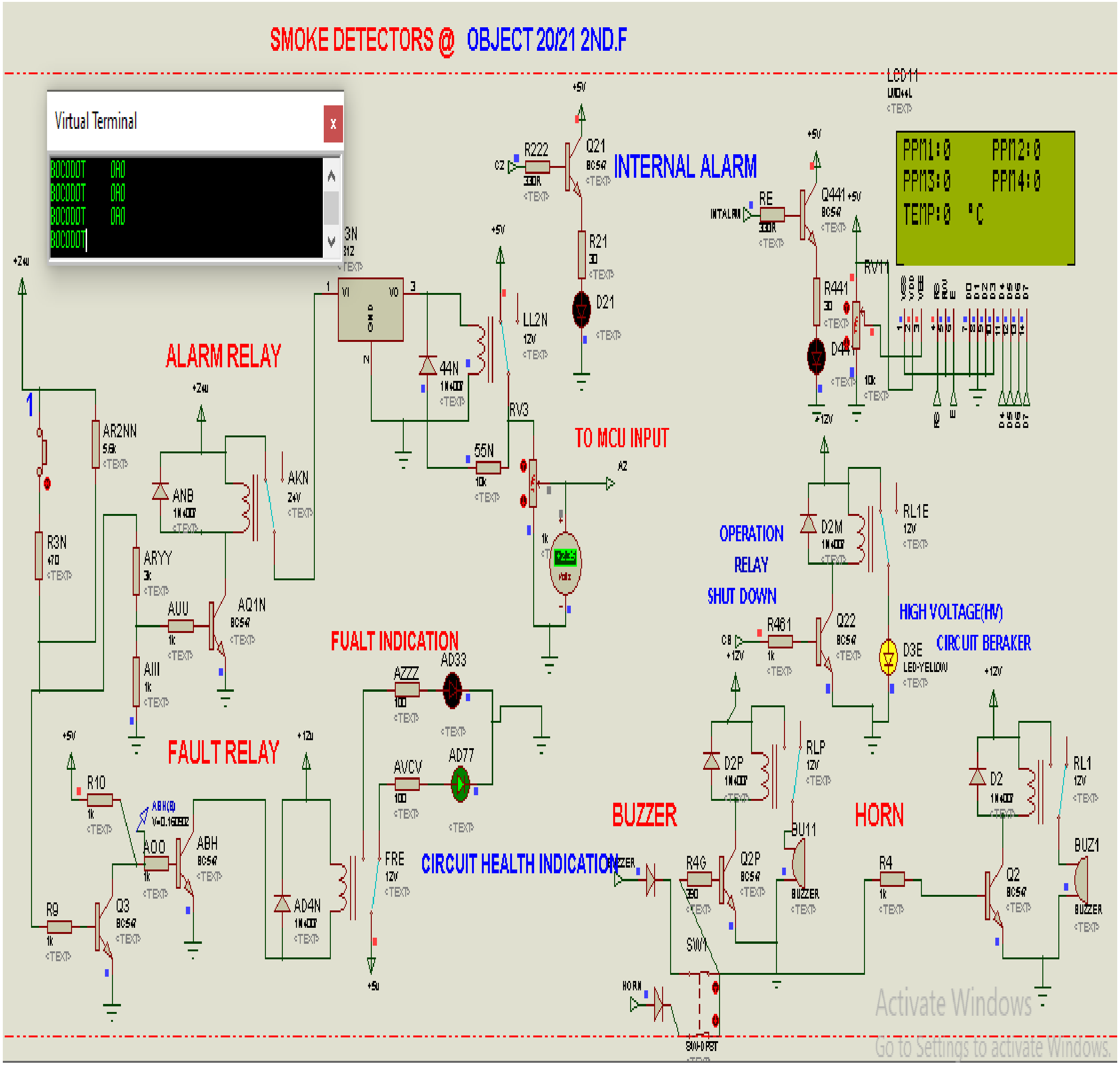


FIGURE 4.15. Second floor Scenario One Smoke concentration/ppm simulation result

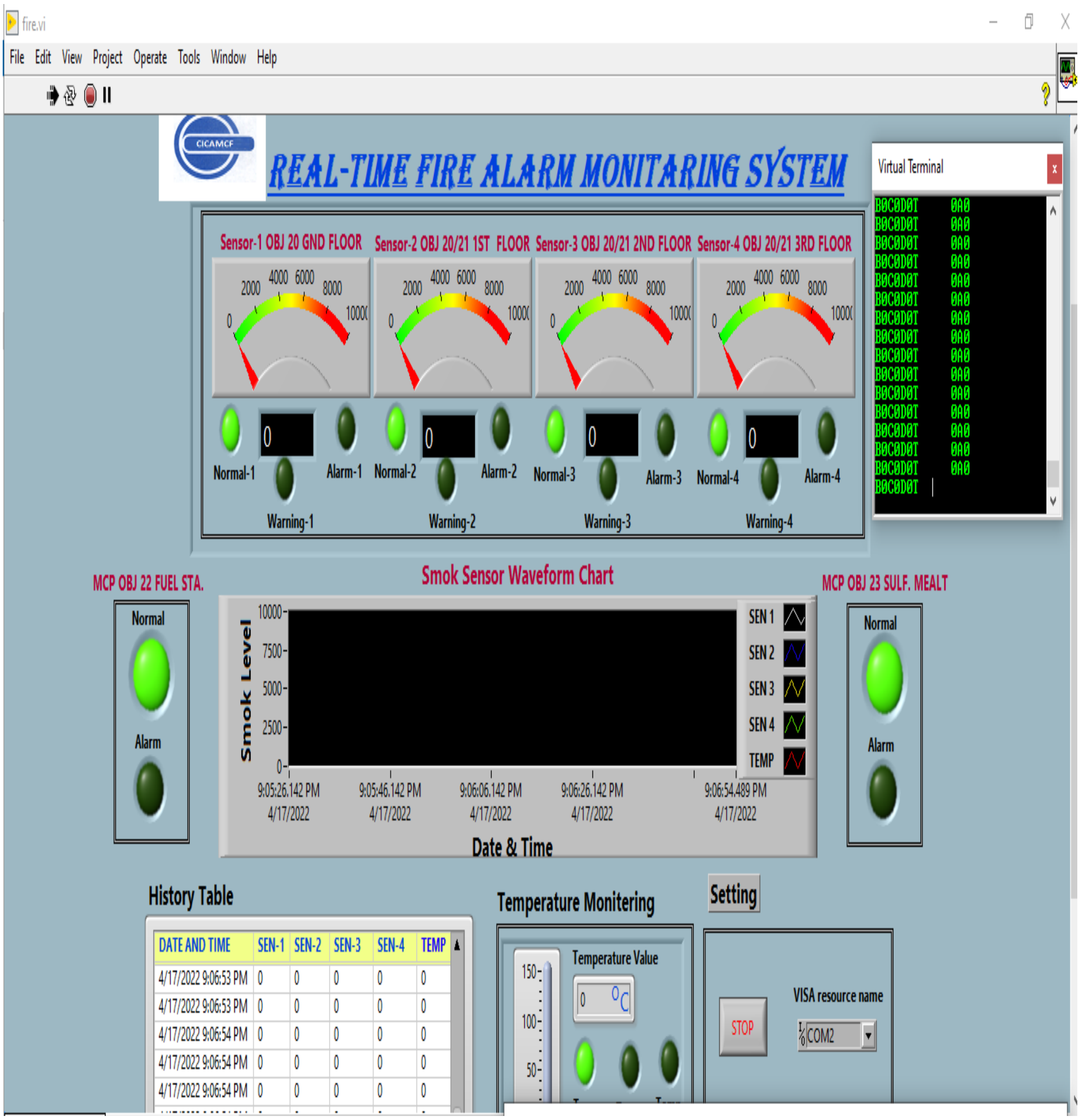


FIGURE 4.16. Second floor Scenario one Smoke concentration graphical simulation result

Scenario One: Test Result

Table 4.7. Second floor Smoke sensor Scenario one: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
0 PPM	without Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Second floor: Scenario Two: (Smoldering fire (non-flame) greater than 4273ppm)

The simulation result (figure 4.17) shows that the smoke level in a room in a warning condition (with smoke present) ranges from 4237 ppm to < 5000 ppm, depending on the MQ-2 sensor sensitivity in the clean air factor resistance. There are no achieved devices, according to Table 4.8, but a warning Yellow light indication enabled on the SCADA computer (figure 4.18) shows data to graphics SCADA computer, as well as a real-time message sent to the Fire and Insurance department utilizing IoT system. Based on the results of the experiments, the smoke level warning was utilized to notify the employer via a preferred platform and the Fire Department to take preventative action before the system broke down.

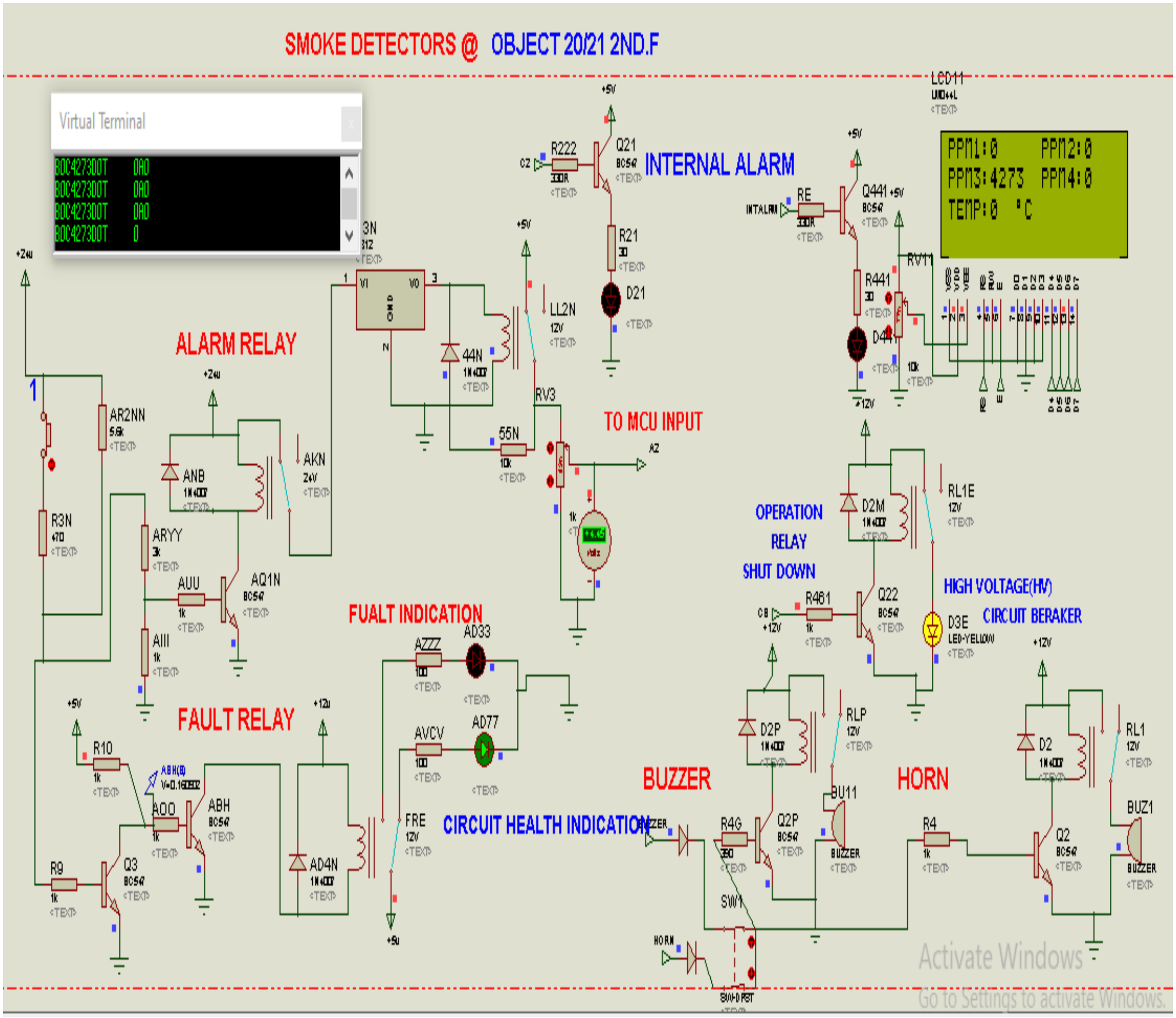


FIGURE 4. 17. Second floor Scenario two Smoke concentration/ppm simulation result

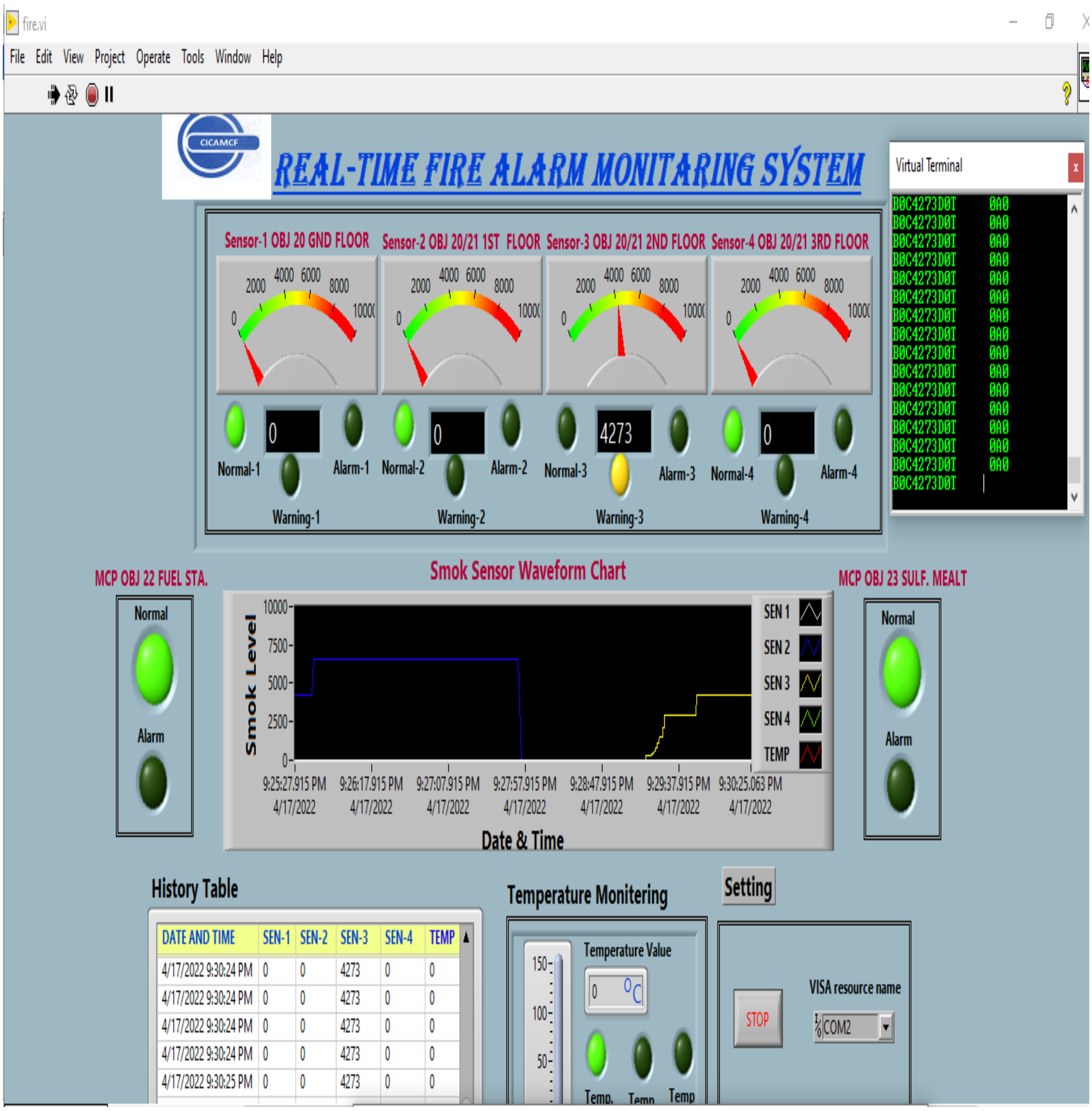


FIGURE 4.18. Second floor Scenario two Smoke concentration graphical simulation result

Scenario Two: Test Result

Table 4.8. Second floor Smoke sensor Scenario Two: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
1PPM–4273PPM	Thin Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Second floor: Scenario Three: (Fire with a concentration of more than 5000ppm)

The simulation result (figure 4.19) shows that in a room in Alarm condition (with a high level of smoke), the smoke level is between 5001 ppm and 6602 ppm, depending on the MQ-2 sensor sensitivity in clean air factor resistance. According Table 4.9 shows that the buzzer and horn devices were successfully installed, and the Red alarm led indicator on the SCADA computer (figure 4.20) was enabled, as well as a real-time notification to the Fire and Insurance Department via the IoT system. According to the experiment, the Fire Department will get an alarm message via IoT if the smoke level surpasses the threshold amount, as illustrated in Figure 4.48. The notification message to the fire department contains all of the pertinent information, including the name of the factory, recorded data, data, and time.

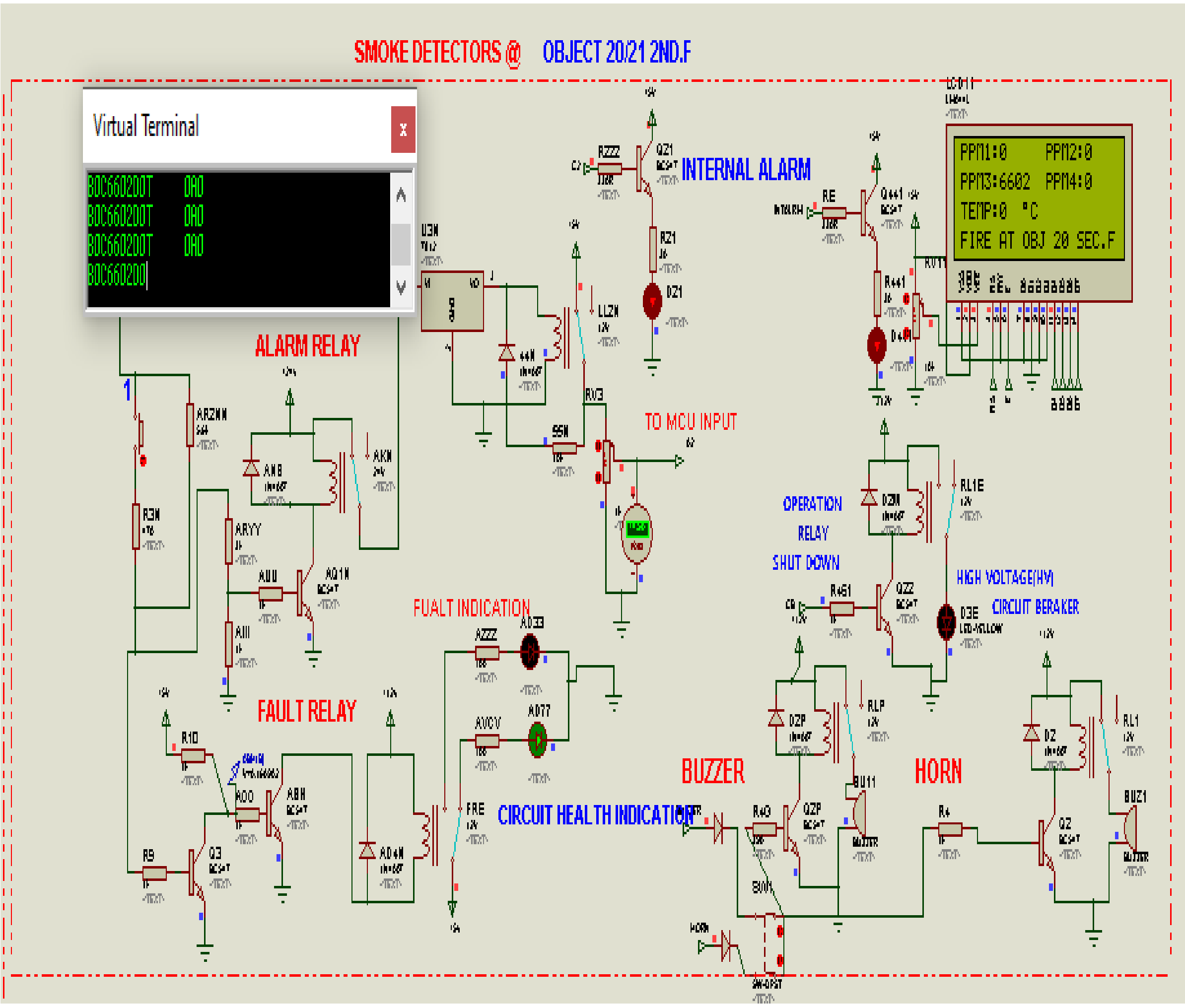


FIGURE 4.19. Second floor Scenario Three Smoke concentration/ppm simulation result

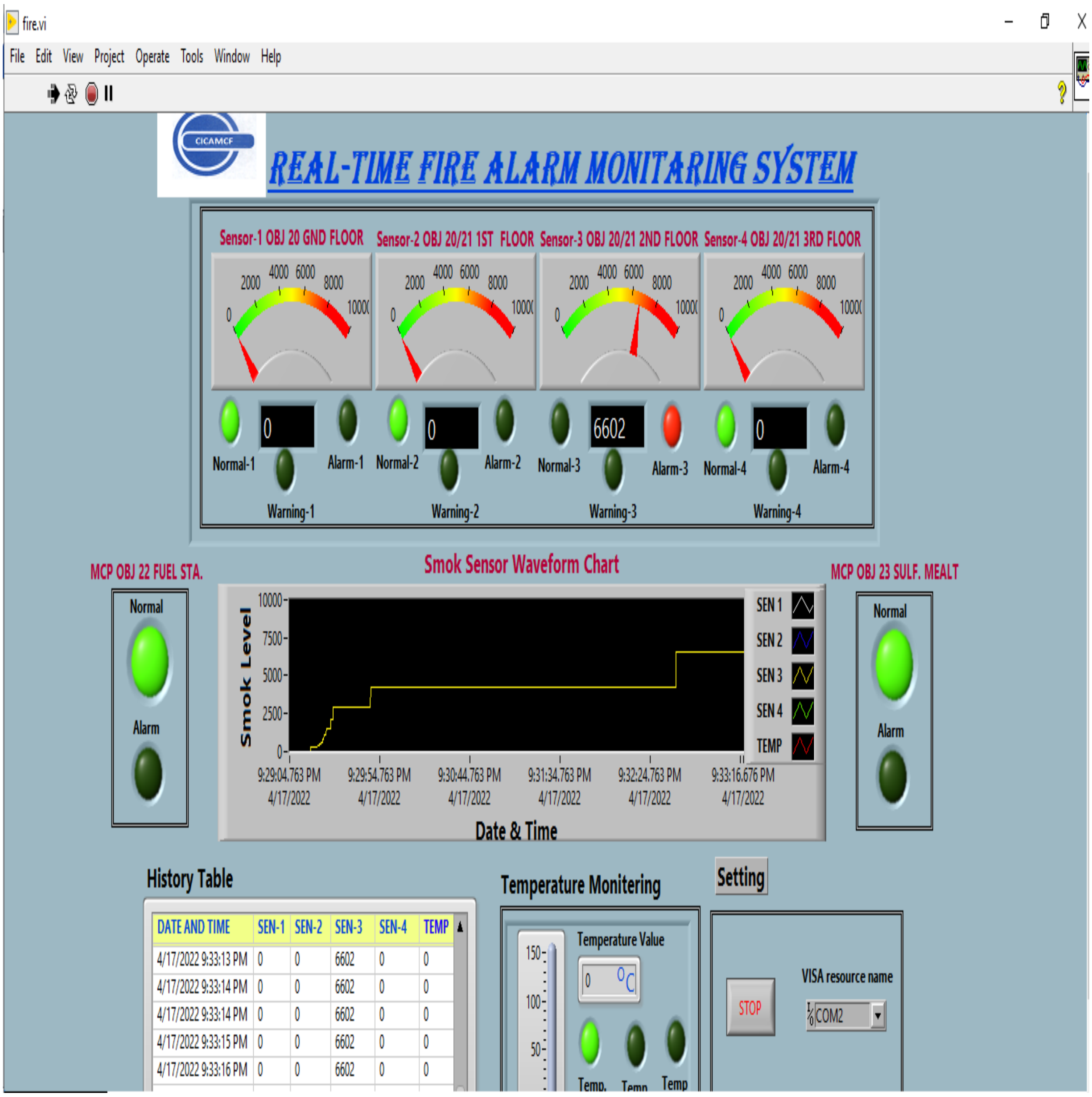


FIGURE 4.20. Second floor Scenario Three Smoke concentration graphical simulation result

Scenario Three: Test Result

Table 4.9. Second floor Smoke sensor Scenario Three: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
5000PPM — 6602PPM	Thick Smoke	ON	ON	ON	ON	OFF	OFF	OFF

Visualization of Experimental Data

Figure 4.21 show how smoke levels varied over time for several of the combustible materials used in these studies, as well as the periods when visible smoke and flame appeared and the times when the relevant sensor alarms were activated. Sensor one (SEN3) is recognized by yellow horizontal lines, followed by sensor symbols that denote the sensor's alert times. The x-axis shows the time and date it took for the material to ignite, while the y-axis shows how the sensor responded to the smouldering and PPM settings.

Lower smoke present is defined as a smoke value ranging from 0 to 4273 ppm. When a room smoke level is greater than 4273 ppm the microcontroller gets an input signal from the MQ-2 sensor and the microcontroller sent Warning output signal to the SCADA graphics computer as the same time real-time data will be sent to the monitoring station using internet. Therefore, the alarm smoke level chosen for this experiment is larger than 5000 parts per million. The smoke sensor MQ-2 detects smoke and activates the buzzer, and horn, switch off the main circuit breaker and display the status in real-time.

The visualization of smoke concentration (ppm) in the room from 11:24 to 11:26 on April 17 is shown in Figure 4.21. Because the collected data is updated every second, a system of automated updating every second is used to ensure the data's timeliness and proper display function.

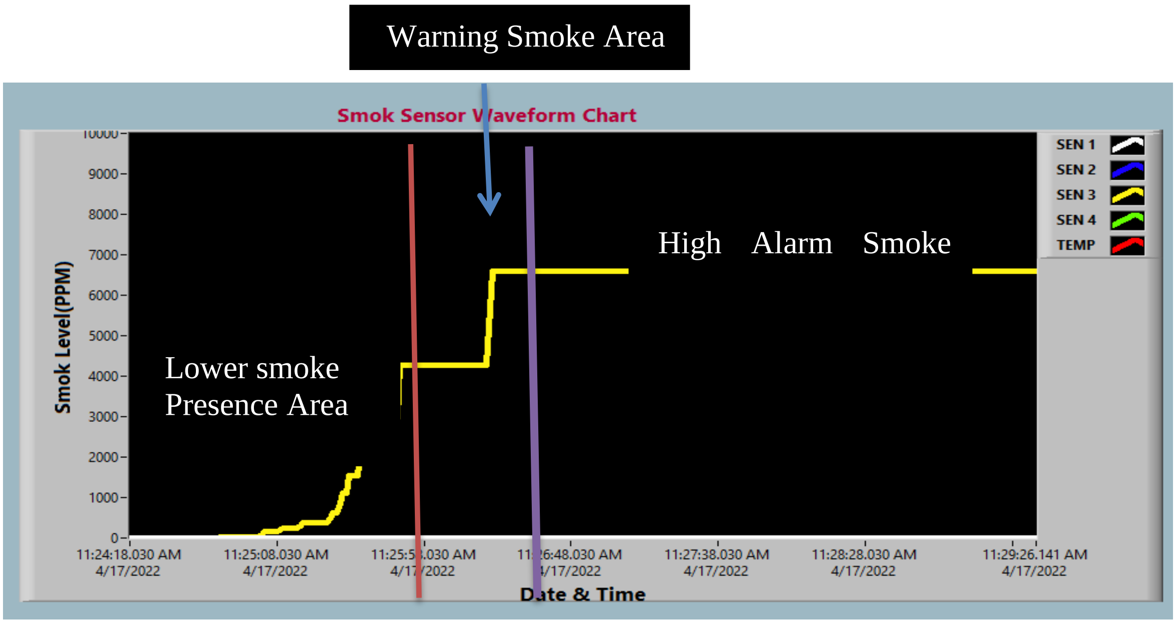


FIGURE 4.21. Third floor Smoke sensor concentration/ppm waveform chart

4.1.4 Third floor Smoke sensor monitoring simulation result

Third floor: Scenario one: (There is no smoke presence (0 ppm / system Normal).

The simulation result (figure 4.22) shows that the smoke level in a room in normal conditions (without smoke) is 0 ppm, which is dependent on the MQ-2 sensor sensitivity in clean air factor resistance. Table 4.9 shows that no devices have been reached, and a real-time monitoring result (figure 4.23) shows data being transmitted to a graphical SCADA computer, as well as a real-time notification being sent to the Fire and Insurance Department via the IoT system.

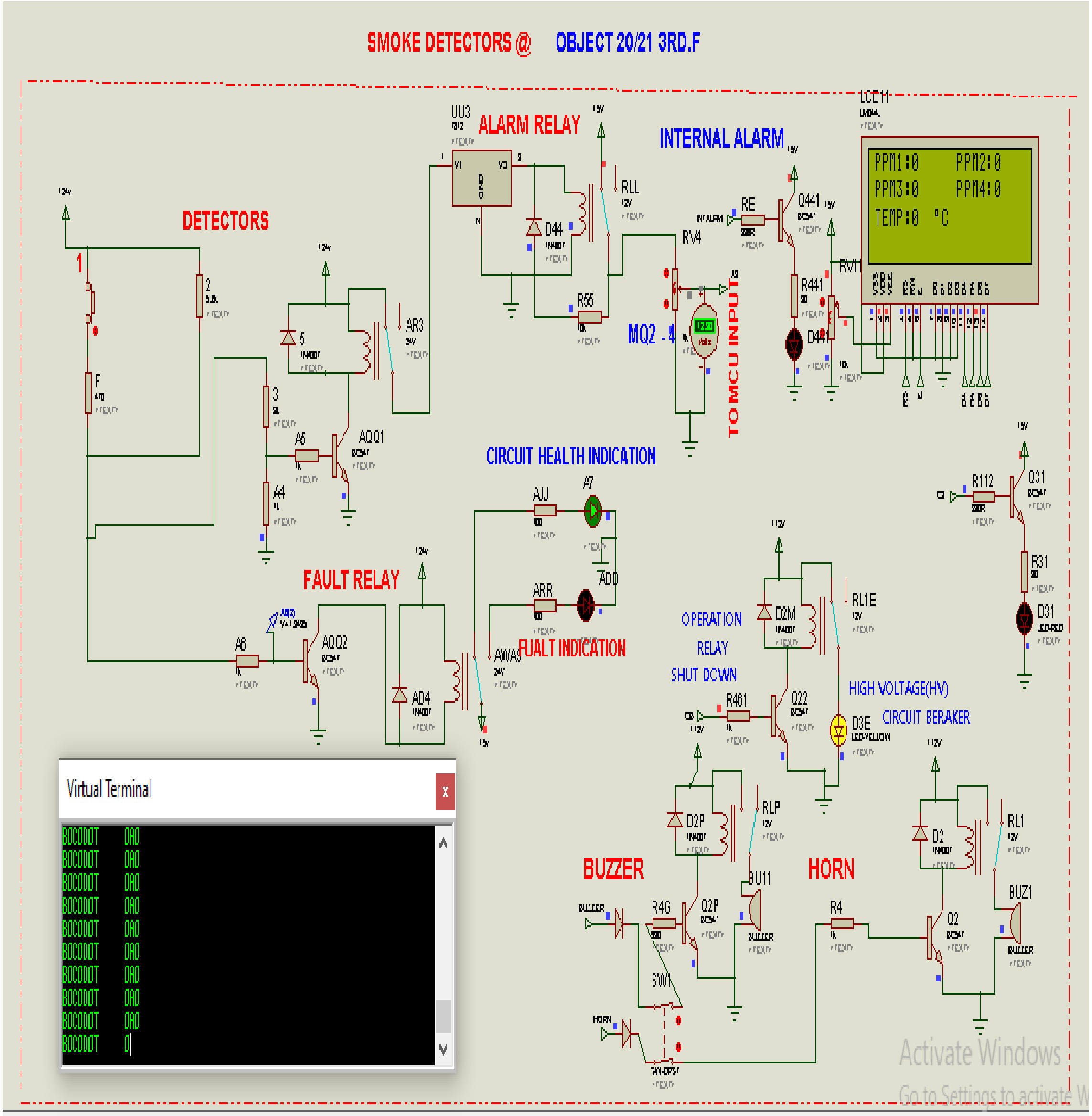


FIGURE 4.22. Third floor Scenario one Smoke concentration/ppm simulation result

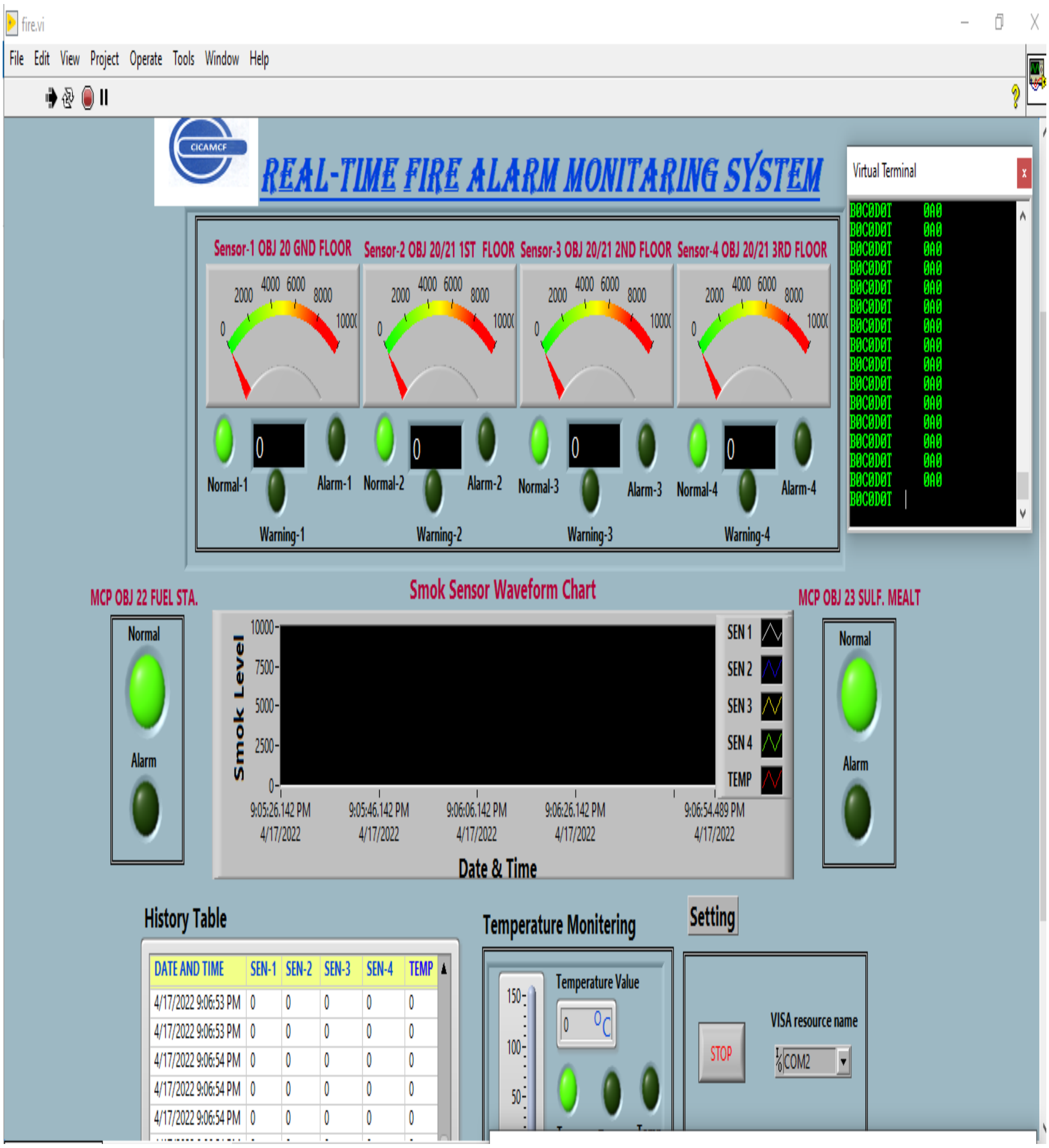


FIGURE 4.23. Third floor Scenario one Smoke concentration graphical simulation result

Scenario one: Test Result

Table 4.10. Third floor Smoke sensor Scenario one : Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
0 PPM	without Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Third floor: Scenario Two: (Smoldering fire (non-flame) greater than 4273ppm)

The simulation result (figure 4.24) shows that the smoke level in a room in a warning condition (with smoke present) ranges from 4237 ppm to < 5000 ppm, depending on the MQ-2 sensor sensitivity in the clean air factor resistance. There are no achieved devices, according to Table 4.10, but a warning Yellow light indication enabled on the SCADA computer (figure 4.25) shows data to graphics SCADA computer, as well as a real-time message sent to the Fire and Insurance department utilizing IoT system. Based on the results of the experiments, the smoke level warning was utilized to notify the employer via a preferred platform and the Fire Department to take preventative action before the system broke down.

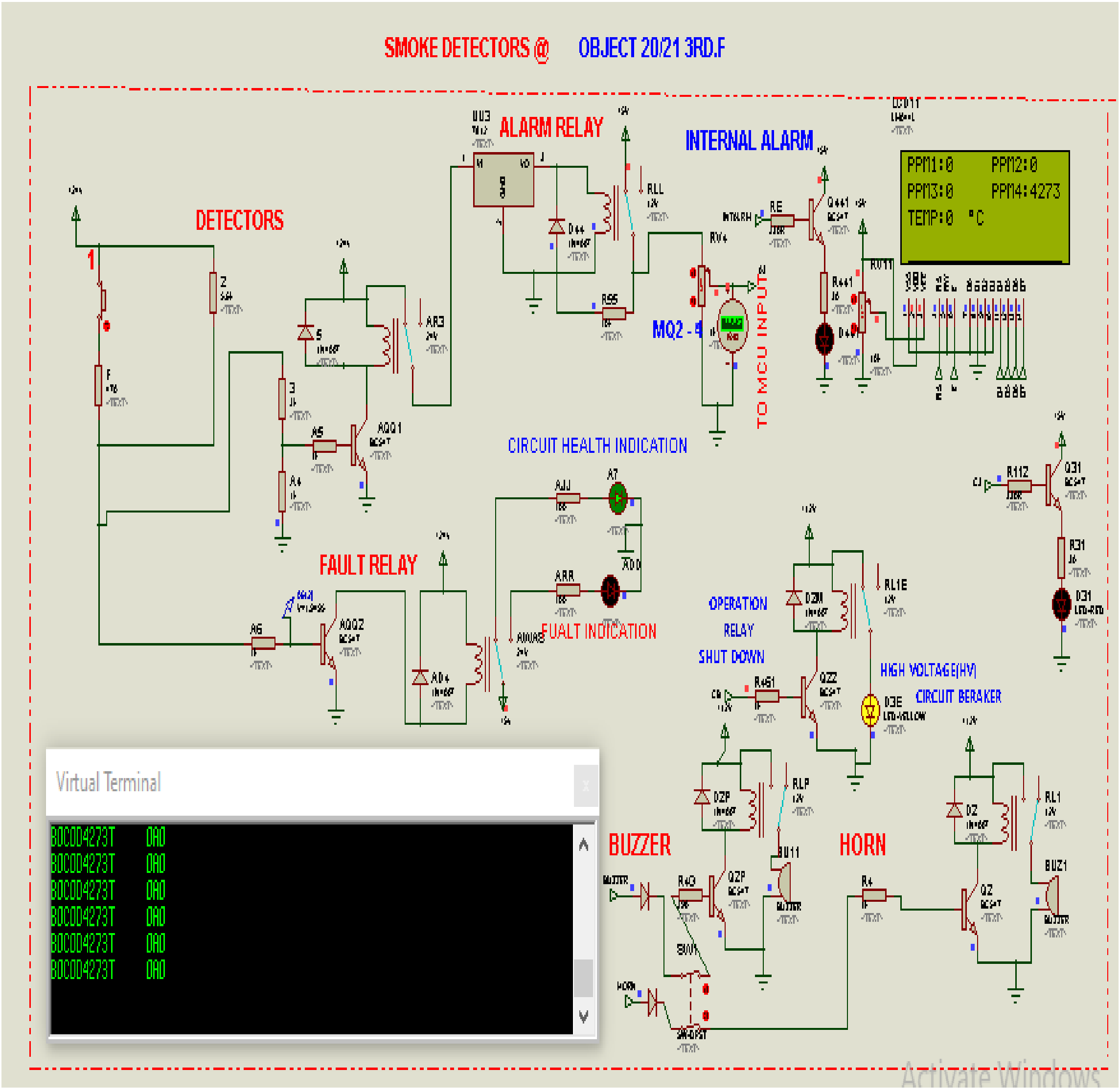


FIGURE 4.24. Third floor Scenario two Smoke concentration/ppm simulation result

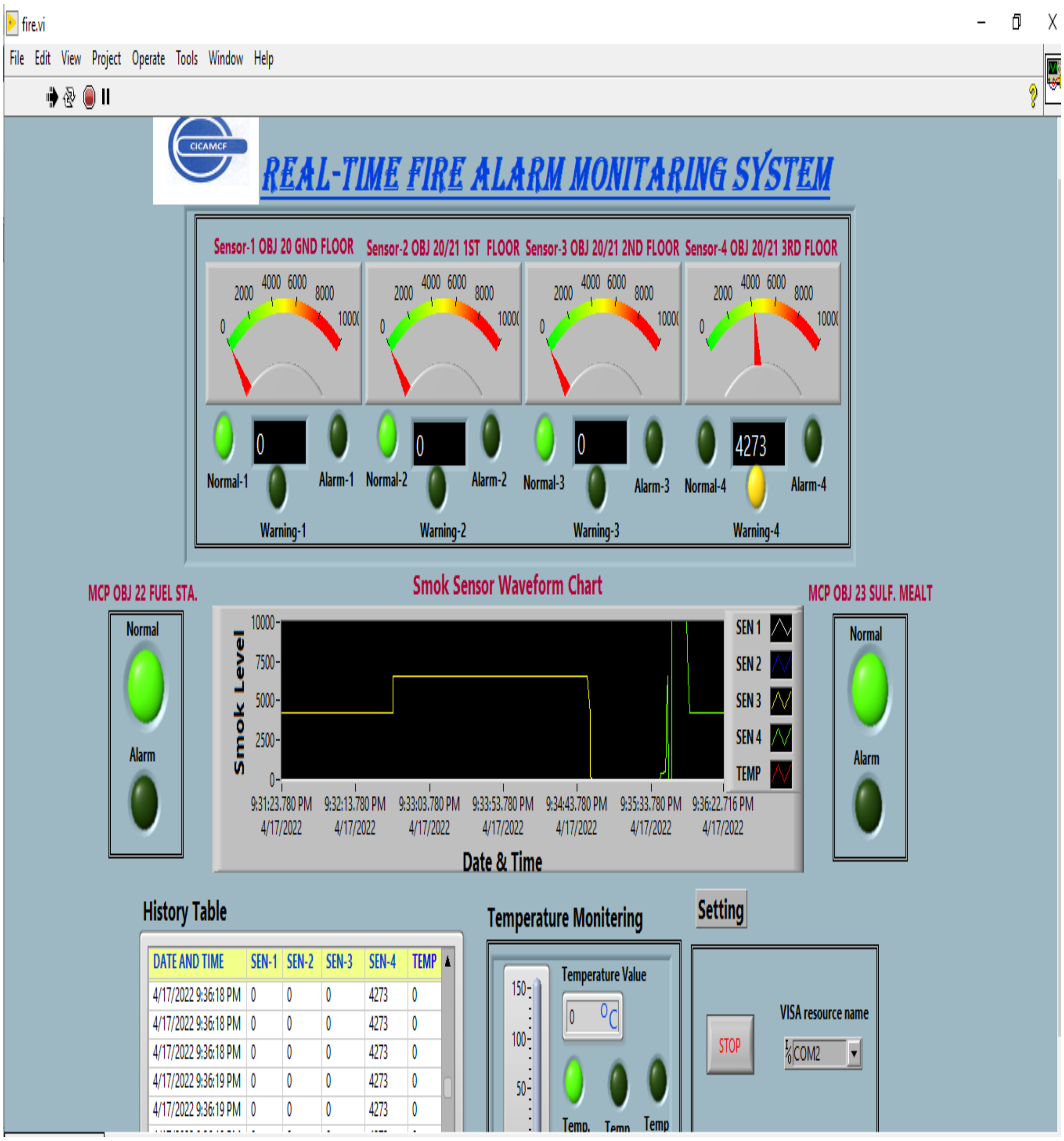


FIGURE 4.25. Third floor Scenario two Smoke concentration graphical simulation result

Scenario Two: Test Result

Table 4.11. Third floor Smoke sensor Scenario two: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
1PPM–4273PPM	Thin Smoke	ON	OFF	OFF	OFF	OFF	ON	OFF

Third floor: Scenario Three: (Fire with a concentration of more than 5000ppm)

The simulation result (figure 4.26) shows that in a room in Alarm condition (with a high level of smoke), the smoke level is between 5001 ppm and 6602 ppm, depending on the MQ-2 sensor sensitivity in clean air factor resistance. According Table 4.11 shows that the buzzer and horn devices were successfully installed, and the Red alarm led indicator on the SCADA computer (figure 4.27) was enabled, as well as a real-time notification to the Fire and Insurance Department via the IoT system. According to the experiment, the Fire Department will get an alarm message via IoT if the smoke level surpasses the threshold amount, as illustrated in Figure 4.48. The notification message to the fire department contains all of the pertinent information, including the name of the factory, recorded data, data, and time.

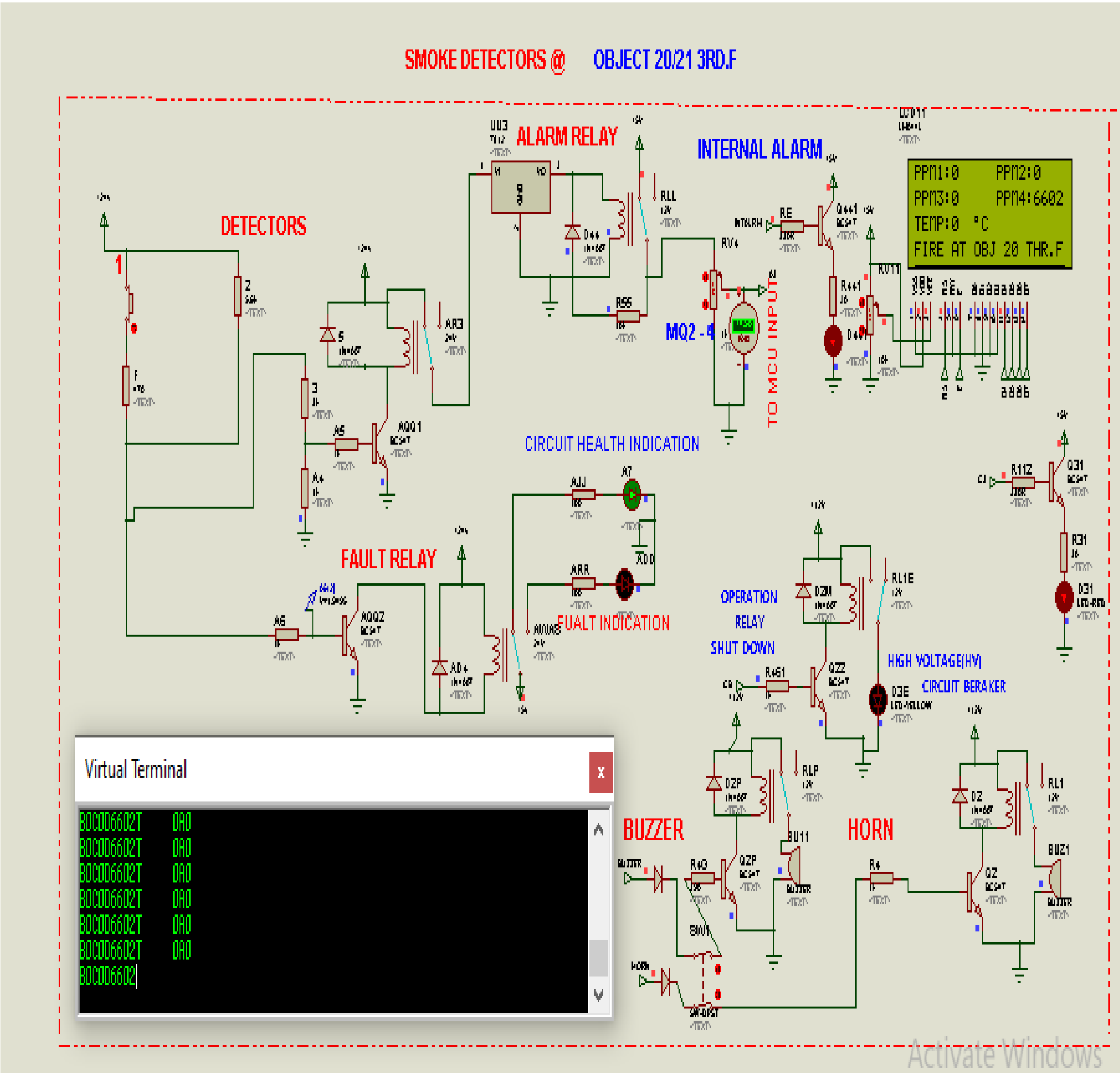


FIGURE 4.26. Third floor Scenario Three Smoke concentration/ppm simulation result

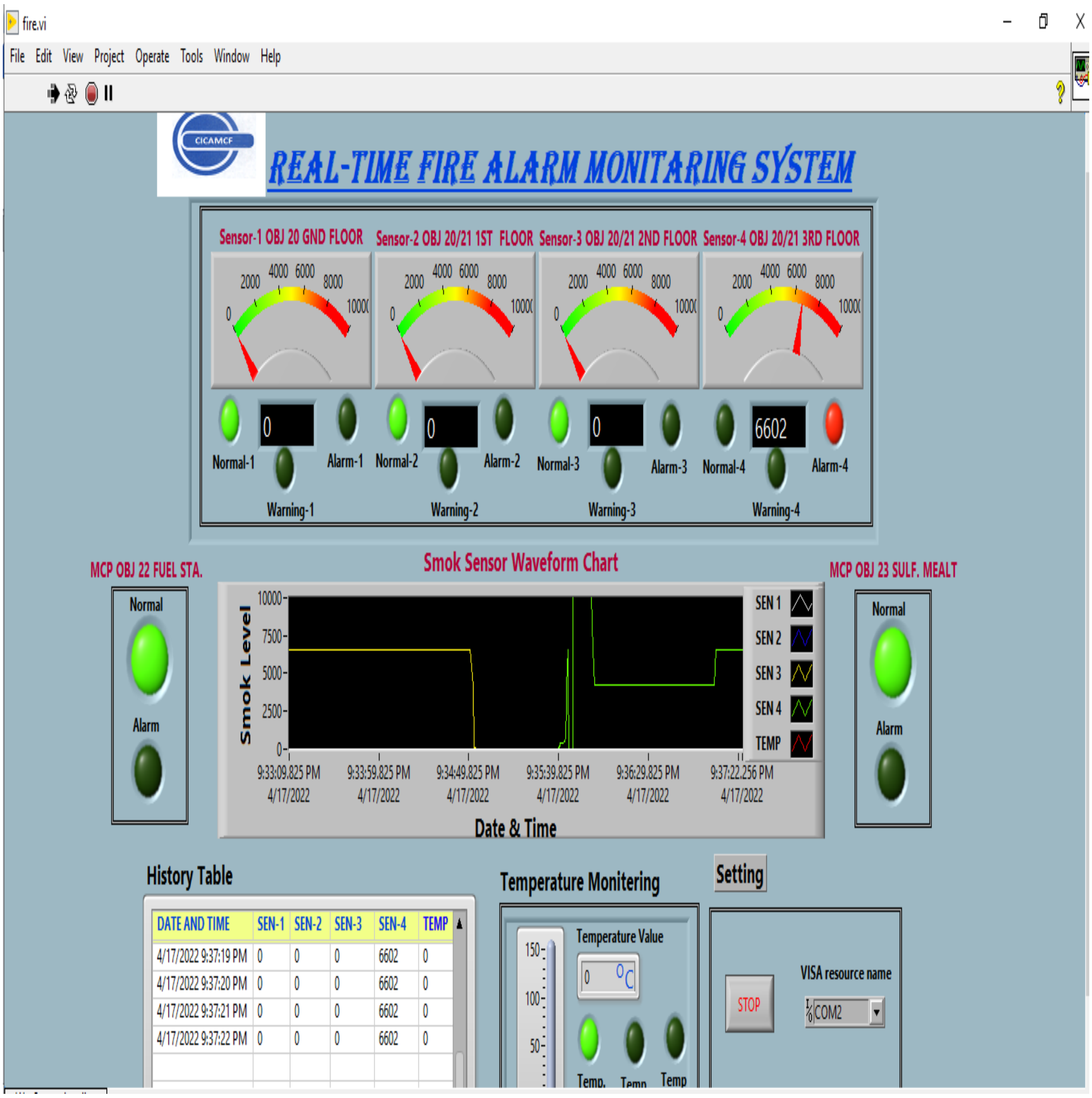


FIGURE 4.27. Third floor Scenario Three Smoke concentration/ppm simulation result

Scenario Three: Test Result

Table 4.12. Third floor Smoke sensor Scenario Three: Test Result

MQ2 Smoke sensor	Smoke level	Circuit health Green led	Fire alarm RED led	Internal Alarm RED	Alarm Relay	Fault Relay	CB	Buzzer & Horn
5000PPM __ 6602PPM	Thick Smoke	ON	ON	ON	ON	OFF	OFF	OFF

Visualization of Experimental Data

Figure 4.28 show how smoke levels varied over time for several of the combustible materials used in these studies, as well as the periods when visible smoke and flame appeared and the times when the relevant sensor alarms were activated. Sensor one (SEN4) is recognized by green horizontal lines, followed by sensor symbols that denote the sensor's alert times. The x-axis shows the time and date it took for the material to ignite, while the y-axis shows how the sensor responded to the smouldering and PPM settings.

Lower smoke present is defined as a smoke value ranging from 0 to 4273 ppm. When a room smoke level is greater than 4273 ppm the microcontroller gets an input signal from the MQ-2 sensor and the microcontroller sent Warning output signal to the SCADA graphics computer as the same time real-time data will be sent to the monitoring station using internet. Therefore, the alarm smoke level chosen for this experiment is larger than 5000 parts per million. The smoke sensor MQ-2 detects smoke and activates the buzzer, and horn, switch off the main circuit breaker and display the status in real-time.

The visualization of smoke concentration (ppm) in the room from 11:32 to 11:37 on April 17 is shown in Figure 4.28. Because the collected data is updated every second, a system of automated updating every second is used to ensure the data's timeliness and proper display function.

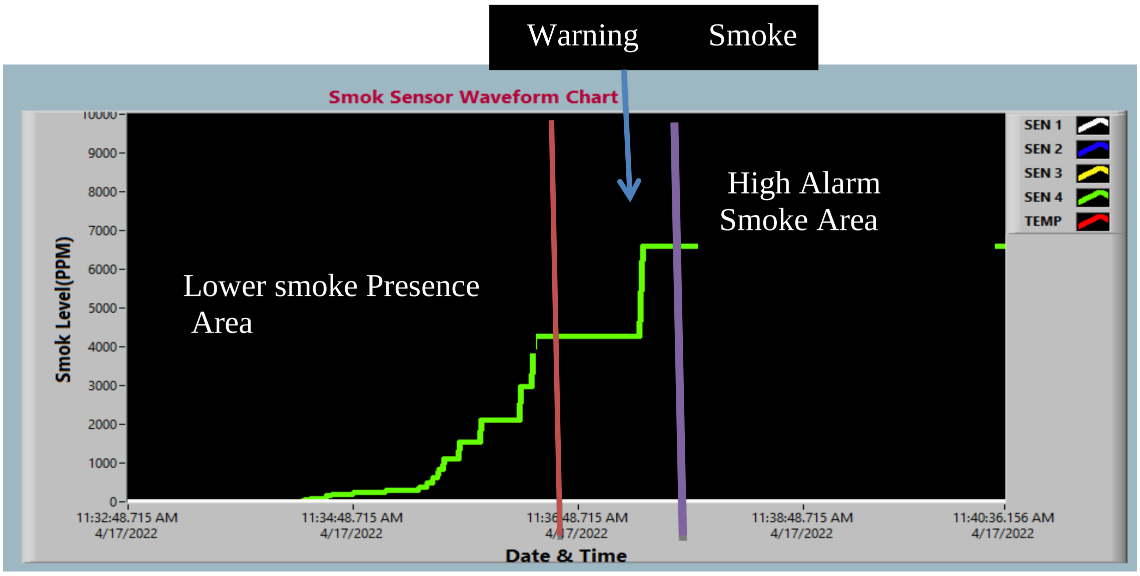


FIGURE 4.28. Fourth floor Smoke sensor concentration/ppm waveform chart

Figure 4.29 illustrate the whole four smoke sensors waveforms chart which is for SENSOR 1 with White horizontal lines, SENSOR 2 with Blue horizontal lines, SENSOR 3 with Yellow horizontal lines, and SENSOR 4 with Green horizontal lines for some of the combustible materials used in these studies, how the levels of smoke changed over time.

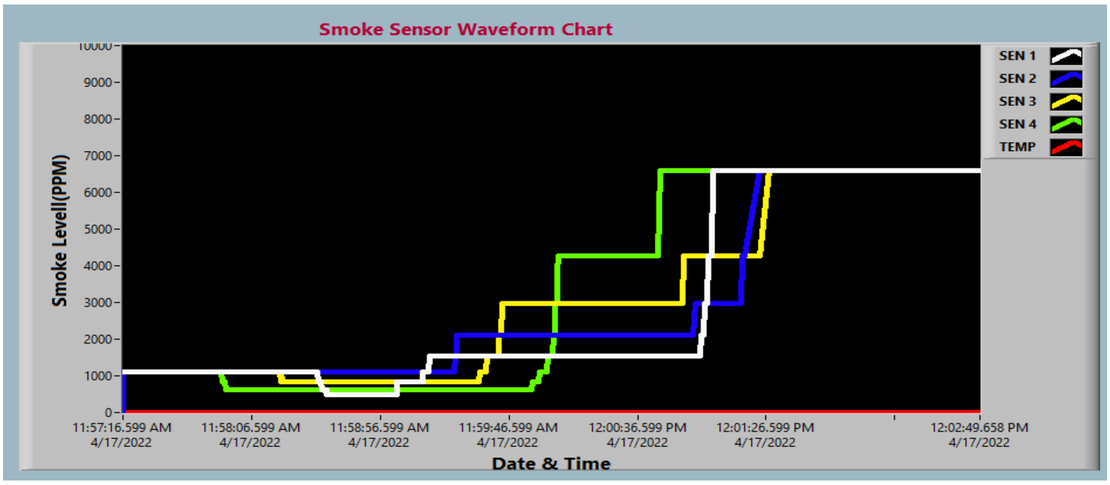


FIGURE 4.29. All Smoke sensor concentration/ppm waveform chart

Table 4.13. Smoke sensors/ppm vs. input voltage Test Result

Condition	MQ2 smoke sensor	Sensor output Voltage
Without Smoke	0 PPM	0V - 2.35V
Thin Smoke	1 PPM - 2473 PPM	2.40V - 4.34V
Medium Smoke	2474 PPM -4999 PPM	4.44V - 4.49V
Thick Smoke	5000 PPM -6602 PPM	4.50V - 4.55V

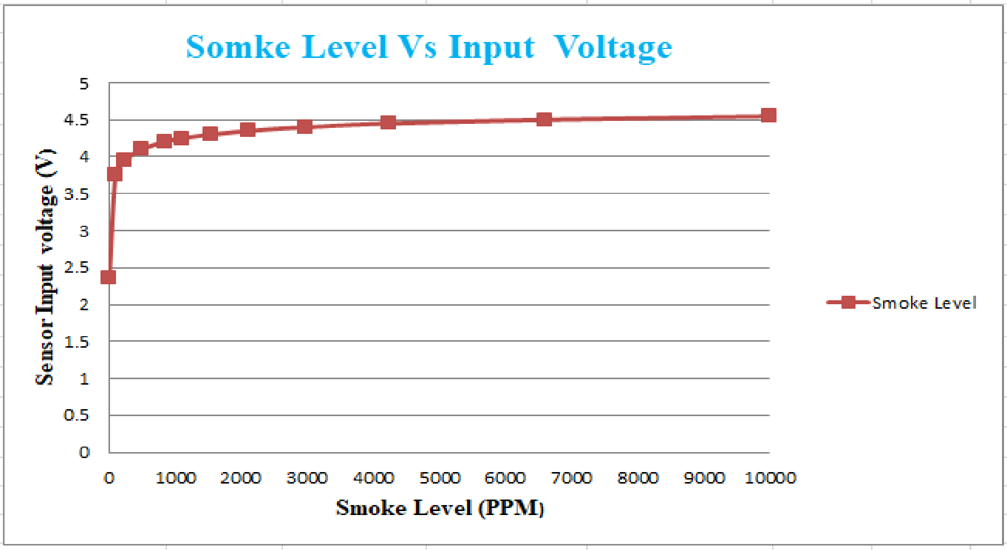


FIGURE 4.30. Smoke concentration/ppm vs. input voltage graphs

Table 4.14. Smoke sensors simulation result summery

Mentoring Parameters & status	Smoke Level PPM. value 0 %	Smoke Level PPM. Value < 4273%	Smoke Level PPM. Value >= 5000 %	Smoke Level PPM. Value >6602 % & 10000 %
On LCD	Display Smoke Level	Display Smoke Level	Display Smoke Level and alarm Objet no/Zone	Display Smoke Level and alarm Objet no/Zone
On SCADA	Smoke Level Displayed in Digital normal Green Led ON	Smoke Level Displayed in Analog & digital normal Green Led ON	Smoke Level Displayed in Analog & digital Alarm Red Led ON	Smoke Level Displayed in Analog & digital Alarm Red Led ON
On IoT	Smoke Level Displayed in Digital & normal Green Led ON	Smoke Level Displayed in Digital & normal Green Led ON	Smoke Level Displayed in Digital & Alarm Red Led ON	Smoke Level Displayed in Digital & Alarm Red Led ON
On virtual terminal display	A,B,C&D	Smoke Level Current Value displayed	Smoke Level Current Value displayed	Smoke Level Current Value displayed
System health indication Green LED	ON	ON	ON	ON
Object/Zone Fire alarm indication	OFF	OFF	BLINK	BLINK

Internal Fire alarm indication Red LED	OFF	OFF	ON	ON
Fire Alarm Relay	DIENERGIZED	DIENERGIZED	ENERGIZED	ENERGIZED
Fault indication Relay	DIENERGIZED	DIENERGIZED	DIENERGIZED	DIENERGIZED
Buzzer (ON/OFF)	OFF	OFF	ON	ON
HV Circuit breaker (ON/OFF)	ON	ON	OFF	OFF
Horn(ON/OFF)	OFF	OFF	ON	ON

4.1.5 Gas Station Manual call point monitoring simulation result

Gas Station: Scenario One: (Normal situation / no fire /no broken glass)

The simulation result obtained (figure 4.31) indicates there are no fire object/zone displays on LCD and a real-time monitoring result obtained (figure 4.32) indicates system normal indication Green led ON to Lab VIEW software/SCADA/ and IoT.

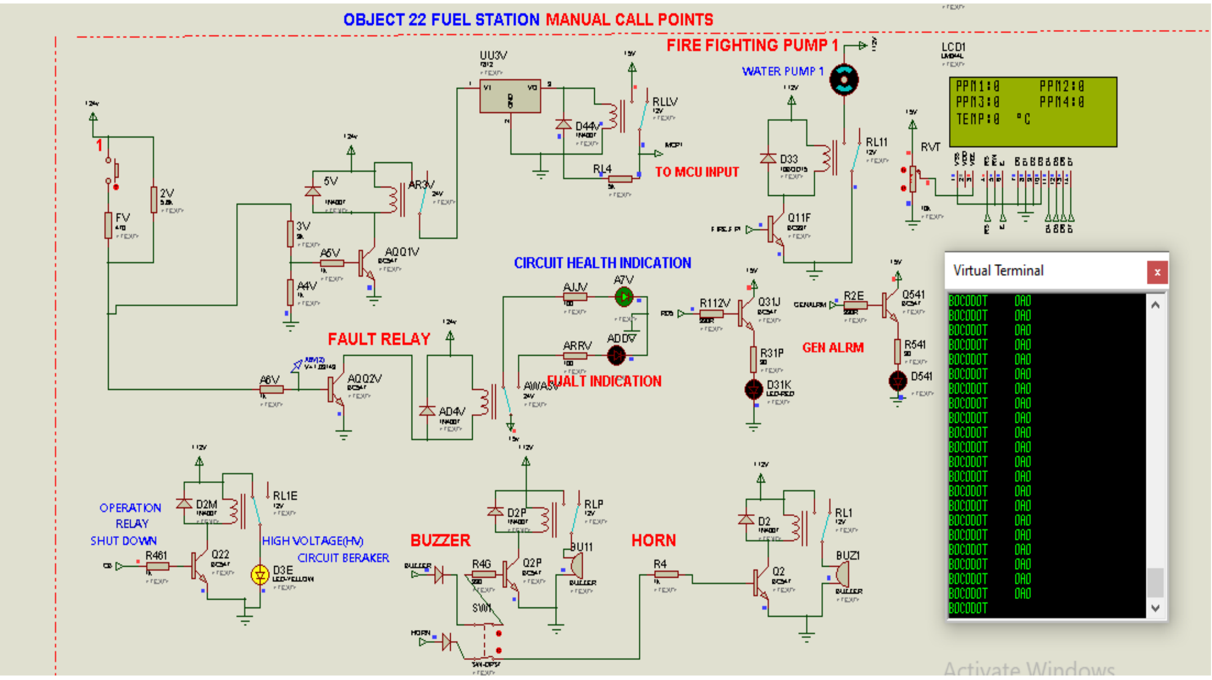


FIGURE 4.31. Gas Station Scenario one Manual call point normal situation simulation result

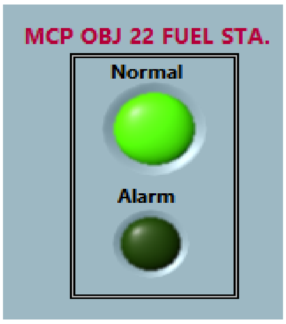


FIGURE 4.32. Gas Station Scenario One Manual call point normal situation graphical simulation result

Scenario One: Test Result

Table 4.15. Gas Station MCP Scenario one: normal situation Test Result

MCP	Circuit health Green led	Fire alarm RED led	General Alarm RED led	Alarm Relay	Fault Relay	Circuit breaker	Buzzer & Horn	Pump
Case of no fire		OFF	OFF	OFF	OFF	ON	OFF	STOP

Gas Station: Scenario Two: Fire situation (broken glass)

Simulation result obtained (figure 4.33 and figure 4.34) indicates that when there is a fire person will break the glass and press the buttons then the system circuit gets a closed loop and activate an alarm in the control room and displays the object/zone on the LCD and system Fire indication Red led ON data will be sent to Lab VIEW software/SCADA/ using serial port communication that connecting to a computer.

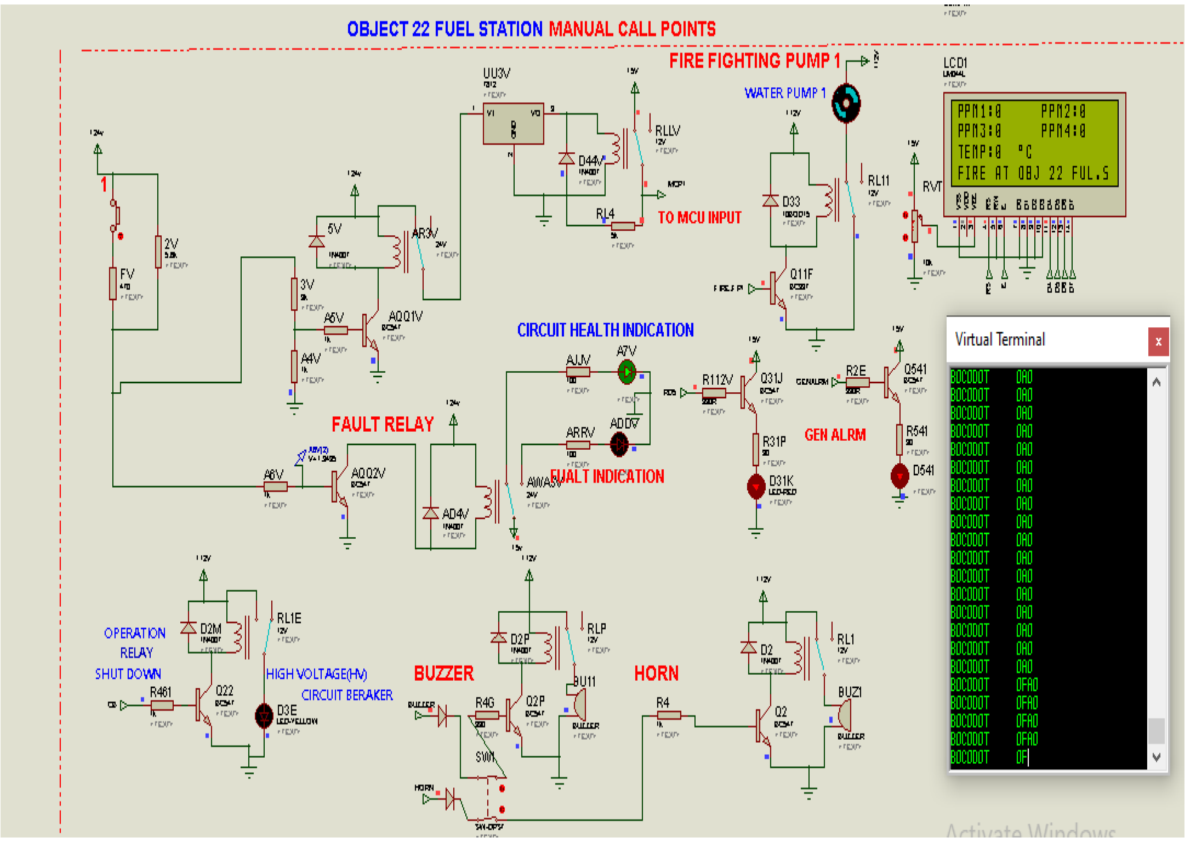


FIGURE 4.33. Gas Station Scenario two Manual call point fire situation simulation result

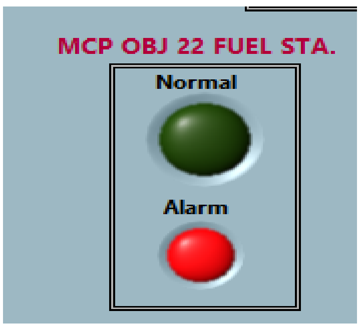


FIGURE 4.34. Gas Station Scenario two Manual call point fire situation graphical simulation result

Scenario Two: Test Result

Table 4.16. Gas Station MCP Scenario Two: fire situation Test Result

MCP	Circuit health Green led	Fire alarm RED led	General Alarm RED led	Alarm Relay	Fault Relay	Circuit breaker	Buzzer & Horn	Pump
Case of fire	ON	ON	ON	ON	OFF	OFF	ON	START

4.1.6 Sulfur Melting area Manual call point monitoring simulation result

Sulfur Melting Area: Scenario one: (Normal situation (no fire, no broken glass)

The simulation result obtained (figure 4.35) indicates there are no fire object/zone displays on LCD and a real-time monitoring result obtained (figure 4.36) indicates system normal indication Green led ON to Lab VIEW software/SCADA/.

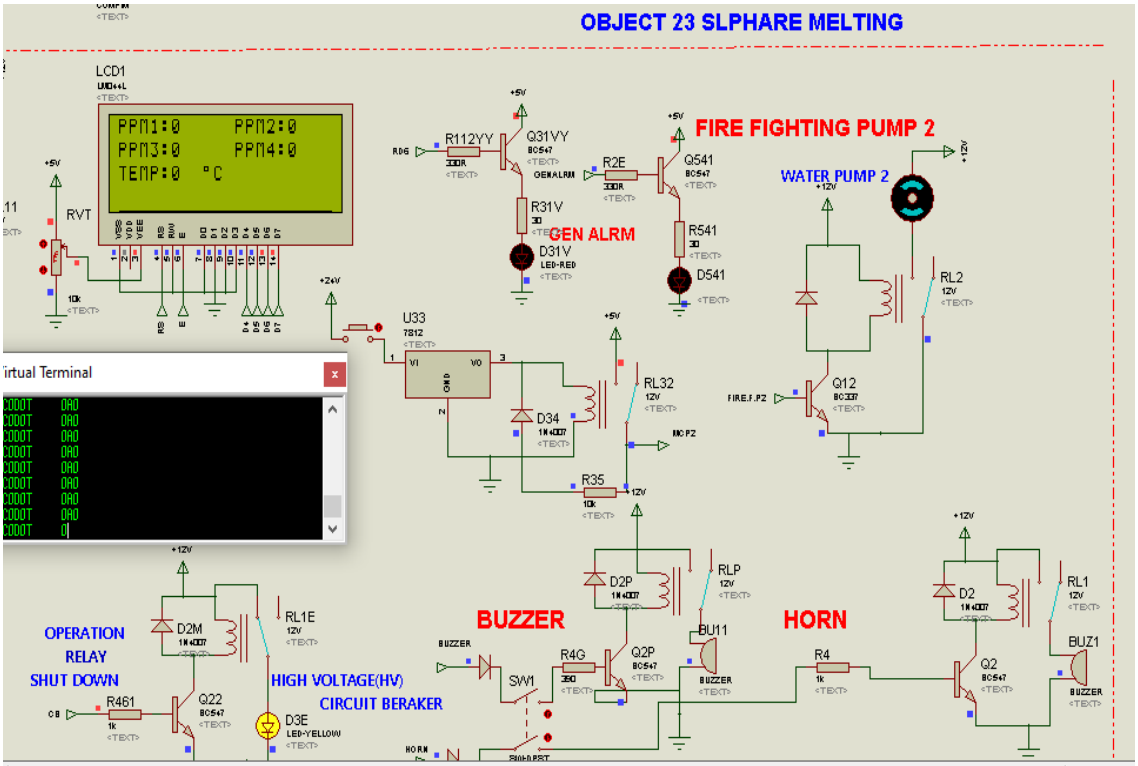


FIGURE 4.35. Sulphur Melting area Scenario one Manual call point normal situation simulation result

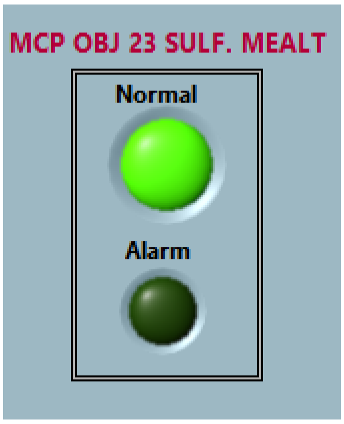


FIGURE 4.36. Sulphur Melting area Scenario one Manual call point normal situation monitoring simulation result

Scenario one: Test Result

Table 4.17. Sulphur Melting area MCP Scenario one: normal situation Test Result

MCP	Circuit health Green led	Fire alarm RED led	General Alarm RED led	Alarm Relay	Fault Relay	Circuit breaker	Buzzer & Horn	Pump
Case of no fire		OFF	OFF	OFF	OFF	ON	OFF	STOP

Sulfur Melting Area: Scenario Two: Fire situation (broken glass)

Simulation result obtained (figure 4.37 and figure 4.38) indicates that when there is a fire a person will break the glass and press the buttons then the system circuit gets a closed loop and activate an alarm in the control room and displays the object/zone on the LCD and system Fire indication Red led ON data will be sent to Lab VIEW software/SCADA/ using serial port communication that connecting to a computer.

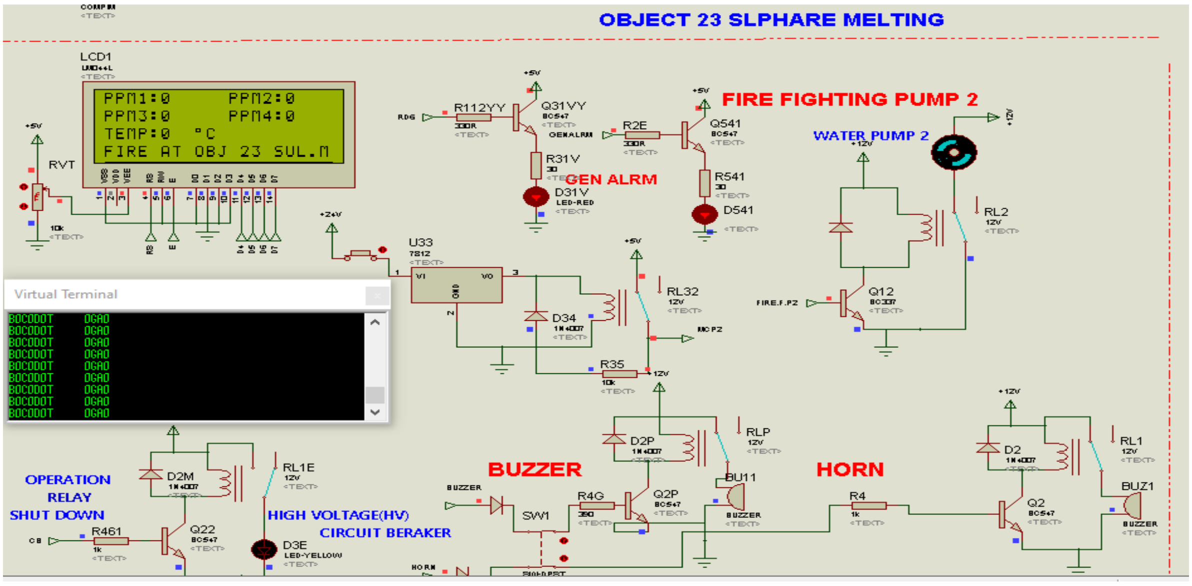


FIGURE 4.37. Sulphur Melting Area Scenario two Manual call point fire situation simulation result

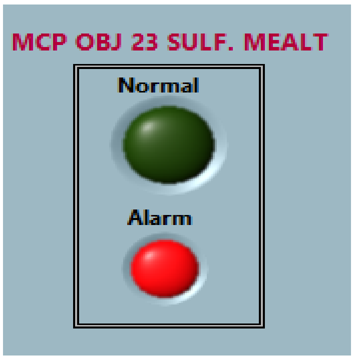


FIGURE 4.38. Sulphur Melting Area Scenario two Manual call point fire situation graphical simulation result

Scenario Two: Test Result

Table 4.18. Sulphur Melting area MCP Scenario Two: fire situation Test Result

MCP	Circuit health Green led	Fire alarm RED led	General Alarm RED led	Alarm Relay	Fault Relay	Circuit breaker	Buzzer & Horn	Pump
Case of fire	ON	ON	ON	ON	OFF	OFF	ON	START

Table 4.19. Manual call points simulation result summery

Mentoring Parameters & status	Normal condition	Fire condition
On LCD	No Display	Display alarm Object no/Zone
On SCADA	Normal Green	Alarm Red Led ON
On IoT	Led ON	Alarm Red Led ON
On virtual terminal display	Normal Green Led ON	F and G
System health indication Green LED	No display	ON
Object no/Zone Fire alarm indication Red LED	ON OFF	BLINK
General Fire alarm indication Red LED	OFF	ON
Fire Alarm Relay	DIENERGIZE	ENERGIZED
Fault indication Relay	DIENERGIZE	DIENERGIZED

Buzzer	OFF	ON
HV CB Shutdown operating relay (ON/OFF)	ON	OFF
Horn(ON/OFF)	OFF	ON
Firefighting Pump 1&2 run/stop	STOP	RUN

4.1.7 Normal state 15KV switchgear room Temperature monitoring simulation result

Scenario One: (System at normal state is set to 0 ^{o}C up $\leq$ 57^{o}C)

These are normal conditions, and the Simulation result (figure 4.39) shows that the room temperature real-time reading value will be displayed on LCD, and the microcontroller will transmit a signal via output PORT RE1. The current room temperature is displayed utilizing serial port communication that links to the computer by Lab VIEW software/SCADA. Table 4.20 shows that no devices have been reached, and a real-time monitoring result (figure 4.40) shows data being transmitted to a graphical SCADA computer, as well as a real-time notification being sent to the Fire and Insurance Department via the IoT system.

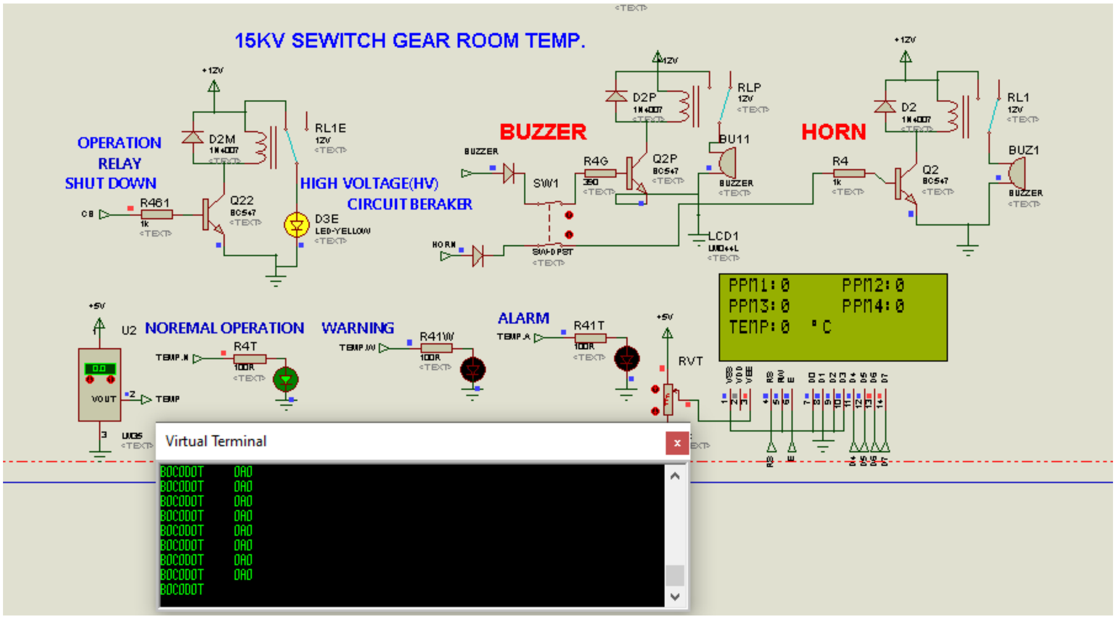


FIGURE 4.39. Normal state Scenario one 15KV switchgear room temperature monitoring simulation result

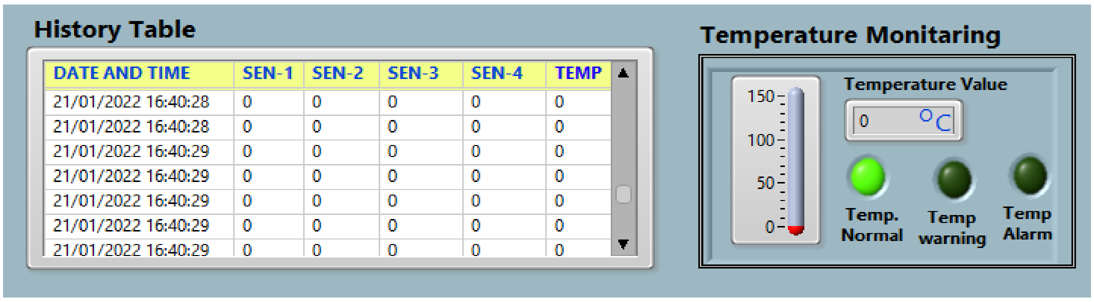


FIGURE 4.40. Normal state Scenario one 15KV switchgear room temperature graphical simulation result

Scenario One: Test Result

Table 4.20. Normal state 15KV switchgear room temperature Scenario one: Test Result

Temperature sensor	Condition	Normal operation Green Led	Warning operation Yellow Led	Alarm operation Red Led	Circuit breaker	Buzzer & Horn
0°C - 57°C	Normal	ON	OFF	OFF	ON	OFF

4.1.8 Alert State 15KV switchgear room Temperature monitoring simulation result

Scenario Two: (System alert is set to >57°C & goes up to ≤ 90°C)

These are warning conditions that are on the verge of becoming critical. The simulation result (figure 4.41) shows that the room temperature real-time reading value will be shown on LCD, and the microcontroller will transmit a signal via output PORT RD4 to indicate that the system is in a warning state. The current room temperature is displayed utilizing serial port communication that links to the computer by Lab VIEW software/SCADA. Table 4.21 shows that buzzer and horn devices were installed, and a real-time monitoring result (figure 4.42) shows that data is transferred to a graphical SCADA computer, as well as a real-time notification to the Fire and Insurance Department via the IoT system.

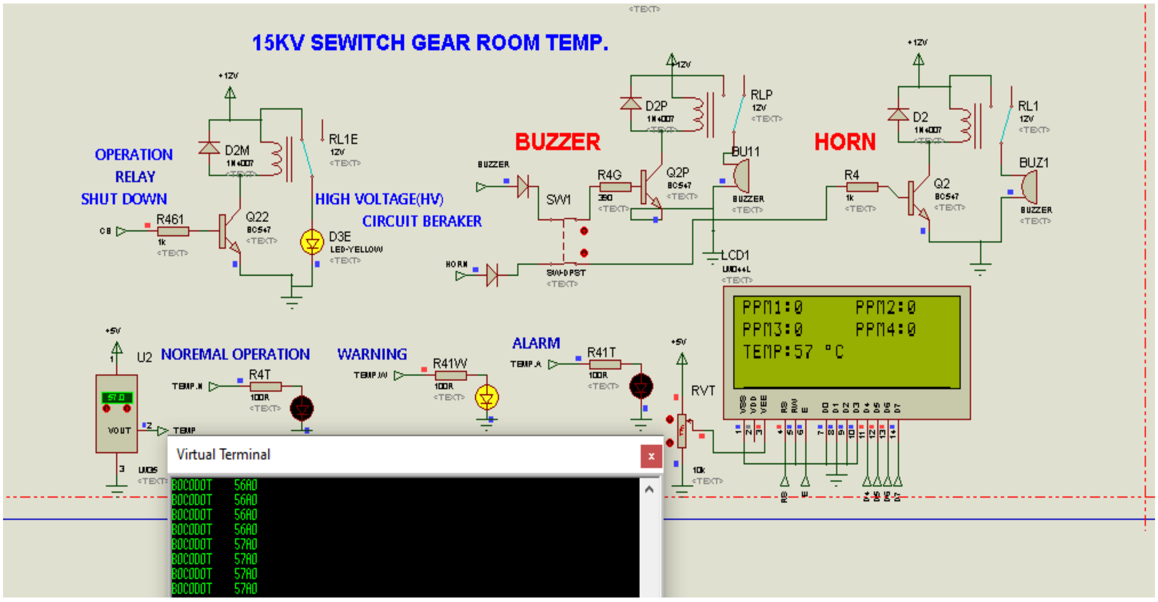


FIGURE 4.41. Alert State Scenario two 15KV switchgear room temperature monitoring simulation result

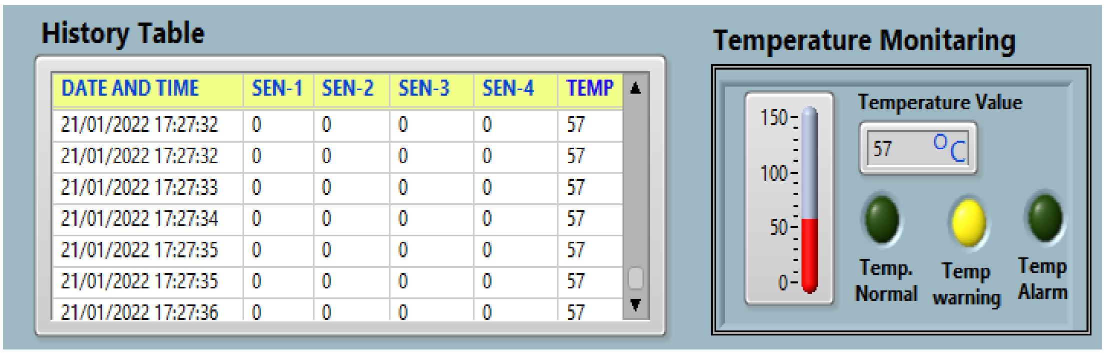


FIGURE 4.42. Alert State Scenario two 15KV switchgear room temperature graphical simulation result

Scenario Two: Test Result

Table 4.21. Alert State 15KV switchgear room temperature Scenario two: Test Result

Temperature sensor	Condition	Normal operation Green Led	Warning operation Yellow Led	Alarm operation Red Led	Circuit breaker	Buzzer & Horn
$\leq 57^{o}$C - 90^{o}C	Warning	OFF	ON	OFF	ON	OFF

4.1.9 Trip state 15KV switchgear room Temperature monitoring simulation result

Scenario Three: (System alarm (trip) temperature is set to > 90^{o}C)

These are critical/alarm situations, and the Simulation result (figure 4.43) indicates that the room temperature real-time reading value will be displayed on LCD, and the microcontroller will transmit a signal using output PORT RE2, indicating the system is in Alarm condition. The current room temperature is displayed utilizing serial port communication that links to the computer by Lab VIEW software/SCADA. Table 4.22 shows that buzzer and horn devices were installed, and a real-time monitoring result (figure 4.44) shows that data is transferred to a graphical SCADA computer, as well as a real-time notification to the Fire and Insurance Department via the IoT system.

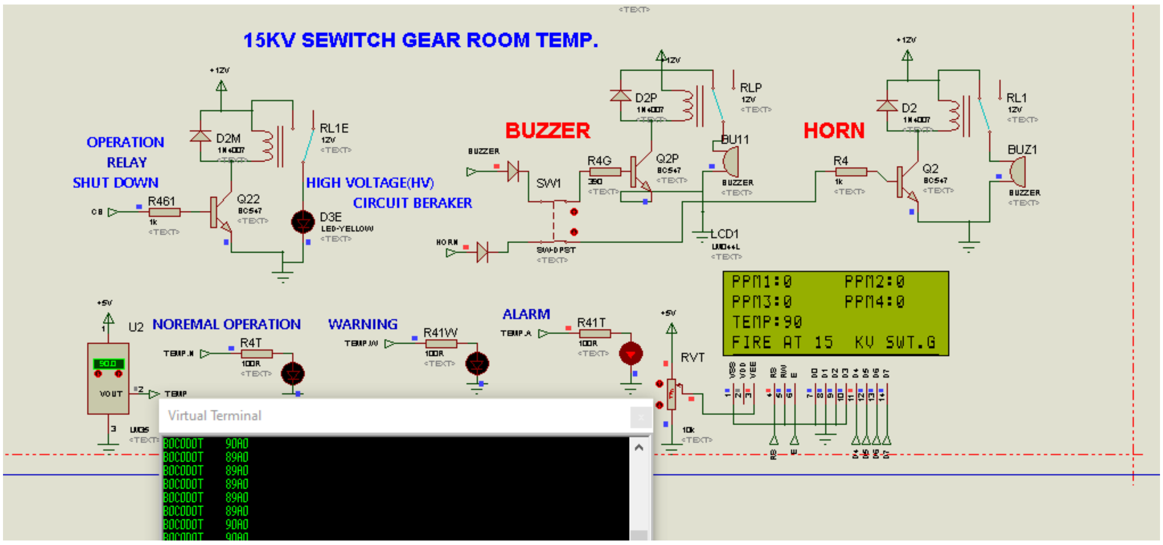


FIGURE 4.43. Trip state Scenario Three 15KV switchgear room temperature monitoring simulation result

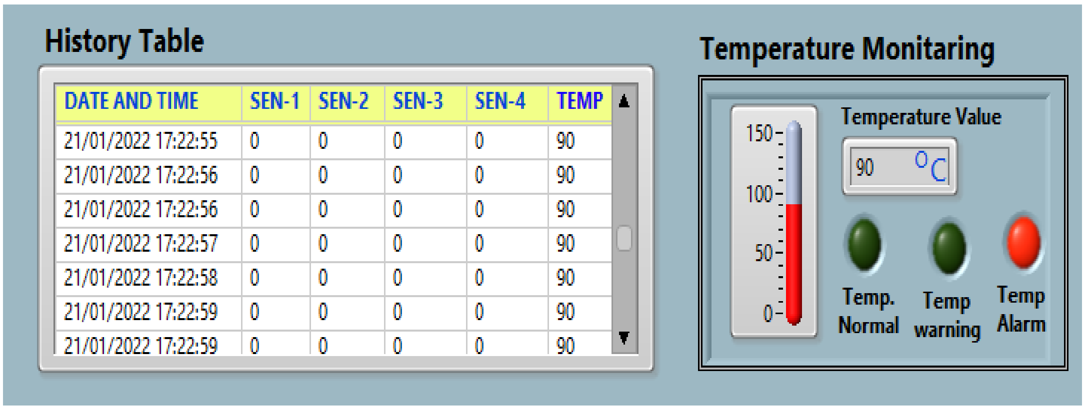


FIGURE 4.44. Trip state Scenario Three 15KV switchgear room temperature graphical simulation result

Scenario Three: Test Result

Table 4.22. Trip state 15KV switchgear room temperature Scenario Three: Test Result

Temperature sensor	Condition	Normal operation Green Led	Warning operation Yellow Led	Alarm operation Red Led	Circuit breaker	Buzzer & Horn
$\geq 90^{o}$C	Alarm	OFF	OFF	ON	OFF	ON

Visualization of Experimental Data

Figure 4:45 depicts how the temperature of the room varies based on when the individual sensor alerts were triggered. LM35 is the temperature. Red horizontal lines indicate sensors, which are followed by sensor symbols that indicate the sensor's alarm times. The x-axis indicates the room temperature measurement time and date, while the y-axis displays the sensor alarm in degrees Celsius.

The Temperature value between > 0°c & < 57°c can be defined as normal, the temperature value between ≥57°c & < 90°c can be defined as a warning and the temperature value ≥90°c can be defined as shutdown or high alarm. In all steps, real-time temperature data will be sent to a SCADA graphics computer and data will be sent to the monitoring station via the internet at the same time. Therefore, according to programming activate the buzzer, and horn, switch off the main circuit breaker, and display the status in real-time.

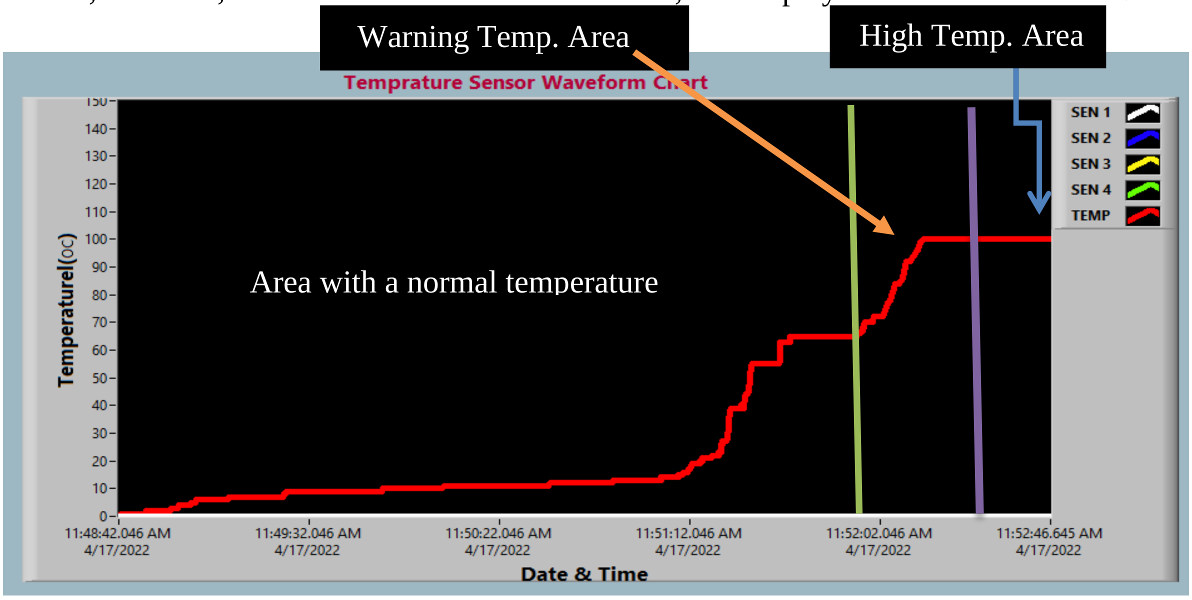


Figure 4.45. Temperature sensor waveform chart

Table 4.23. Temperature Sensor Test Result

Condition	LM35 Temperature sensor	Sensor Voltage
Normal Operation	$0\ ^0C - 56^0C$	0V - 0.56V
Warning	$\leq 57\ ^0C - 89^0C$	0.57V - 0.89V
Alarm	≥ 90	0.9V

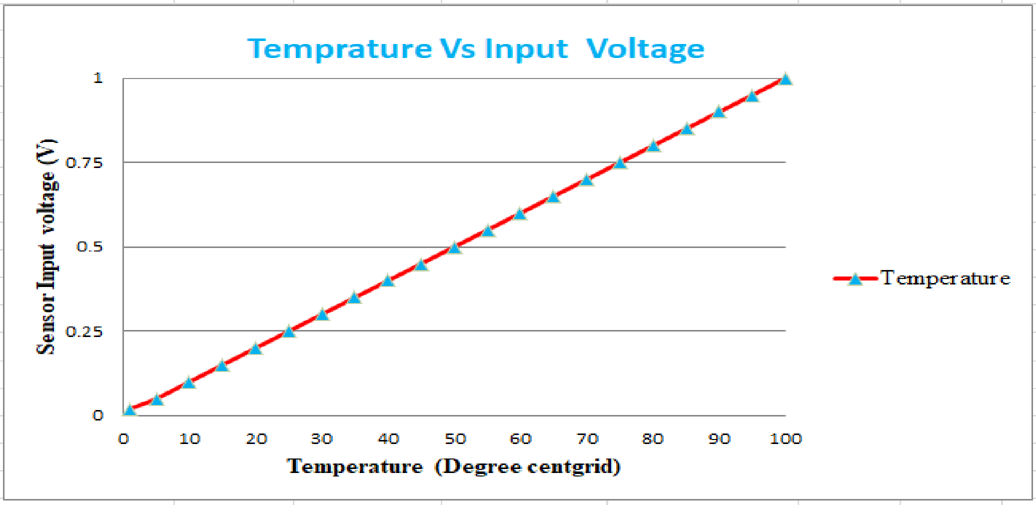


FIGURE 4.46. Temperature in degrees Celsius vs. input voltage graph

Table 4.24. 15KV switchgear room temperature simulation result summery

Mentoring Parameters status	15KV switch gear room, Temp. value >0°c &<57°c	15KV switch gear room, Temp. value ≥57°c& <90°c	15KV switch gear room, Temp. value ≥90°c
On LCD	Temp. Value Displayed in °c	Temp. Value Display in °c Room.Temp. Too high Display alarm area/location	Temp. Value Display in °c Room Temp. Temp. trip and Display alarm area/location
On SCADA	Normal Green Led ON	Warning Yellow Led ON	Alarm Red Led ON
On IoT	Green indication Normal LED	Yellow indication warning LED ON	Red indication Alarm LED ON
On the virtual terminal SMS message	T display	Temperature Current Value displayed	Temperature Current Value displayed
Buzzer (ON/OFF)	OFF	OFF	ON
HV Circuit breaker (ON/OFF)	ON	ON	OFF
Horn(ON/OFF)	OFF	OFF	ON

4.1.10 Fault Relay simulation result

The fault signalling relay is located in the FACP and the operating power supply is DC12v. Normally closed (NC) contact of relay is used for system health conditions and normally open(NO) contact of relay is used for Fault indication.

Fault Relay operating:

- Impedance faults
- Open circuit
- Short circuit

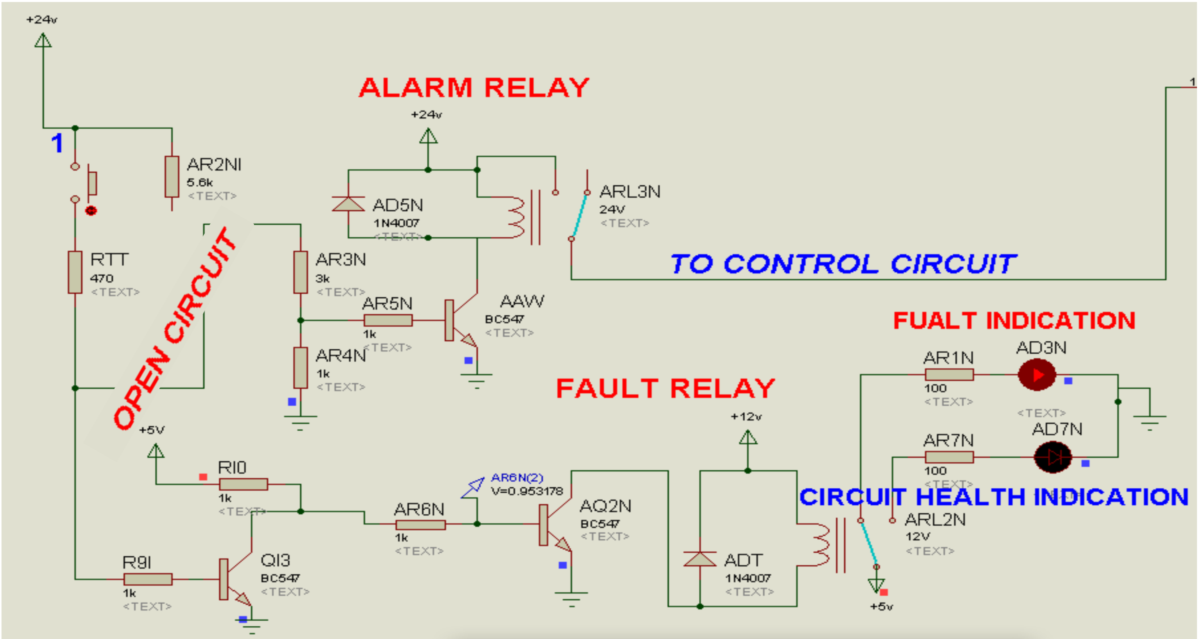


Figure 4.47. Fault relay simulation result

4.1.11 System Status Display Using Web page

This proposed work is based on an Internet of Things (IoT), all of the readings taken by the system's sensors are relayed to a remote monitoring station over the Internet. The HTML website made by LabVIEW software was published. Every second, after processing the data from the sensor, the MCU sends all of the data to the specific website via the internet using LabVIEW software. So, from that website server, it is extremely simple to monitor all of the sensor's real-time readings, as well as to gather the factory's record reading status. The website's user interface is depicted in Figure 4.48.

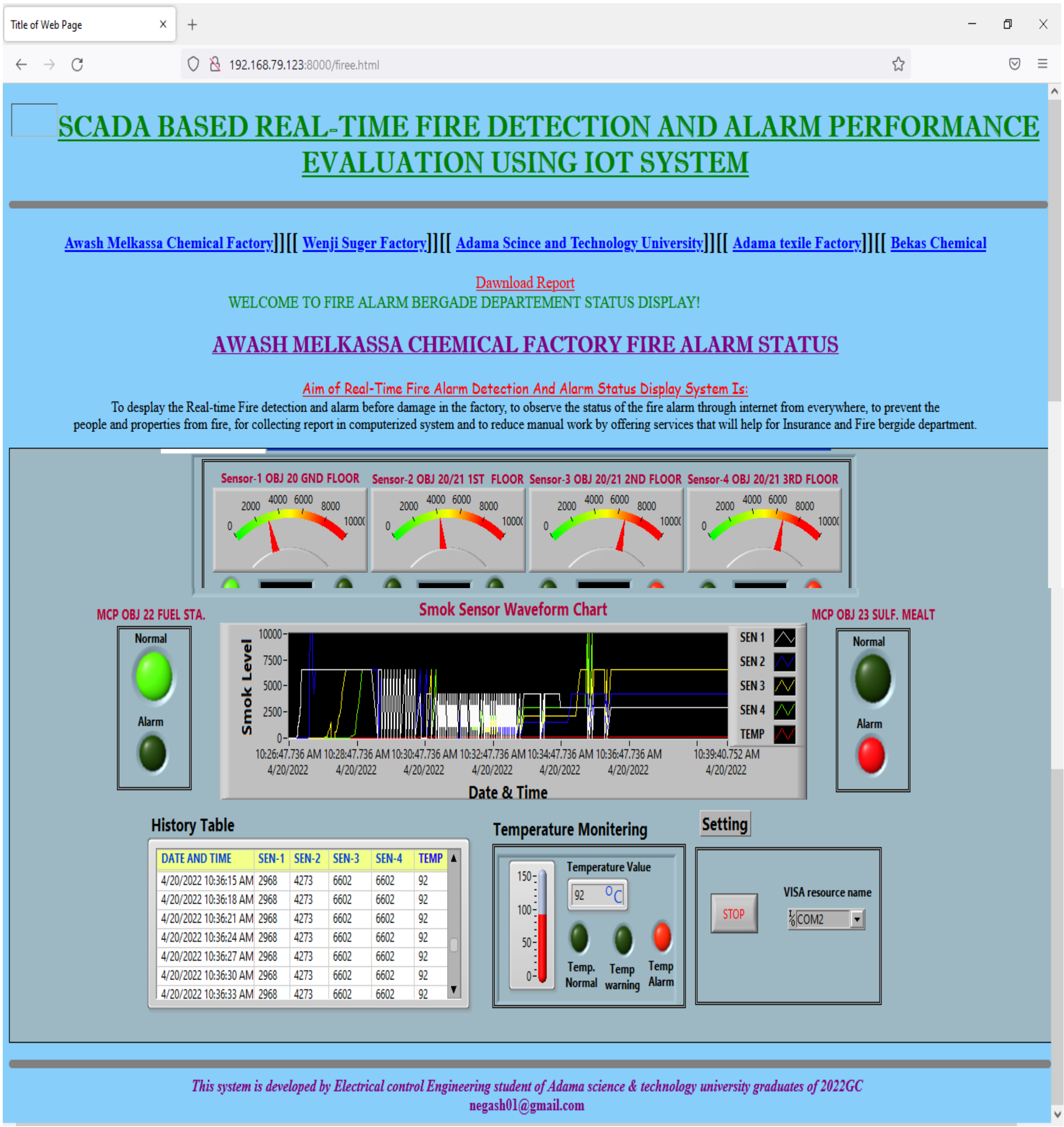
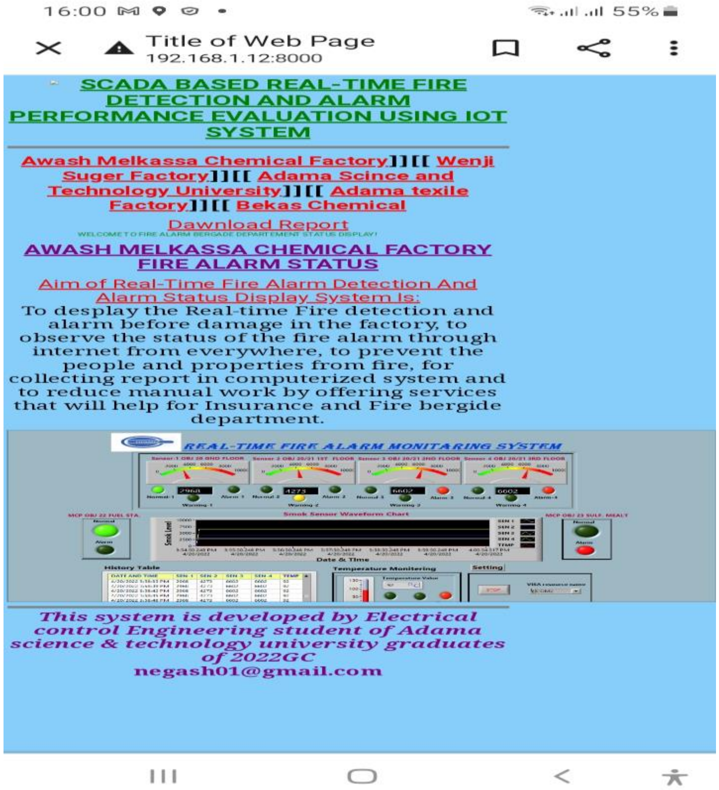


Figure 4.48. System Status display on web page

4.1.12 System Status display using mobile phone



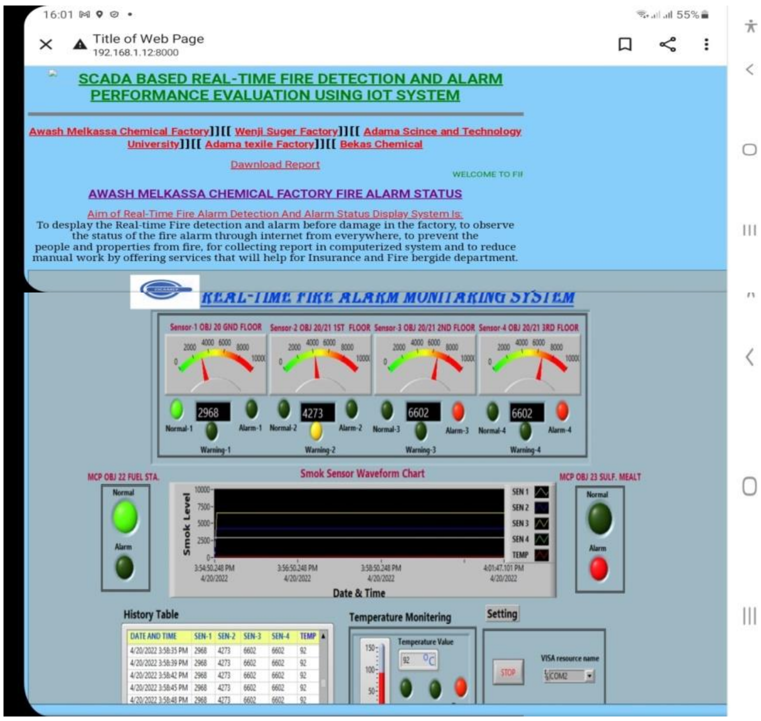


FIGURE 4.49. System Status display using mobile phone

4.1.13 Real-Time Archive data recorded in excel

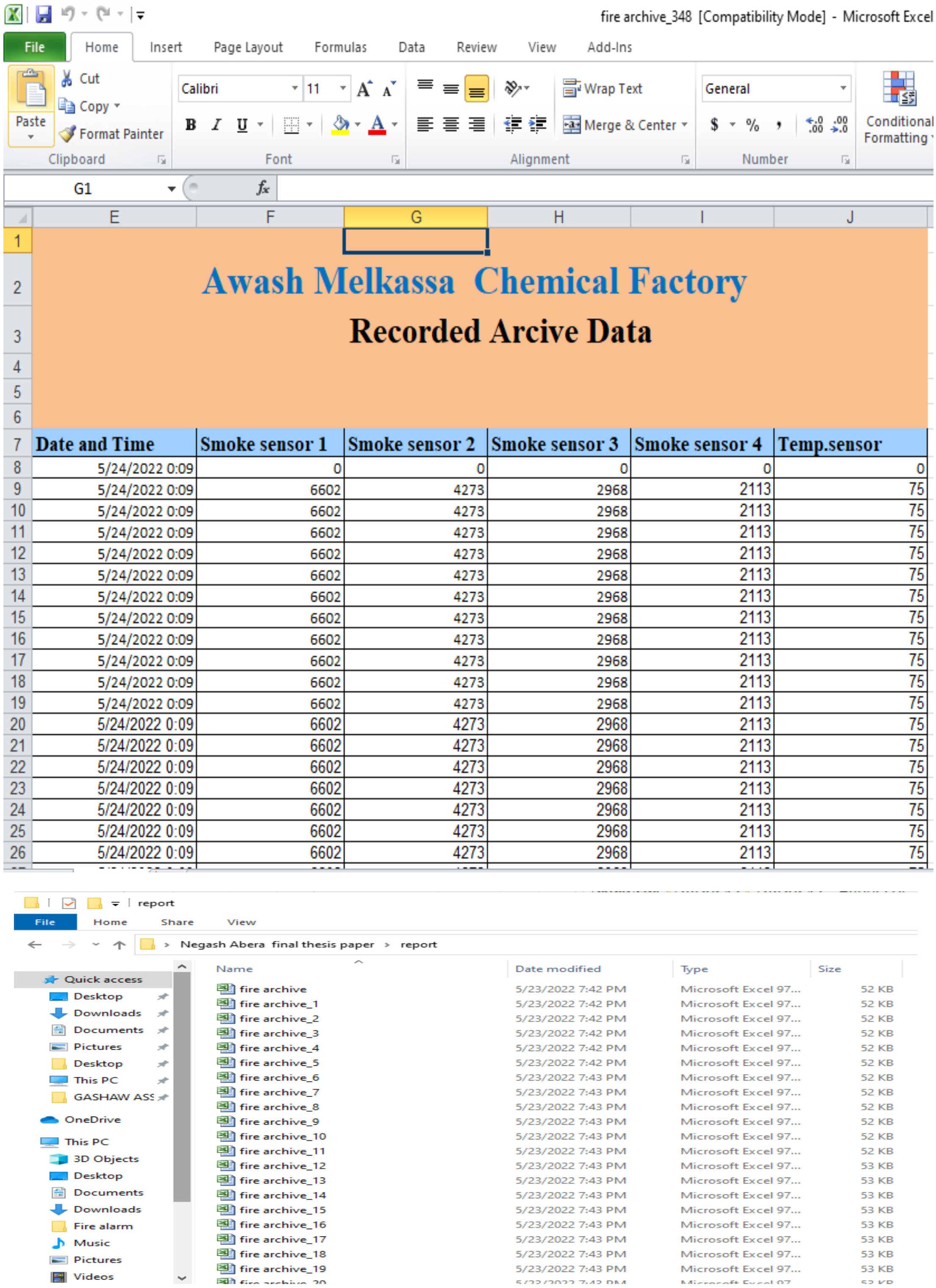


FIGURE 4.50. Real-Time Archive data recorded in excel

4.2 Discussion

Chemical businesses are currently facing enormous issues as a result of fires that occur by chance. It is because they do have no Real-time fire alarm detection and monitoring system. Thus, the "Microcontroller based chemical companies real-time fire alarm protection and monitoring system using IoT based SCADA system had been designed and simulated successfully. Integrated features of all the hardware components used had developed. The presence of every alarm and fault had been reasoned out and placed carefully, thus contributing to the best protection and monitoring of fire alarm system. The smoke sensors determine how much smoke is present in a room, if the amount of smoke value is found above the desired value the sensors send an input signal to Microcontroller and display the status of the alarm zone location on the LCD and local server SCADA computer. Serial port communication connects the microcontroller and the local server.

When smoke sensors alert the microcontroller, the local computer sends the state of the system. If the microcontroller is notified by smoke sensors, the local computer sent the status of the system to the central control station which is insurance and fire brigade department. If the manual call point glass is broken and pressed, the microcontroller will get the input signal and according to the program code, it will activate the output relays.

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this paper Real-Time Fire Detection and Monitoring System using IoT are described with the drawbacks of the existing system. The requirements and the implementation methodologies of the system are clearly explained. Industrial safety is a major concern and therefore this system can help in emergencies with immediate response and quick action. Thus, the limitations in the performance of the existing systems can be overcome and the proposed Real-Time Fire Detection and Monitoring System using IoT system is an efficient and reliable system. The paper aimed at designing preferable driving circuit for a smoke detection system using the microcontroller and to initiate a response alert, indicate areas/locations at risk of fire, pass fire information to the fire department, automatically turn off the main power circuit breaker, extinguished fire automatically, to display computerized based fire alarm system using Lab VIEW software , to monitor the status of a fire alarm system through the Favorite platform by using a personal computer, laptop or mobile phone using IoT and to record real-time event archive data for smoke & Temperature sensors. The proposed system is flexible and applies in many areas and can monitor the system status from anywhere using IoT. The embedded controllers are capable of sensing, monitoring, and protection chemical companies in a normal and abnormal condition. This proposed system provides the real-time fire alarm detection and performance evaluation using IoT gives a solution for chemical factories. SCADA-based fire alarm system can provide a convenient method for effective monitoring of fire and temperature in real-time. The embedded control system is one of a wide scope of applications in the field of remote monitoring in chemical factories and is cost-effective.

5.2 Recommendation

Any work and investigation on chemical factories monitoring and protection is very advantageous and challenging based on the present time, it can be observed that the number of chemical companies is increasing rapidly which means the need of chemical is also increasing. Therefore, demands on chemical will be high and these will lead to demands of highly sophisticated monitoring and protection devices. Based on the work done in this paper which monitoring and protects chemical factories using Microcontroller some improvements need to be made in the future work such as monitoring of all components are not included in this thesis. Also, a web application based on the Google maps for navigation by the fire department once an alert is sent can be developed during alarming times to let key people know about any alarm by sending a text message and alerts by Voice Notification also an Email Notification. The paper couldn't include a camera system for the other researchers I recommend it is better to include all that I left and it is better to control the system from anywhere using a server.

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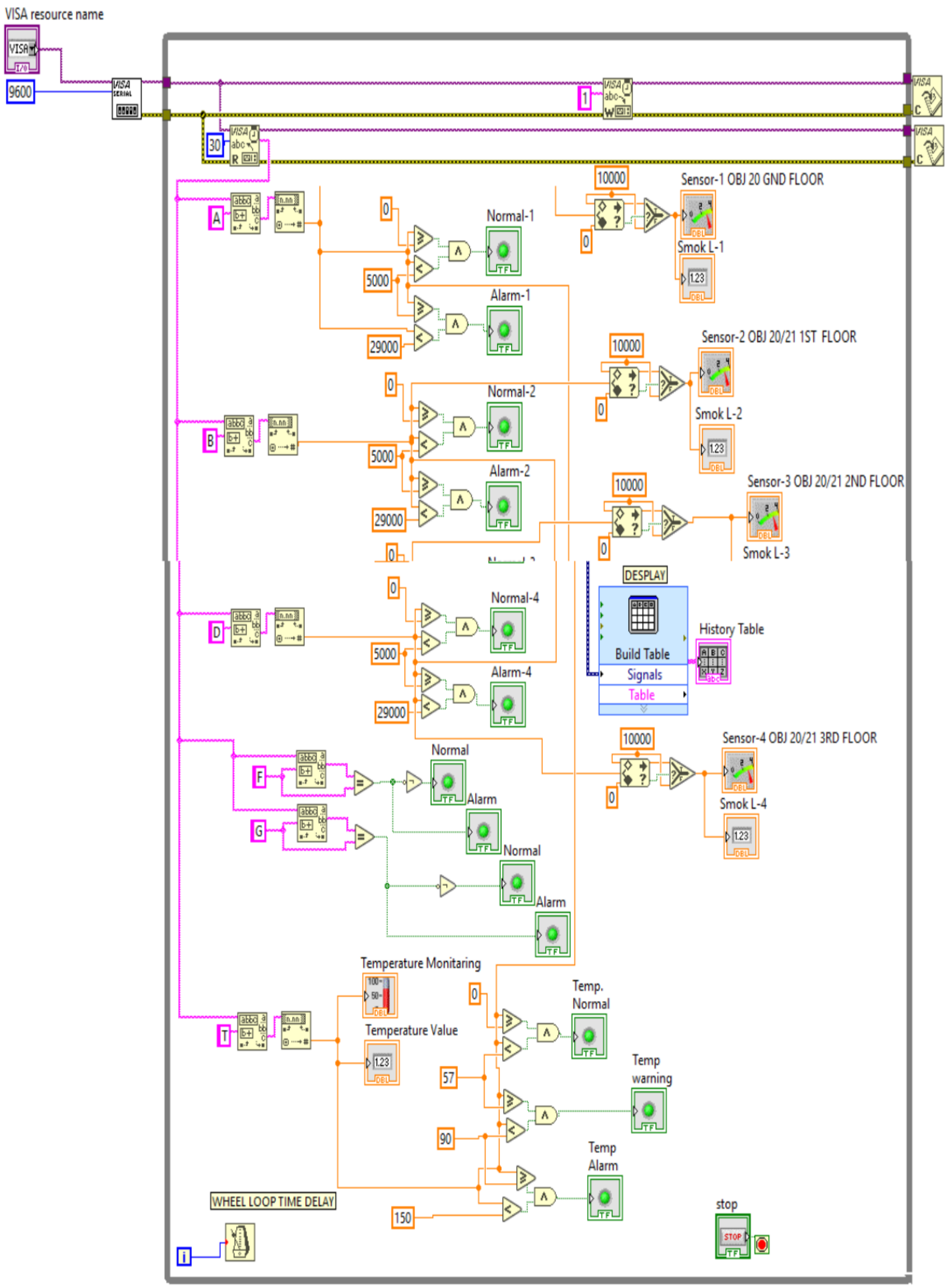
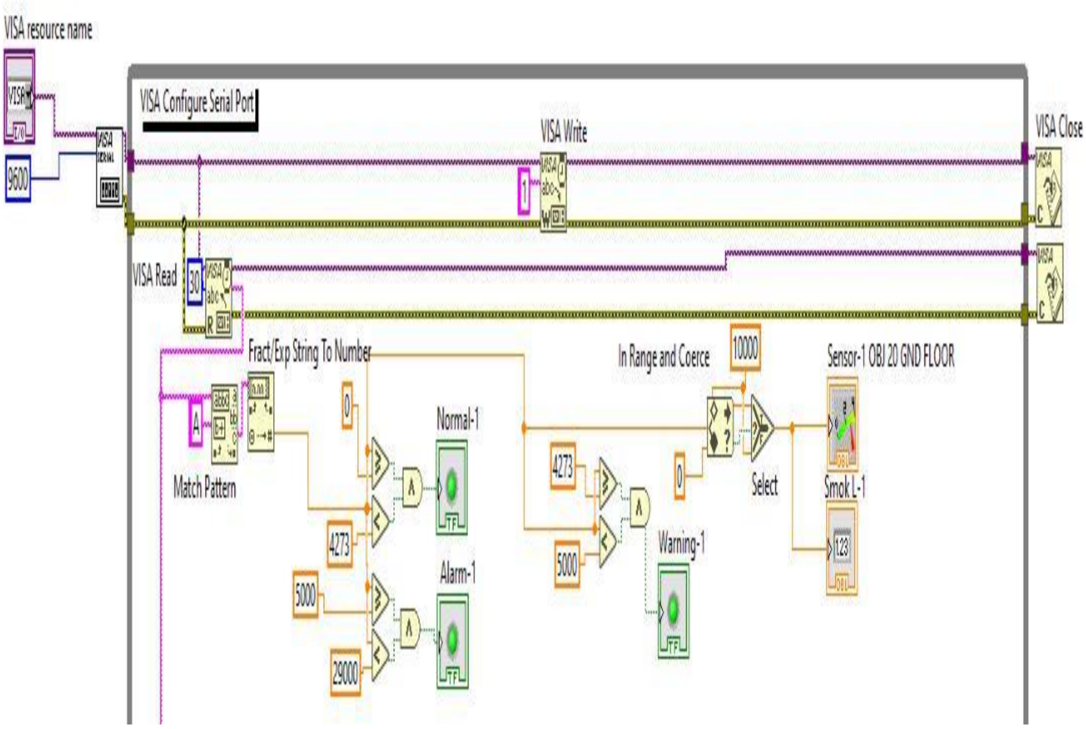
APPENDICES

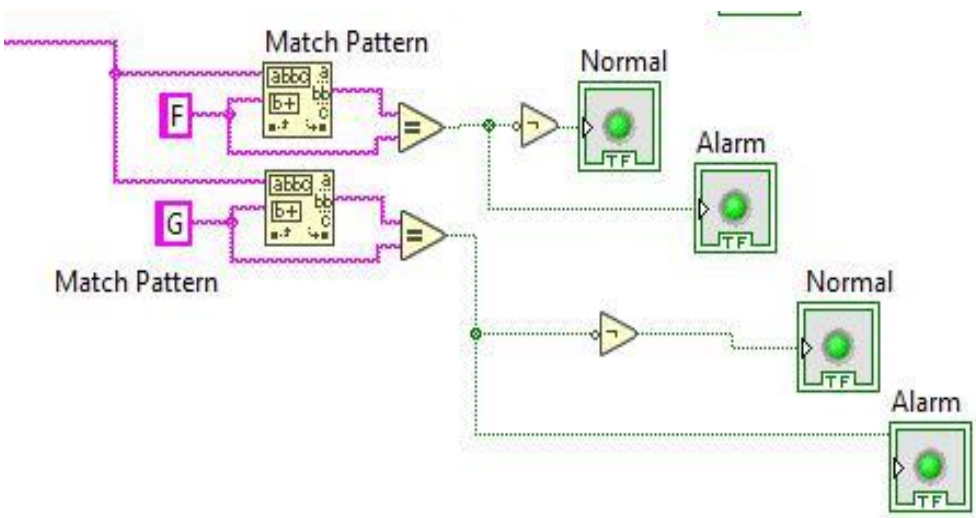
Appendices A: Lab VIEW Back panel design



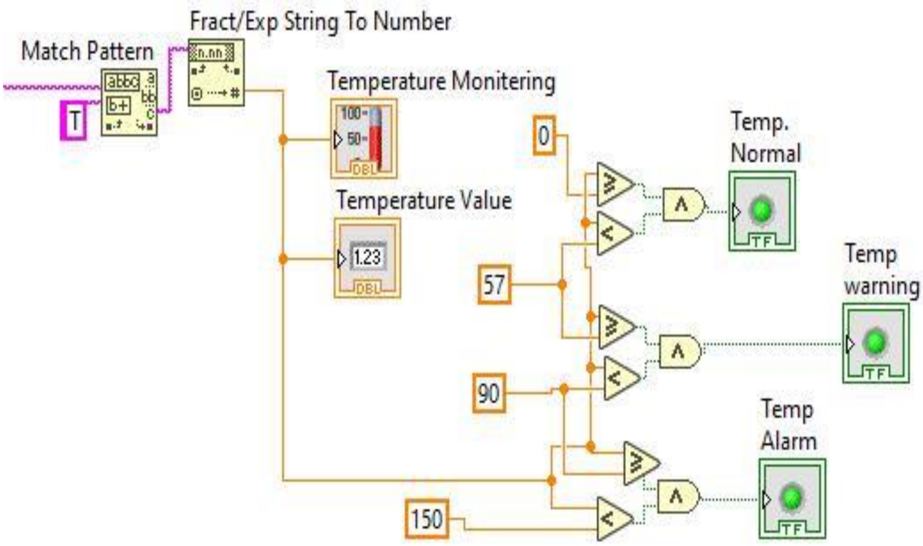
Appendices B: LabVIEW Back panel design for smoke sensor



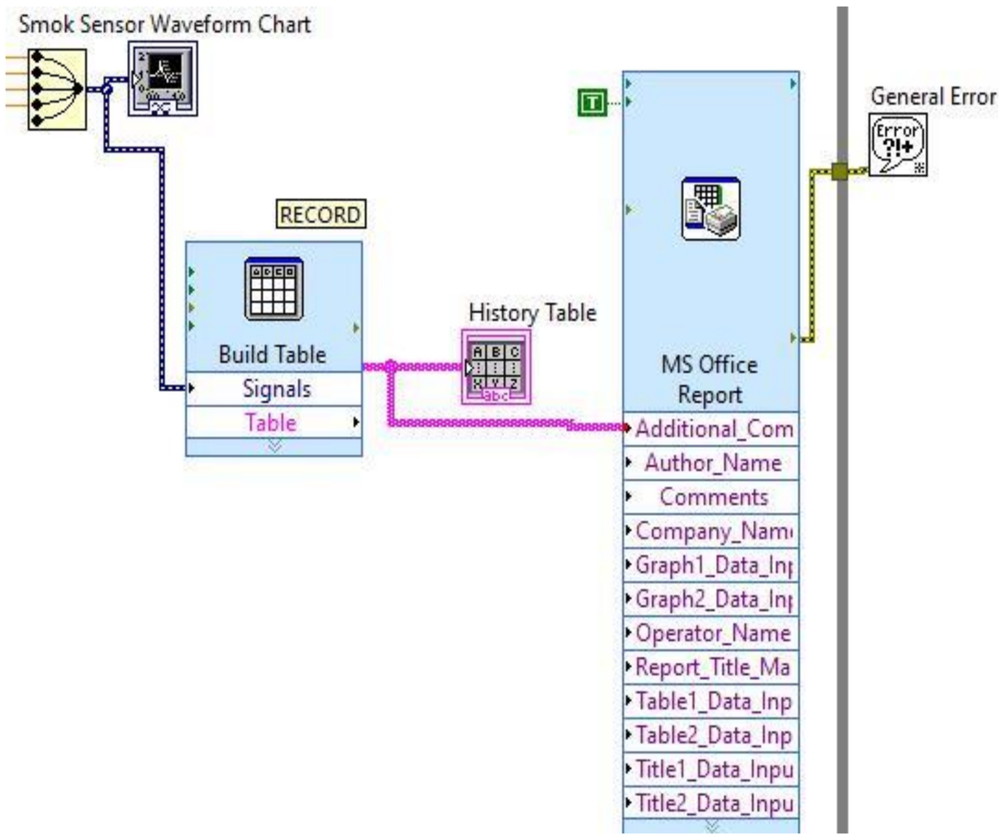
Appendices C: LabVIEW Back panel design for Manuel call points



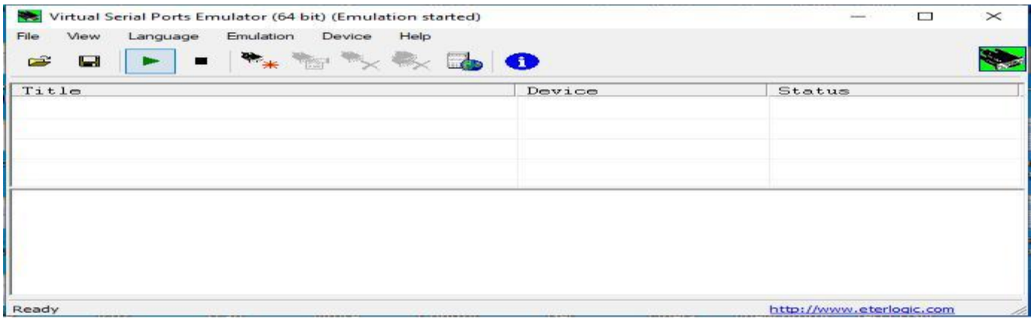
Appendices D: LabVIEW Back panel design for Temperature sensor

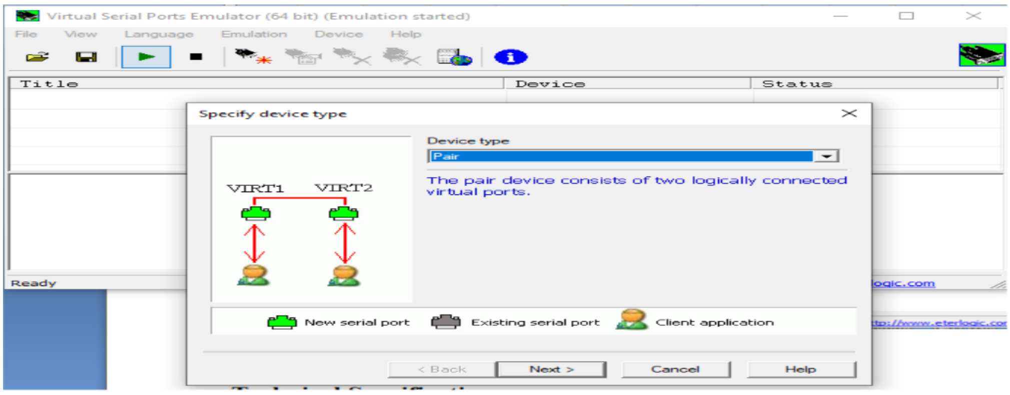


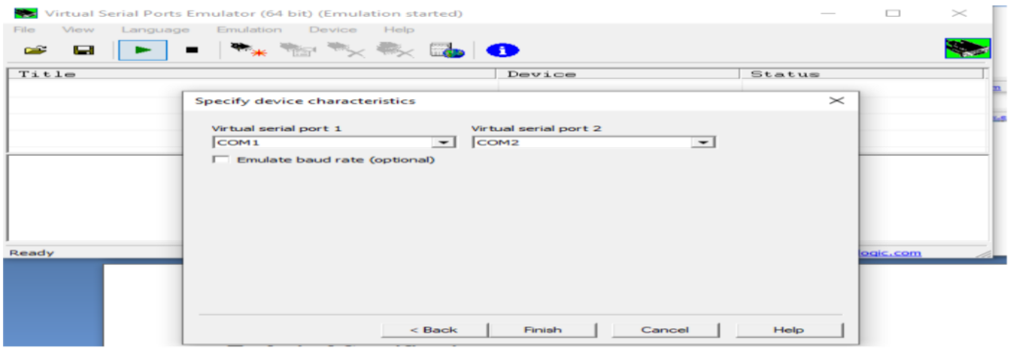
Appendices E: LabVIEW Back panel design for data archive

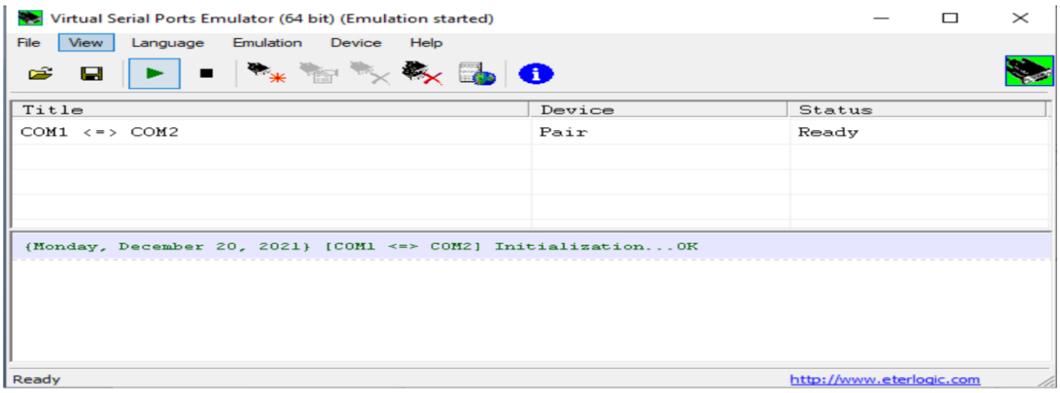


Appendices F: Virtual Serial Ports Communication

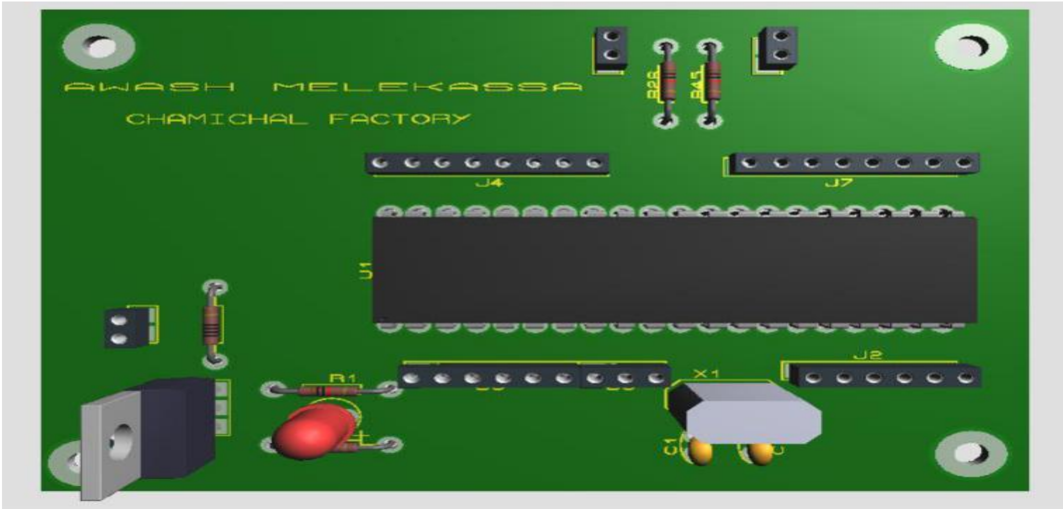




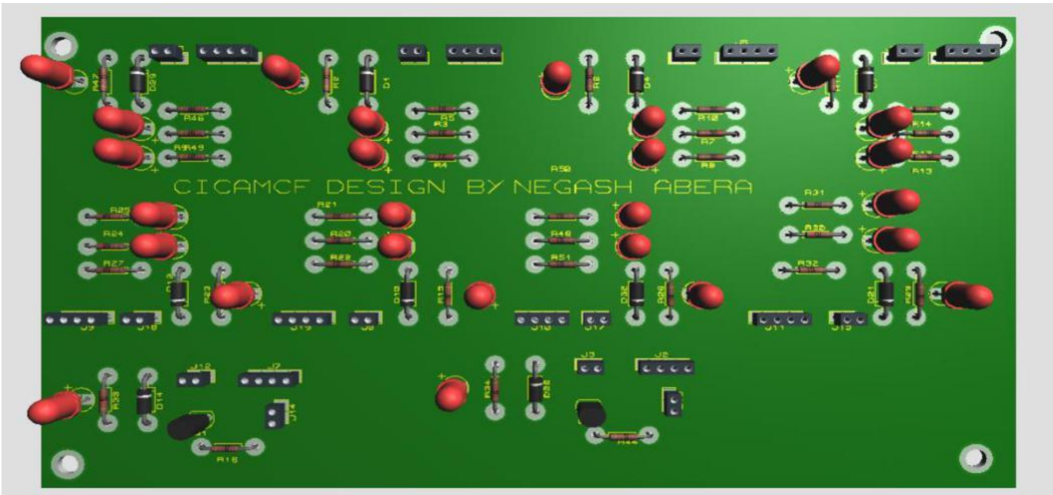




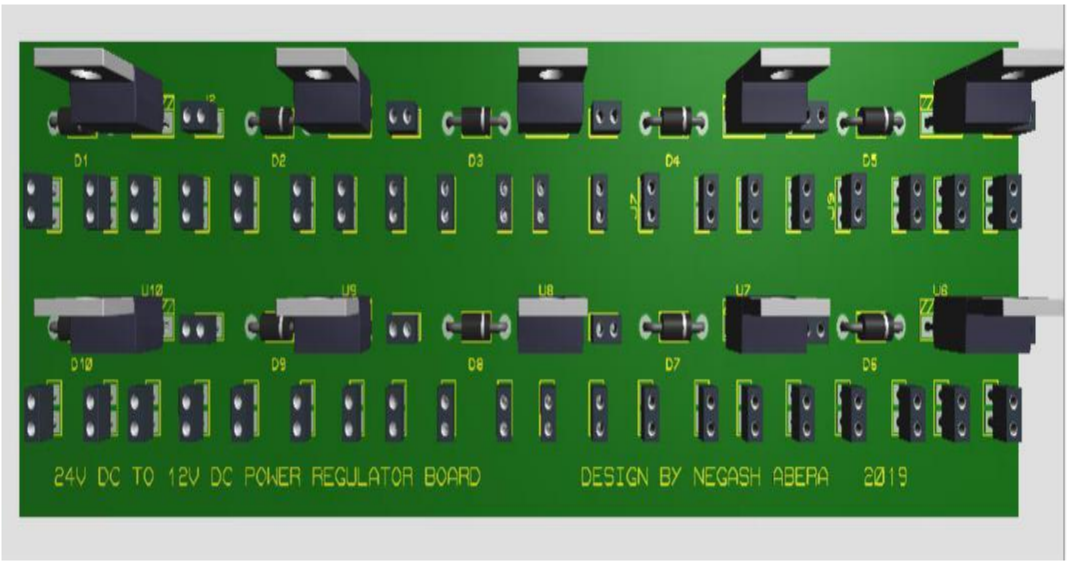
Appendices G: Printing Circuit board (PCB) Design for MCU



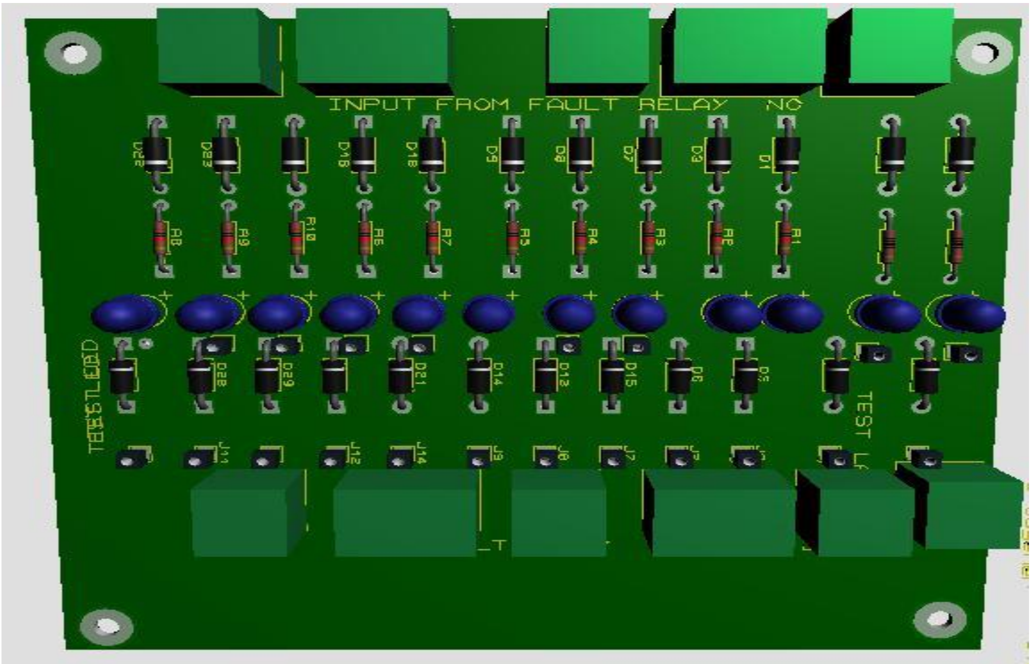
Appendices H: Printing Circuit board (PCB) Design for Relay board



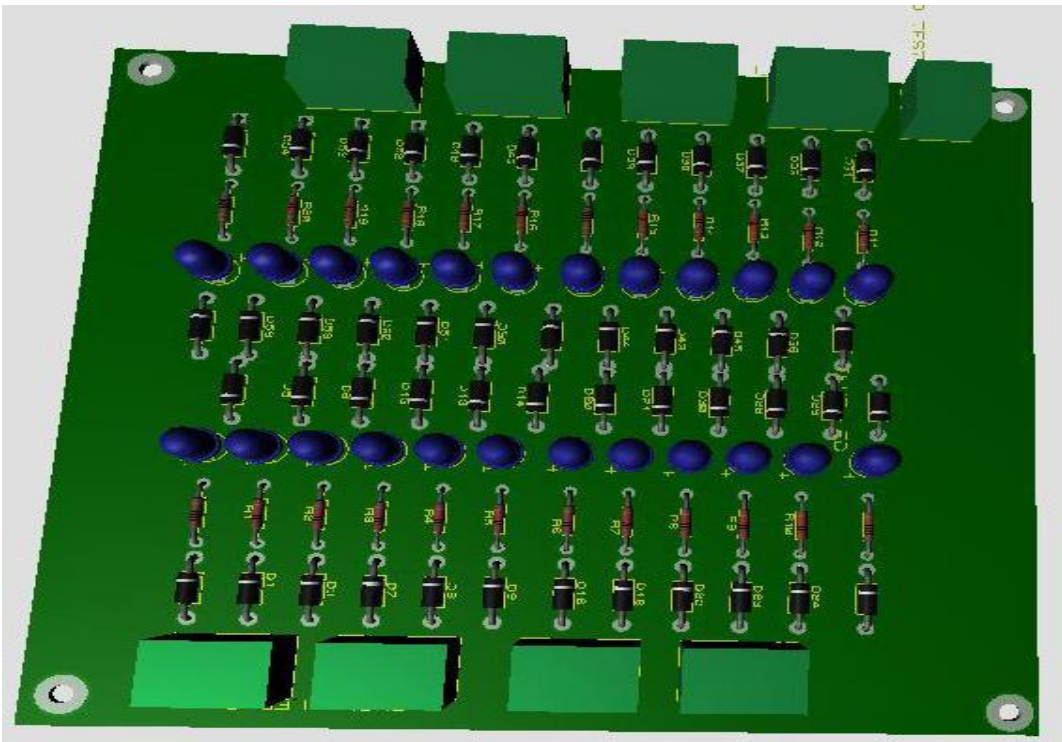
Appendices I: Printing Circuit board (PCB) Design for voltage regulator



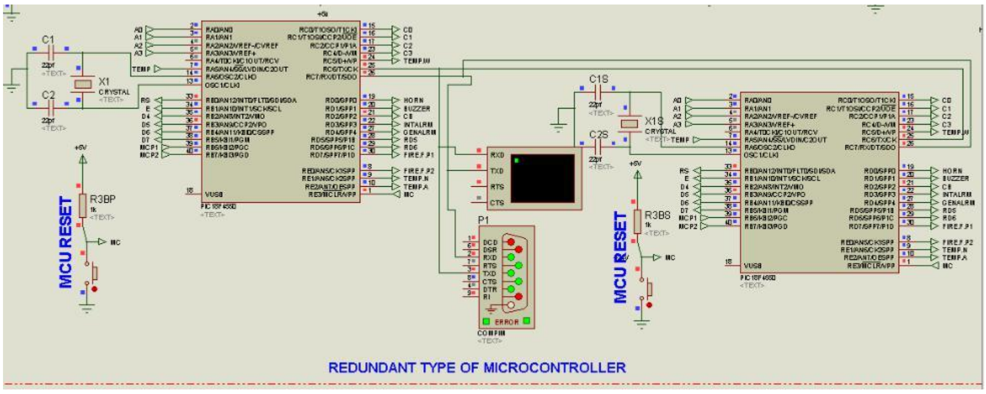
Appendices J: Design of a printed circuit board (PCB) for a Fault relay



Appendices K: Design of a printed circuit board (PCB) for a Alarm relay

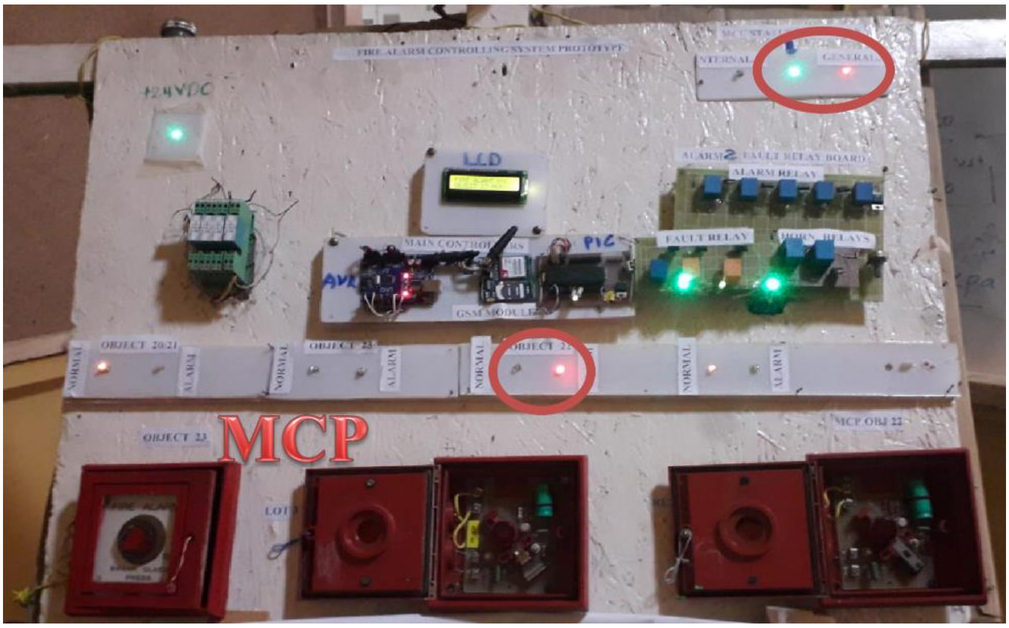


Appendices L: Redundant Type of Microcontrollers

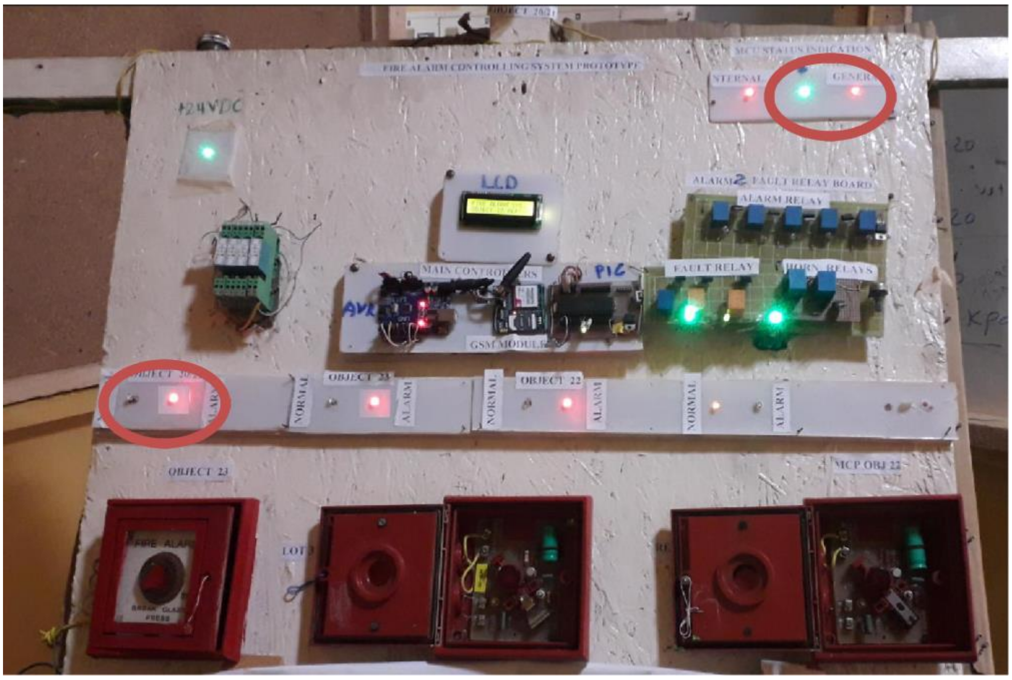


Appendices M: Testing the design & functionality with a Prototype (Normal status)

Appendices N: Testing the design & functionality with a Prototype (General alarm status)



Appendices O: Testing the design & functionality with a Prototype (Internal Alarm status)



Appendices P: Existing and Proposed System Overview

Proposed System Overview

Existing System Overview

Appendices Q: Micro C code

```
sbit LCD_RS at LATB0_bit;
sbit LCD_EN at LATB1_bit;
sbit LCD_D4 at LATB2_bit;
sbit LCD_D5 at LATB3_bit;
sbit LCD_D6 at LATB4_bit;
sbit LCD_D7 at LATB5_bit;
sbit LCD_RS_Direction at TRISB0_bit;
sbit LCD_EN_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB2_bit;
sbit LCD_D5_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB4_bit;
sbit LCD_D7_Direction at TRISB5_bit;
  char h;
  int value;
  double dc_v;
  int x=0;
  float VRL();
  float RL = 5;
  int m = -0.476  ;
  int b = 1.714;
 int Ro;
  float Rs;
  float ratio;
 unsigned int smoke;
  char z9[7];
  int analog_value;
   float VRL;
   float  ppm;
   void READ_VRL(),
   void data_converstion (),
   void display (),
   void fire(),
     int tmp=0;
```

```
int t=0,
int xx=0;
char vt1;
char v;
void sc();
void temperature();
void display_temp();
void pt();
void main()
{
UART1_Init(9600);
 TRISA =0xFF;
TRISC =0;
TRISB =192;
PORTC =0;
TRISD =0;
PORTD =0;
TRISE=3;
PORTE=0x00;
ADC_Init();
Lcd_Init();
LCD_Cmd(_LCD_CURSOR_OFF);
LCD_Cmd(_LCD_CLEAR);
Lcd_Out(1,1,"PPM1:");
Lcd_Out(1,12,"PPM2:");
Lcd_Out(2,1,"PPM3:");
Lcd_Out(2,12,"PPM4:");
Lcd_Out(3,1,"PPM5:");
lcd_out(3,10,"TEMP:");


 while(1)
 {
   READ_VRL();
```

```
    data_converstion (),
    display (),
    fire(),
       h=UART1_read();
   temperature();
  display_temp();
   pt();
    /*-----------------------------------------------------------------
                              MCP 1 & 2
   -----------------------------------------------------------------*/
 if(portb.f6==1)     // port b6 as MCP
{
     portd.f7=1;
     portd.f0=1;
     portd.f1=1;
     portd.f5=~portd.f5;
     Delay_ms(100);
     if (Data_Ready())
    {
       UART1_read();
    }
}
    if(portb.f6==1 && x5==0)
   {
     portd.f5=1;
     portd.f2=1;
     portd.f4=1;
      x5=1;
   }
     if(portb.f6==0 && x5==1)
   {
     portd.f5=0;
     portd.f2=0;
     portd.f4=0;
```

```
x5=0;
}
/*-----------------------------------------------------------------
SMOKE SENSOR
-----------------------------------------------------------------*/
void READ_VRL(void)
{
float Rs;
float ratio;
VRL = adc_read(0)*(5.0/1023.0);
Rs = ((5.0*RL)/VRL)-RL
// we already get ratio value Rs/Ro is 9.8
Ro = Rs/9.8;
ratio = Rs/Ro;
}
}
```

…………………………………………………………………..…………………..

The Thesis Code is secured

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