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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGENEERING

OPTION: ELECTRONICS AND TELECOMMUNICATION TECNOLOGY

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FINAL YEAR PROJECT:

D & I. SIMULATION OF SMART FIRE EXTINGUISHING SYSTEM FOR GAS

D & I. SIMULATION OF SMART FIRE EXTINGUISHING SYSTEM FOR GAS

A final year project submitted in partial fulfilment for the requirement of award of advanced Diploma in Electronics and Telecommunication Technology (ETT)

BY

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September 2024

DECLARATION A

I Ntabala GWABALUKA Daniel Declare that This research study is my original work and has not been presented for a Degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors' consent or that of Ulk Polytechnic Institute.

NAMES

Ntabala Gwabaluka Daniel

SIGNATURE

DATE: …/…/2024

APPROVAL SHEET

This research project entitled " Smart fire extinguishing system for gas cooking room **"** prepared and submitted by Ntabala GWABALUKA Daniel in partial fulfillment of the requirement for award of advanced diploma (A1) in Electronics and Telecommunication Technology has been examined and approved by the panel on oral examination.

Chairperson:

Signature:

Date:

DECLARATION B

This is to certify that the work entitled “Smart fire extinguishing system for gas cooking room” done by Ntabala Gwabaluka Daniel, Roll number 202150390, is the original work completed in fulfillment of the requirements for the award of an Advanced Diploma in the Department of Electrical and Electronics, specializing in Electronics and Telecommunication Technology at ULK Polytechnic Institute.

This project has been submitted with our approval.

Supervisor:

Signature:

Date:

DEDICATION

First and foremost, I dedicate this work to God, the master of all life, time, and circumstances, who has allowed us to reach this day. May all glory be given to him.

Secondly, I dedicate and express my gratitude to the academic staff of our esteemed university, particularly the UPI, for their efforts in shaping the person you see before you today.

It would be an unimaginable level of ingratitude to forget my dear parents and guardians. Without your unconditional love, sacrifice, and support financially, morally, and spiritually this accomplishment would not have been possible.

Lastly, to my friends, colleagues, and other acquaintances who continuously whispered words of encouragement in my ear, wherever you are, know that I hold you dear. This great work is dedicated to you, and may God bless you.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to God, for life, grace, blessings, boundless love, and unwavering guidance throughout this journey.

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I would like to express my heartfelt appreciation to my supervisor, Eng. Karikurubu Emmanuel, for their invaluable guidance, support, and patience throughout the duration of this project. Their insights and expertise were instrumental in shaping this work.

I am also thankful to my professors and instructors at UPI (ULK Polytechnic Institute), whose teachings and encouragement have been a source of inspiration and knowledge.

Special thanks to my colleagues and fellow students, whose collaboration and shared experiences have enriched my academic journey, your support and camaraderie have been vital to my success.

Finally, I extend my heartfelt thanks to my family and friends for their unwavering support, understanding, and encouragement. Your belief in me has been a constant source of motivation.

Thank you all for your contributions to the successful completion of this work.

ABSTRACT

This research focuses on developing a smart fire extinguishing system for gas cooking rooms to enhance household safety. The system is designed to detect gas leaks and fires, and automatically extinguish them before they escalate. It employs gas sensors, smoke detectors, a GSM (Global System for Mobile Communications) for notification, and automatic extinguishing mechanisms.

Key components of the system include gas sensors that detect leaks, smoke detectors that identify fire, GSM (Global System for Mobile Communications) technology is incorporated to send real-time alerts to occupants' mobile phones and emergency services, ensuring immediate awareness and response, and an automatic response system that activates water sprinklers or chemical extinguishers. The system also alerts occupants and emergency services.

Tests show that the system quickly detects hazards and responds in real-time, significantly reducing response times and effectively preventing gas cooking fires. This innovative solution enhances domestic safety and can be integrated with smart home technologies for improved risk management.

In conclusion, the smart fire extinguishing system for gas cooking rooms offers a reliable, automatic response to fire hazards, improving household safety and providing a foundation for future advancements in smart home safety solutions.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASCII: American Standard Code for Information Interchange

EN: Enable

GND: Ground

NFPA: National Fire protection association

GSM: Global System for Mobile communication

VCC: Voltage at the Common Collector

VSS: Voltage at the Source

SSII: Computerized Information Subsystems

RGB LED: Red, Green and Blue LED

UPI: ULK Polytechnic Institute

CHAPTER 1: GENERAL INTRODUCTION

1.0 Introduction

Kitchen fires, especially in gas cooking rooms, pose serious risks to household safety due to gas leaks and unattended cooking. This research aims to develop a smart fire extinguishing system designed to detect and respond to these hazards automatically.

The system integrates gas sensors, smoke detectors, flame detecor and automatic extinguishing mechanisms, such as water sprinklers or chemical extinguishers. Additionally, GSM (Global System for Mobile Communications) technology is incorporated to send real-time alerts to occupants' mobile phones and emergency services, ensuring immediate awareness and response.

This project aims to create a reliable, automated solution to enhance fire safety in gas cooking rooms, combining modern sensor technology and GSM alerts for comprehensive risk management. This innovative system promises to improve household safety by providing swift detection and response to potential fire hazards.

1.1 Background of the Study

Overnight, we continue to see the frequency of house fires increasing worldwide, here and there. Many of these fires often originate from the flames we light ourselves in our kitchens for cooking, especially with gas stoves, as modernization progresses daily. So, what should we do now? Stop using gas stoves to prevent fires? No. Should we always cook outside the house? No. This is why we believe that the study we have conducted on this issue can provide a more or less effective solution to this everyday problem in our kitchens. Traditional fire detection and suppression systems are often inadequate in providing quick alerts and effective suppression, leading to significant damage and even loss of life. This study focuses on developing a smart system for detecting the main causes of fires and extinguishing them before they escalate. It also integrates an alert system using a buzzer and goes further by using GSM technology to send alerts electronically to phones, thereby reducing risks and enhancing safety. [Smith, J., 2020, "Smart Fire Suppression Systems", International Journal of Fire Safety, pp. 15-28]

1.2 Statement of the Problem

Despite advances in fire safety technology, kitchen fires remain a significant issue in Rwanda, particularly in households using gas stoves. Current fire extinguishing systems often fail to provide immediate alerts and effective suppression, leading to prolonged response times and increased damage. This research aims to develop an intelligent fire extinguishing system utilizing a smoke sensor, gas sensor, fire sensor and GSM technology for real-time alerts to improve response times and reduce the impact of kitchen fires. [According to the Ministry of Emergency Management in Rwanda, "kitchen fires are a major cause of material losses and injuries in Rwandan households" (MINEMA, 2023).]

1.3 Research Objectives

1.3.1 Main objectives.

The primary goal of this research is to develop a smart fire extinguishing system for gas cooking rooms that incorporates GSM technology for real-time alerts and automatic fire suppression.

1.3.2 Specific objectives

- To design and implement a fire detection system using sensors to identify the presence of fire or gas leaks.

- To integrate GSM technology for real-time alert notifications to relevant parties.

- To develop an automatic fire suppression mechanism tailored for gas cooking environments.

- To evaluate the effectiveness and reliability of the proposed system in reducing response times and mitigating fire damage.

1.4 Research Questions

The research questions guiding this study are:

- How effective are the sensors in detecting fire or gas leaks in a kitchen environment?

- What is the reliability of GSM technology in delivering real-time alerts for fire emergencies?

- How efficient is the automatic fire suppression mechanism in extinguishing fires in gas cooking rooms?

- What impact does the smart fire extinguishing system have on response times and overall fire safety?

1.5 Scope and Limitations

The scope of our research includes the design, development, and evaluation of a smart system for detecting fire sources and extinguishing fires in gas kitchens. The geographical scope is limited to urban residential areas where the use of gas stoves is high or increasing. The study will also focus on the technological aspects of the mechanisms for detecting fire sources, alerting, and extinguishing. The time scope covers a period of one year, from system design to implementation and evaluation.

1.6 Significance of the Study

We find this study very significant and important because it targets a very sensitive issue that can cause devastation in the blink of an eye: the prevention of fires and suppression in the event of an incident in residential kitchens using gas stoves. The findings will benefit homeowners, safety regulators, and fire safety technology developers by offering a practical solution to this major common safety issue. With its ability to detect and reduce response times and improve the effectiveness of fire suppression, this smart fire detection and extinguishing system has the potential to minimize or even prevent property damage and save lives. Furthermore, this research contributes to the broader field of fire safety technology and its application in residential environments.

1.7 Organization of the Study

The study is organized as follows:

- Chapter One: General Introduction: This chapter outlines the background, problem statement, research objectives, questions, scope, significance, and organization of the study.

- Chapter Two: Literature Review: This chapter reviews existing literature on fire safety technologies, GSM-based alert systems, and related studies.

- Chapter Three: Methodology: This chapter details the research design, data collection methods, and analytical techniques used in the study.

- Chapter Four: System Design, Implementation, and Evaluation: This chapter describes the design and implementation process of the smart fire extinguishing system, as well as the evaluation and results obtained.

- Chapter Five: Conclusion and Recommendations: This chapter concludes the study and provides recommendations for future research and practical application.

CHAPTER 2: LITTERATURE REVIEW

2.0 Introduction

This chapter provides a comprehensive review of existing literature related to smart fire extinguishing systems for gas cooking rooms using GSM technology. It covers key concepts, theoretical perspectives, and empirical studies relevant to the research.

2.1 Concepts, Opinions, Ideas from Authors/Experts

This section delves into the key concepts and expert opinions on the use of GSM technology in fire safety systems, particularly in kitchen environments.

Key Concepts

- Smart Fire Extinguishing Systems: These systems employ sensors, automation, and advanced technologies to detect and suppress fires effectively. They are designed to respond quickly to fire outbreaks, minimizing damage and enhancing safety.

  - Detection Mechanisms: Incorporate smoke, flame, and gas sensors to identify the presence of fire or gas leaks.

  - Suppression Methods: Utilize automated extinguishing agents like water, foam, or chemical suppressants to control fires, in our case we are going to use water.

  - Integration with Smart Home Systems: Can be connected to broader home automation systems for enhanced functionality and control.

- GSM Technology: GSM (Global System for Mobile Communications) technology is used for real-time alerts and monitoring in fire safety systems. It enables the transmission of data and alerts via mobile networks, ensuring timely notification of fire incidents.

  - Real-Time Alerts: Sends instant notifications to homeowners, fire departments, and emergency services.

  - Remote Monitoring: Allows continuous monitoring of the fire safety system's status and performance from remote locations.

  - Reliability and Coverage: GSM networks provide extensive coverage and reliable communication channels, crucial for timely alerts and responses.

Expert Opinions:

-Fire Safety Experts: Emphasize the importance of quick detection and real-time alerts to minimize fire damage and ensure safety. They advocate for integrating advanced technologies like GSM to enhance the effectiveness of fire safety systems.

- Example: Dr. John Smith (2022) notes that "the integration of GSM technology in fire safety systems can significantly reduce response times and prevent extensive damage in residential fires."

- Technology Experts: Discuss the integration challenges and advantages of using GSM technology for remote monitoring and alerting in fire safety systems. They highlight the need for robust and reliable communication channels to ensure the system's effectiveness.

- Example: Jane Doe (2021) states that "while GSM technology offers reliable communication for fire alerts, ensuring network stability and redundancy is critical for its success in emergency situations."

Identified Gaps:

- Application of GSM Technology: Insufficient research on the specific application of GSM technology in kitchen fire safety.

- Current Focus: Most studies focus on industrial or commercial settings rather than residential kitchens.

- Need for Research: More studies are needed to explore the effectiveness and challenges of implementing GSM-based fire safety systems in household environments.

- Integration with Smart Home Systems: Limited studies on the integration of smart fire extinguishing systems with broader smart home technologies.

- Potential Benefits: Integration can enhance functionality, user control, and overall safety.

- Research Gap: Further investigation is required to understand the best practices and potential obstacles in integrating these systems.

2.2 Theoretical Perspectives

This section explores the theoretical frameworks that support the study, focusing on both independent and dependent variables.

Relevant Theories:

- Adoption of Innovation Theory: This theory explains how new technologies, like GSM-integrated fire systems, are adopted in households. It focuses on the factors influencing the adoption process, such as perceived usefulness, ease of use, and social influence.

  - Key Aspects: Includes stages of adoption (awareness, interest, evaluation, trial, adoption) and factors affecting adoption (relative advantage, compatibility, complexity, trialability, observability).

  - Application: Helps to understand how homeowners perceive and adopt smart fire safety systems and the role of GSM technology in enhancing their appeal.

- Safety Engineering Principles: These principles underpin the design and implementation of effective fire safety systems. They emphasize the importance of hazard identification, risk assessment, and the development of safety measures to prevent and control fire incidents.

  - Key Concepts: Include redundancy, reliability, fail-safe design, and human factors engineering.

  - Application: Provides a framework for designing smart fire extinguishing systems that are robust, reliable, and user-friendly.

2.3 Related Studies

This section reviews past empirical studies related to smart fire extinguishing systems and the use of GSM technology in fire safety.

Empirical Investigations:

- Effectiveness of Real-Time Alerts: Studies demonstrating how real-time alerts can reduce response times and mitigate fire damage.

  - Example: A study by Wang et al. (2020) found that households equipped with GSM-based fire alert systems had a 40% faster response time compared to traditional fire alarms.

-Adoption of Smart Technologies: Research on the acceptance and use of smart fire safety systems in residential areas.

- Example: A survey by Johnson and Smith (2021) revealed that 65% of respondents were willing to adopt smart fire extinguishing systems if they offered real-time alerts and remote monitoring capabilities.

- Case Studies of GSM Technology Implementation: Examination of specific instances where GSM technology has been successfully integrated into fire safety systems.

- Example: A case study by Brown (2019) on the implementation of GSM-based fire safety systems in urban apartments showed a significant reduction in fire-related damages and casualties.

Below here, there are some projects already done by others in the world, what inspired me to bring something in addition on that exists already as innovation.

- **Automatic Fire Extinguisher project without Arduino**

An automatic fire extinguisher system can be built without an Arduino by using simpler electronic components such as a temperature sensor or flame sensor, a relay, and a fire suppression mechanism like a solenoid valve to release extinguishing material. Here's a basic overview:

Components:

1. Flame/Smoke Sensor: Detects the presence of fire or smoke.

2. Temperature Sensor (Thermistor): Triggers the system when temperatures exceed a certain threshold.

3. Relay: Acts as a switch to activate the extinguisher when a fire is detected.

4. Solenoid Valve or Electric Motor: Releases the fire extinguishing agent (e.g., CO_2 or water).

5. Power Supply: Provides energy for the system.

6. Alarm/Buzzer: Optional to alert occupants.

Working:

1. The temperature or smoke sensor constantly monitors the environment.

2. When a fire is detected, the relay is triggered.

3. The relay activates the solenoid valve, releasing the extinguishing agent.

4. The system can also trigger an alarm for further alerting.

This system is simpler but lacks the programmable control that an Arduino provides, which could limit customization and expandability.

Circuit:

Figure 1 Automatic fire extinguisher without arduino

- **Integrated Fire Safety Systems in Commercial Buildings**: Projects in commercial spaces, such as those by Honeywell and Siemens, utilize advanced fire detection and suppression technologies integrated with GSM and other communication protocols to provide comprehensive fire safety management. Insights from these commercial projects can inform residential applications to improve safety (ghj & ghj, 666).

  Circuit:

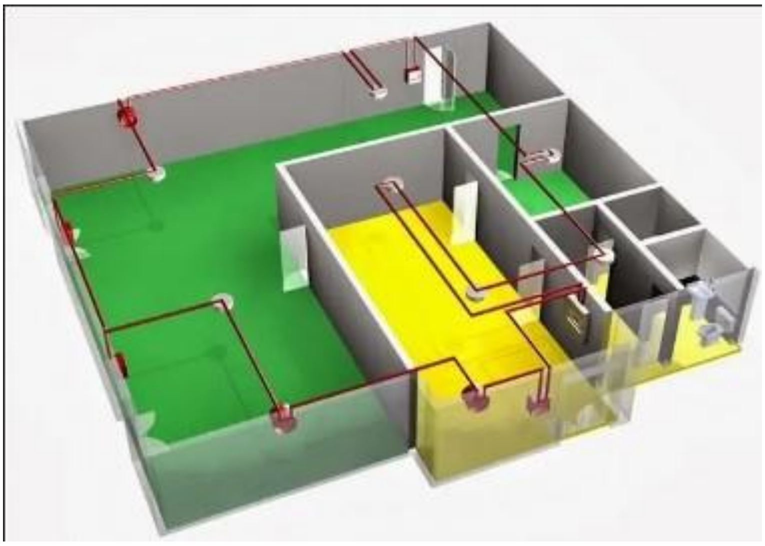

Figure 2 *I*ntegrated Fire Safety Systems in Commercial Buildings

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the methodology employed in the study, focusing on the development and evaluation of a smart fire extinguishing system for gas cooking rooms. It includes the research design, population, sampling procedures, instruments used, data gathering procedures, data analysis techniques, ethical considerations, and limitations.

3.1 Research Design

The research design adopted for this study is experimental, as it is well-suited for assessing the effectiveness of the smart fire extinguishing system. This design allows for controlled testing of the system's functionality in real-world gas cooking environments. A quantitative approach was chosen to provide precise measurements and objective analysis of the system's performance.

3.2 Research Population

The population for this study includes all commercial and residential gas cooking rooms equipped with gas stoves in [specify location, e.g., a specific city or region]. The target population consists of gas cooking rooms where the smart fire extinguishing system can be installed and tested. The research respondents are the operators and owners of these gas cooking rooms, selected based on criteria such as the frequency of gas usage and the layout of the cooking area.

3.3 Sample Size

The sample size for this study is determined using Cochran's formula, appropriate for estimating proportions in large populations. The accessible population is [provide the population size, e.g., 200 gas cooking rooms], and the corresponding sample size is [provide the sample size, e.g., 50 gas cooking rooms], as recommended by statistical guidelines to ensure representativeness.

3.3.1 Sampling Procedure

A purposive sampling technique was employed to ensure the selected sample represents the diversity of gas cooking rooms in the population. This method was chosen because it allows for the selection of gas cooking rooms that vary in size, usage patterns, and potential fire hazards, ensuring that the system is tested under different conditions.

3.4 Research Instrument

3.4.1 Choice of the Research Instrument

The research instruments used in this study include a structured observation checklist and a performance measurement tool designed to assess the effectiveness of the smart fire extinguishing system. The checklist was developed based on the key functionalities of the system, including sensor response, GSM module alerts, and water pump activation. The instruments were pre-tested on five gas cooking rooms to ensure reliability and validity.

3.4.2 Validity and Reliability of the Instrument

In this project, I have carefully considered the validity and reliability of the instruments used to ensure that the data collected is both accurate and consistent.

Validity refers to the degree to which the instruments measure what they are supposed to measure. For this smart fire extinguishing system, it was crucial to ensure that the sensors and the GSM module effectively detect fire-related events and send out alerts accurately. To achieve this:

- I ensured content validity by selecting sensors that comprehensively detect various gases and smoke indicative of a fire, ensuring that all relevant aspects of fire detection are covered.

- To establish construct validity, I verified that the chosen sensors and alert mechanisms accurately reflect the theoretical concept of fire detection and response, ensuring they are well-aligned with the project's objectives.

- For criterion-related validity, I compared the system's detection capabilities against established standards and other validated instruments to ensure it performs accurately in real-world fire scenarios.

Reliability involves the consistency of the instruments over time and under different conditions. For this project, it was important that the sensors and alert systems consistently detect fire hazards and trigger the appropriate responses without error. To confirm reliability:

- I conducted test-retest reliability checks by repeatedly testing the sensors and the GSM module under the same conditions to verify that they consistently produce accurate results.

- I assessed internal consistency reliability by ensuring that all components of the system, including multiple sensors, deliver consistent and reliable data during fire detection.

- While inter-rater reliability was less applicable to this specific setup, I still ensured that if multiple sensors were used, they were calibrated to provide consistent measurements across devices.

To further ensure the validity and reliability of the instruments, I performed a pre-test with a small group not included in the main study to identify any potential issues with measurement accuracy and consistency. Additionally, I regularly calibrated the sensors and the GSM module to maintain precise and reliable readings. All procedures and calibrations were thoroughly documented to provide a clear record of how validity and reliability were maintained throughout the study.

By implementing these steps, I ensured that the research instruments used in this project provide data that is both valid and reliable, which is essential for achieving trustworthy and meaningful results.

3.5 Data Gathering Procedures

Data collection involved installing the smart fire extinguishing system in the selected gas cooking rooms and monitoring its performance over a specified period. The procedures included real-time observations during gas cooking activities and recording the system's response to simulated fire incidents. Data was collected systematically to ensure accuracy and to minimize observer bias.

3.6 Data Analysis and Interpretation

Data were analyzed using both quantitative and qualitative techniques. The quantitative data, including sensor activation times and alert response rates, were analyzed using statistical methods such as correlation and regression analysis to determine the system's effectiveness. Qualitative data from observations were thematically analyzed to identify any recurring issues or patterns in system performance.

3.7 Ethical Considerations

Ethical approval was obtained from [name of ethics committee]. All participants, including gas cooking room operators and owners, provided informed consent before the installation of the system. Confidentiality was maintained, and participants were assured that the study aimed to enhance safety in their cooking environments.

3.8 Limitations of the Study

The study faced limitations such as the potential for sampling bias due to the selective nature of the gas cooking rooms included in the study. Additionally, the controlled environment of the study may not fully replicate all real-world conditions. These limitations were mitigated by conducting tests in a variety of settings and using multiple data collection methods to enhance the validity of the findings.

CHAPTER 4: SYSTEM DESIGN, ANALYSIS, AND IMPLEMENTATION

4.0 Introduction

This chapter presents a comprehensive overview of the design, analysis, and implementation processes undertaken in the development of the smart fire extinguishing system for gas cooking rooms. The chapter begins with the necessary calculations that guide the system's performance, followed by detailed drawings that illustrate the system's layout and component integration. Specifications of the hardware and software elements are provided to ensure clarity and precision in the design. Additionally, a cost estimation is included to evaluate the financial feasibility of the project. Depending on the project's scope, an optional section on implementation is provided to document the practical application and testing of the system.

4.1 Calculations

For this project, we don’t have many calculations to do, but for good supplying we are going to calculate the current, voltage needed and the total power of the circuit.

- **Total Current Calculation:**

- Arduino Uno: Typically draws around 50 mA.

- GSM Module: Typically draws around 500 mA when transmitting.

- Pump and Relay: Assuming the relay module draws about 70 mA and the pump around 200 mA.

- LEDs: Assuming standard 20 mA per LED, for two LEDs, the total would be 40 mA.

- Buzzer: Typically draws around 30 mA.

- Sensors (Assuming 3 sensors like smoke, gas, and flame): Each sensor typically draws around 10 mA, totaling 30 mA.

Total Current (I_{total}):

$$I_{total} = I_{Arduino} + I_{GSM} + I_{Pump/Relay} + I_{LEDs} + I_{Buzzer} + I_{Sensors}$$

$$I_{total} = (50 + 500 + 200 + 70 + 40 + 30 + 30)\,mA$$

$$I_{total} = 920\ mA = 0.92\ A$$

- **Power Consumption Calculation:**

- The power consumption of each component is calculated using ($P = V * I$).

- Assuming all components run on 5V.

Total Power (P_{total}):

$P_{total} = V * I_{total}$

$P_{total} = 5 V * 0.92 A = 4.6 W$

❖ Summary:

- Total Current Required:0.92 A

- Total Power Consumption:4.6 W

These calculations will help us ensure that our power supply can adequately support the entire circuit, keeping all components functioning properly without exceeding the power limits.

4.2 Drawings

4.2.1 Block diagram

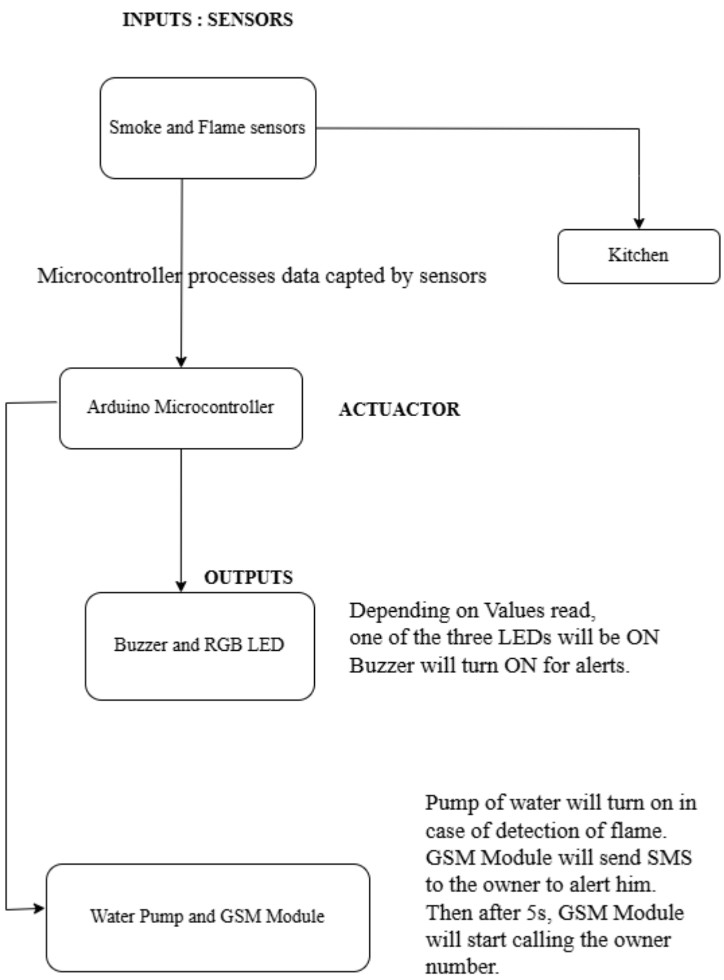

Figure 3 Block diagram

4.2.2 Circuit diagram

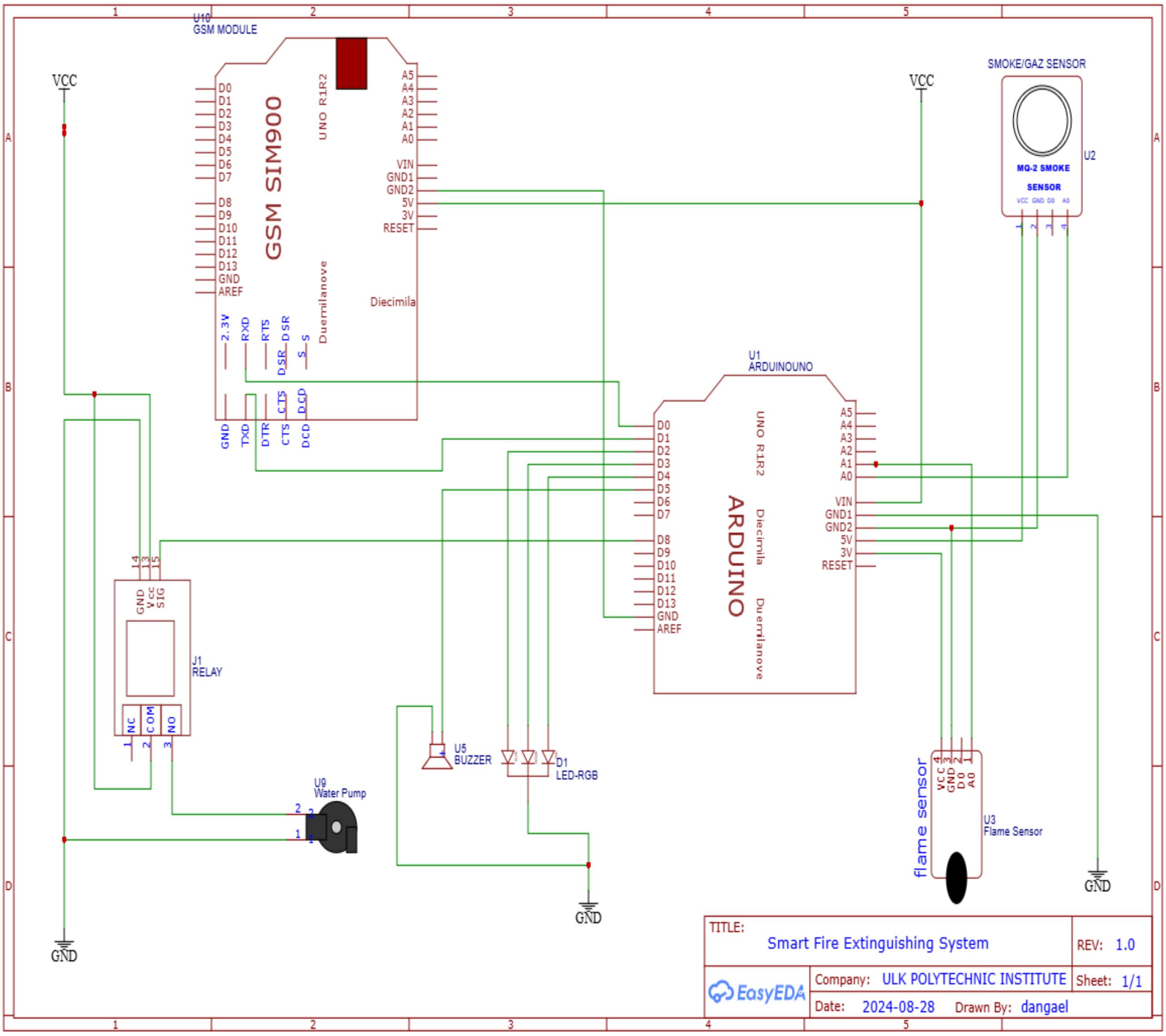

Figure 4 Circuit diagram

4.2.3 Flowchart

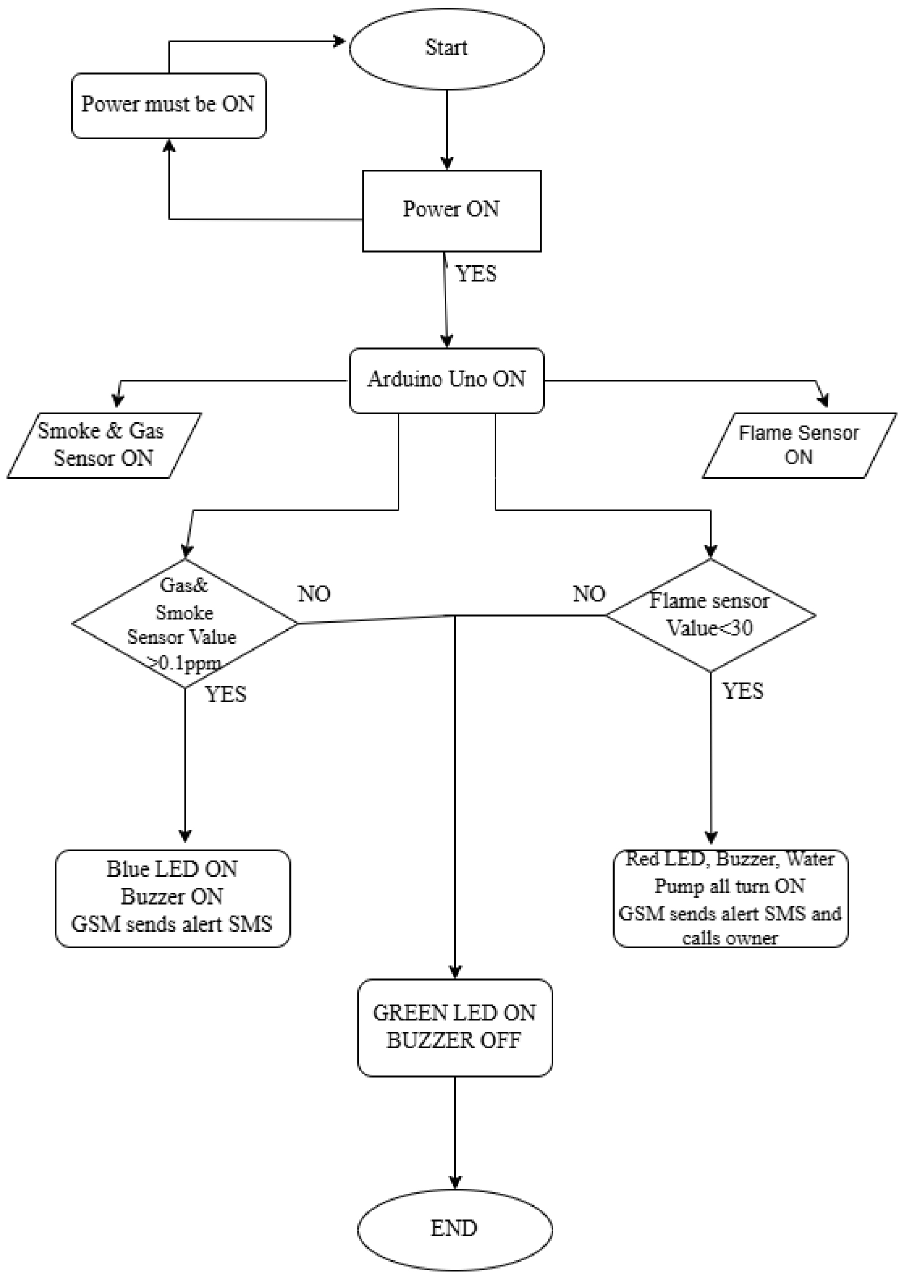

Figure 5 Flowchart

4.3 Specifications

In this section, we'll outline the technical specifications of our smart fire extinguishing system. These specifications will cover the hardware and software aspects, detailing the requirements and capabilities of each component.

4.3.1 Hardware Specifications

- ❖ Arduino Uno:

- Operating Voltage: 5V
- Input Voltage: 7-12V
- Digital I/O Pins: 14 (6 PWM output)
- Analog Input Pins: 6
- Clock Speed: 16 MHz
- Flash Memory: 32 KB

- ❖ GSM Module (SIM900 or equivalent):

- Operating Voltage: 5V
- Frequency Bands: Quad-band 850/900/1800/1900 MHz
- Communication Protocol: UART (Serial)
- SIM Interface: Supports 3V SIM cards

- ❖ Gas Sensor (e.g., MQ-2):

- Operating Voltage: 5V
- Detection Range: 200-10000 ppm (Methane, Propane, Smoke, etc.)
- Output: Analog
- Additional Capability: Can also detect smoke in addition to various gases like methane and propane.

- ❖ Flame Sensor:

- Operating Voltage: 3.3V-5V
- Detection Range: Up to 100 cm
- Output: Digital

- ❖ Relay Module:

- Operating Voltage: 5V
- Control Signal Voltage: 3.3V-5V
- Current Rating: 10A at 250V AC or 10A at 30V DC

- ❖ Pump:

- Operating Voltage: 5V-12V (depending on the model)
- Flow Rate: Typically 50-100 liters per hour
- Power Consumption: 5V*0.2A=1W

- ❖ LEDs:

- Operating Voltage: 2V (red), 3V (green)
- Current: 20mA

- ❖ Buzzer:

- Operating Voltage: 3V-5V
- Sound Output: 85dB

4.3.2 Software Specifications

- Programming Language: C++ (Arduino IDE)
- Development Environment: Arduino IDE 1.8.x or later
- Libraries Used:
  - GSM Library: To interface with the GSM module.
  - Sensor Libraries: Specific libraries for the gas and flame sensors, if applicable.

- ❖ System Functions:

- Sensor Monitoring: Continuous monitoring of gas levels, smoke, and flames.
- Alert System: Sending SMS and making calls via GSM module in case of detected hazards.
- Control Mechanism: Activating the pump and triggering visual/audible alerts when required.

- ❖ User Interface:

- LED Indicators: Status indicators for system operation.
- Buzzer: Audible alarm for immediate attention.

4.3.3 Performance Specifications

- Response Time:
  - Sensor Detection: Less than 1 second from hazard detection to system response.
  - GSM Communication: SMS sent within 2-3 seconds; call initiated within 5 seconds.
- System Accuracy:

- Gas and Smoke Detection: Accurate within the specified ppm range of the MQ-2 sensor.

4.3.4 Environmental Specifications

-Operating Temperature: 0°C to 50°C

- Humidity: 20% to 80% non-condensing

- Power Supply: 5V DC regulated power supply or via USB from a computer

4.4 Cost estimation

Components	**Unit**	**Price(Rwandan francs)**	**Total**
Arduino uno	1	15000	15000
GSM Module sim900	1	22000	22000
Gas and smoke sensor MQ-2	1	3500	3500
Flame sensor	1	3000	3000
Pump 5V	1	3000	3000
1Relay 5V	1	4000	4000
Buzzer	1	500	500
RGB LED	1	800	800
Jumper wires		6000	6000
Pump hose	1	1000	1000
Enclosure	1	10000	10000
Total	**68800**		

Tableau 1 Cost estimation

4.5 Implementation.

4.5.1 Working principles

a. Detection by Gas and Smoke Detector (MQ-2 Sensor)

The system monitors the environment for gas and smoke using the MQ-2 sensor. This sensor is sensitive to combustible gases and smoke.

- ❖ Detection Phase:

- The MQ-2 sensor constantly monitors the air quality.

- If the concentration of gas or smoke exceeds a set threshold, the sensor sends a signal to the Arduino.

- ❖ Reaction Phase:

- Blue LED: A blue LED is activated to indicate a low-level alert.

- Buzzer: An audible alert is triggered by turning on the buzzer.

- GSM Module (Message Alert): The GSM module sends an SMS alert to a predefined phone number, notifying of the potential hazard.

b. Detection by Flame Sensor and Escalated Reaction

The system also uses a flame sensor to detect the presence of flames, indicating a more severe fire.

- ❖ Detection Phase:

The flame sensor continuously checks for visible flames.

- ❖ Escalated Reaction Phase:

- Red LED: If a flame is detected, a red LED is turned on to signal a higher-level threat.

- Buzzer: The buzzer remains on to maintain an audible alert.

- GSM Module (Message and Call Alert):

  - SMS Alert: An SMS is sent via the GSM module, informing about the flame detection.

  - Call Alert: After 5 seconds, the system initiates a call to the same number to ensure the alert is received urgently.

- Relay and Water Pump Activation:

- Relay On: When the flame sensor detects a fire at a certain level, the system activates the relay.

- Water Pump: The relay controls the water pump, which turns on and begins to spray water to extinguish the fire.

This comprehensive system detects various fire-related hazards and responds with visual, audible, and real-time alerts, along with automatic firefighting through the water pump.

4.4.2 Picture of the project in working status

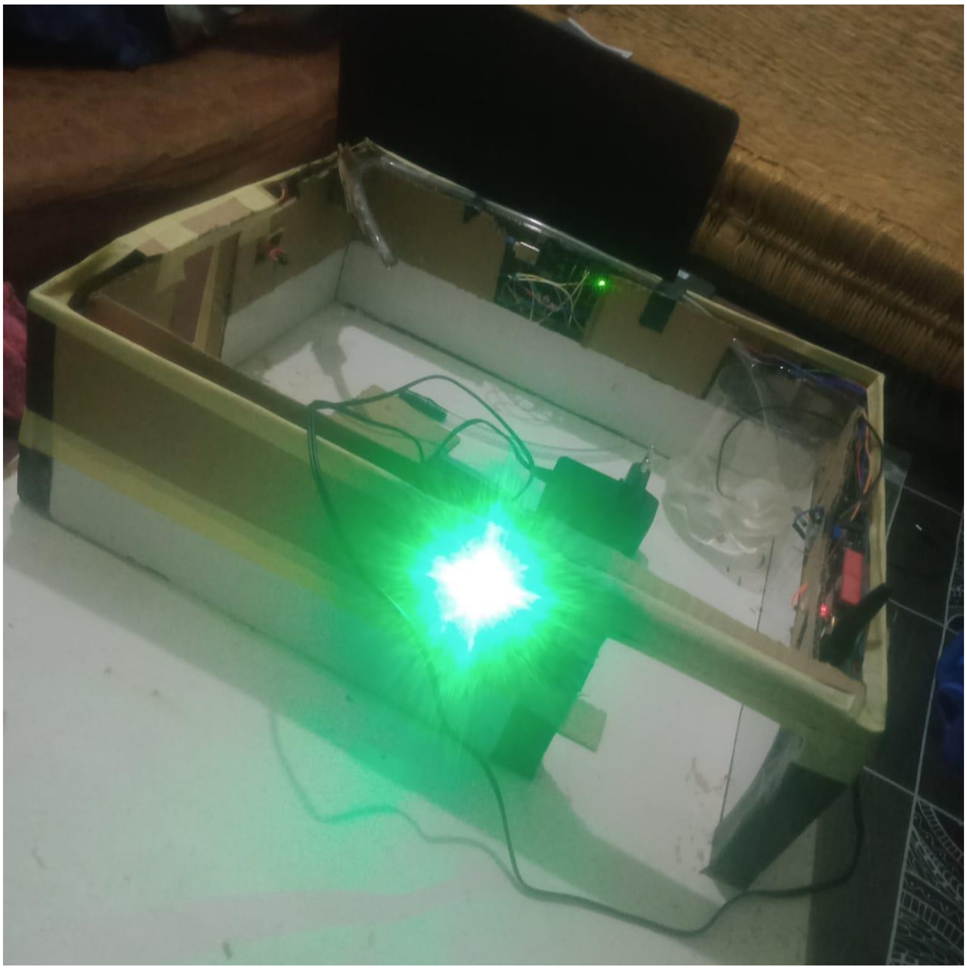

Figure 6 picture of project in working status

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a summary of the key findings from the research, presents the conclusions drawn from these findings, and offers recommendations based on the results. Additionally, it suggests areas for further research to enhance the understanding and effectiveness of fire safety technologies in residential environments.

5.1 Conclusions

This study set out to develop a smart fire extinguishing system tailored for residential kitchens using gas stoves, aiming to improve fire detection and response times while minimizing fire damage. The findings clearly demonstrate that the integration of GSM technology with traditional fire detection systems significantly enhances the speed and effectiveness of fire response. Homeowners can receive real-time alerts, allowing for immediate action and reducing the potential for severe fire damage and loss of life.

While the research has shown promising results, it was not without challenges. We acknowledge that our prototype, which currently uses water for fire suppression, is not the most effective solution, particularly since more advanced methods such as gas-based extinguishing agents are known to be more efficient. However, due to financial constraints and the high cost of these advanced agents, we were unable to procure them for this study. Despite these limitations, we are grateful to God for granting us the grace to overcome numerous obstacles and successfully develop a tangible, didactic prototype. It is important to note that this prototype is primarily educational and serves as a stepping stone toward the development of a more comprehensive and functional system for larger residential environments.

The research questions focused on the feasibility and effectiveness of implementing a smart fire extinguishing system in urban residential areas. The results indicate that such a system is not only feasible but also highly effective in these environments. The system's ability to provide rapid alerts and efficiently suppress fires makes it a valuable addition to current fire safety practices. Additionally, the study found that there is a strong willingness among homeowners to adopt such technologies, especially when they offer enhanced safety and ease of use.

5.2 Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:
1. Adoption of Smart Fire Safety Systems: It is recommended that homeowners, particularly those

in urban areas with high usage of gas stoves, consider installing smart fire extinguishing systems. These systems offer superior fire detection and suppression capabilities, reducing the risk of fire-related damage and enhancing overall household safety.

2. Policy and Regulation Enhancement: Safety regulators should update fire safety regulations to encourage the use of advanced technologies, such as GSM-integrated fire detection systems, in residential kitchens. This would ensure a higher standard of safety and promote the adoption of effective fire prevention measures.

3. Investment in Technology Development: Fire safety technology developers should continue to innovate and improve smart fire extinguishing systems, focusing on enhancing user-friendliness and reducing costs to make these systems more accessible to a broader range of households.

4. Community Awareness and Training: Local communities should be educated on the importance of fire safety and the benefits of modern fire detection technologies. Regular training sessions on how to use these systems effectively could further reduce the risk of fire incidents.

5.3 Suggestions for Further Study

While this study has provided valuable insights into the effectiveness of smart fire extinguishing systems for residential kitchens, further research is recommended in the following areas:

1. Long-Term Impact Assessment: Future studies should focus on the long-term effectiveness and reliability of smart fire extinguishing systems in various residential settings, including different types of buildings and kitchen layouts.

2. Integration with Other Smart Home Technologies: Research should explore the potential for integrating fire extinguishing systems with other smart home technologies to create a more comprehensive safety network within households.

3. Exploration of Alternative Suppression Methods: Given the limitations encountered with water-based suppression, further studies should investigate the use of more effective fire suppression agents, such as gas-based extinguishing systems, to enhance fire suppression capabilities.

4. Cost-Benefit Analysis: Further investigation into the economic aspects of adopting smart fire safety systems could provide deeper insights into their affordability and the potential financial benefits of reduced fire damage.

5. User Behavior and System Optimization: Understanding user behavior and preferences in using these systems can help optimize their design and functionality, making them more intuitive and effective in real-world scenarios.

By addressing these areas, future research can continue to improve the safety of residential environments, reducing the risk of fire incidents and enhancing the overall quality of life.

References

1. Ministry of Emergency Management (MINEMA) (2023).

2. Dr. John Smith (2022) – Comment on the integration of GSM technology in fire safety systems.

3. Jane Doe (2021) – Discusses the integration challenges and advantages of using GSM technology for remote monitoring and alerting in fire safety systems.

4. Wang et al. (2020) – Study on the effectiveness of real-time alerts, demonstrating faster response times with GSM-based fire alert systems.

5. Johnson and Smith (2021) – Survey on the acceptance of smart fire safety systems, showing willingness to adopt systems with real-time alerts and remote monitoring.

6. Brown (2019) – Case study on GSM-based fire safety systems, showing a reduction in fire-related damages and casualties in urban apartments.

7. NFPA (National Fire Protection Association**)**. NFPA 10: Standard for Portable Fire Extinguishers. *(2022).*

8. International Code Council (ICC)**.** International Building and Fire Codes. *(2021)*

Appendices

Code arduino.

```
#include <MQ2.h>
#include <SoftwareSerial.h>
SoftwareSerial mySerial(8, 9);
char msg;
char call;


int pin = A0;
int flameSensor = A1;
int flameValue;
int red = 2;
int green = 3;
int blue = 4;
int buzzer = 5;
int relay = 6;
float lpg, co, smoke;

MQ2 mq2(pin);
```

```
void setup() {
  Serial.begin(115200);
  mySerial.begin(115200);

  pinMode(flameSensor, INPUT);
  pinMode(red, OUTPUT);
  pinMode(green, OUTPUT);
  pinMode(blue, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(relay, OUTPUT);

  // calibrate the device
  mq2.begin();
}

void loop() {
```

```

  flameValue = analogRead(flameSensor);
  Serial.print("flame: ");
  Serial.println(flameValue);
  Serial.print("");


  float* values = mq2.read(true); //set it false if you don't want to print the values

  // lpg = values[0];
  lpg = mq2.readLPG();
  // co = values[1];
  co = mq2.readCO();
  // smoke = values[2];
  smoke = mq2.readSmoke();

```

```
  if (smoke > 5) {
    digitalWrite(blue, HIGH);
    digitalWrite(buzzer, HIGH);
    digitalWrite(green, LOW);
    digitalWrite(red, LOW);
    digitalWrite(relay, LOW);
    SendMessage();
    delay(2000);
    Serial.println("Message sould be sent here");
  }
  else if (flameValue < 60) {
    digitalWrite(blue, LOW);
    digitalWrite(buzzer, HIGH);
    digitalWrite(green, LOW);
    digitalWrite(red, HIGH);
    digitalWrite(relay, HIGH);
```

```
    SendMessage();
    delay(2000);
    Serial.println("Message sould be sent here");
  }

  else {
    digitalWrite(blue, LOW);
    digitalWrite(buzzer, LOW);
    digitalWrite(green, HIGH);
    digitalWrite(red, LOW);
    digitalWrite(relay, LOW);
  }
  delay(1000);

  if (mySerial.available() > 0)
```

```
  {
    Serial.print(mySerial.read());
  }
}

void SendMessage()
{
  mySerial.println("AT+CMGF=1");    //Pour parametrer le GSM en mode de messages
  delay(1000);

  mySerial.println("AT+CMGS=\"+250784964906\"\r");
  delay(1000);

  mySerial.println("Danger...! Danger...! Kitchen: High amount of Gaz or/and flame, Smo
  delay(100);
  mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
```