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College of Science and Technology

AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

Research Thesis Title:

IOT BASED LPG/CNG GAS ACCIDENTS PREVENTION AND REPORTING WITH GSM

A dissertation submitted in partial fulfilment of the requirements for the award of masters of science degree in internet of things: wireless intelligent sensor network

Submitted By:

Name: NIZEYIMANA Jean de Dieu (Ref. No: 213000523)

December, 2021

UNIVERSITY of RWANDA

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Supervised by:

-Name of Main supervisor: Dr. BAKUNZIBAKE Pierre
-Name of co – supervisor: Dr. Abubakar Diwani

December, 2021

DECLARATION

I NIZEYIMANA Jean de Dieu, Master ‘student from African Center of Excellence in internet of things, at University of Rwanda. I declare that this research thesis is my own original work and it has never been presented before anywhere in the world.

Jean de Dieu NIZEYIMANA

Ref: 213000523

Signed: …….

Date: ……/……/……

BONAFIDE CERTIFICATE

This is to certify that this submitted Research Thesis work report is a record of the original work done by Mr. NIZEYIMANA Jean de Dieu (**Ref. No:213000523**), MSc. IoT-WISNET Student at the University of Rwanda / College of Science and Technology / African Center of Excellence in Internet of Things, the Academic year 2020/2021.

This work has been submitted under the supervision of Dr. BAKUNZIBAKE Pierre and Dr. Abubakar Diwani.

Main Supervisor: Dr. BAKUNZIBAKE Pierre. Co-Supervisor: Dr. Abubakar Diwani

Date: Date:

Signature Signature:

The Head of Masters and Training

Dr. James Rwigema

Signature:

Date:

ACKNOWLEDGEMENT

Every work accomplished is a pleasure, a sense of satisfaction. However, a number of people always motivate, criticize and appreciate a work with their objective ideas and opinions, hence I would like to usethis opportunity to thank all, who have directly or indirectly helped me to accomplish this project.

First and foremost, I would like to express my sincere gratitude to the Almighty God who has given me theprecious gift of life and for guiding me all the way through the course of my studies and research project as well. My heartfelt acknowledgement goes to my parents for their unconditional love and invaluable advices that we hold on for daily life.

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I am deeply indebted to all Academic staffs in the African Center of Excellence in Internet of Things ACEIoT and the whole Administration at large for the work done during this academic journey at the University.

To all of my dear classmates for all the sleepless nights we worked together, and for all the fun we have had in the last two years and invaluable friendship.

May God bless you all!

DEDICATION

To the Almighty God
To My beloved parents
To my family
To my friends
To my colleagues
I dedicate this work

ABSTRACT

In the wake of replacement of wood and kerosene by gas cookers for several purposes in Rwanda, gas leakage has caused several damages in domestic household, factory, kitchens in restaurants, canteens among others, installation of a gas leakage detection device was globally inspired to eliminate accidents related to gas leakage. Liquid Petroleum Gas (LPG) and Compressed Natural Gas (CNG) consist of a mixture of gases like propaneand butane. These gases can catch fire easily. LPG is used as propellant, fuel and as a refrigerant. When a leak occurs, the leaked gases may lead to explosion. The number of deaths occurring due to explosion of gas cylinders in Rwanda has increased. So, the leakage should be controlled to protect people from danger by detecting any gas leakage and preventing any accidents.

The aim of this research project is to design an automatic gas accident prevention system that can automatically detect and stop gas leakage in vulnerable premises using MQ 6 gas sensor, This particular gas sensor has high sensitivity to Liquefied Petroleum Gas and natural gases and it detect LPG/CNG gas leakage scenarios and provide a security alert to intended users ,if there is any leakage the system will automatically take the preventive measures to avoid fire accidents like turning off the gas supply by turning off the valve and removing the leaked gas from the premises. For extra precautionary method it turns off the main power supply of house.

In order to achieve the aim of this project, a prototype was developed which consists of GSM (Global System for mobile communications) module, which alerts by sending SMS to the owner, it also consists of a Buzzer, LED, fire sensor (sensing both the flame and smoke) and an extinguisher. The gas and fire sensor send out a signal to ESP8266-NodeMCU as soon as it encounters a gas leakage and or fire. TheNodeMCU processes these signals and sends out a signal to a buzzer and LCD with required message details.

Keywords: GSM (Global System for Mobile communications), Internet of Things, Sensor Technology, Gas monitoring, Gas Accidents Prevention

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	:	Alternating Current
ACEIoT	:	African Center of Excellence in Internet of Things
CNG	:	Compressed Natural Gas
GHG	:	Green House Gases
GSM	:	Global System Mobile
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
LPG	:	Liquid Petroleum Gas
NST1	:	National Strategies for Transformation
PDL	:	Program Description Language
SMS	:	Short Message Service
Wi-Fi	:	Wireless Fidelity

CHAPTER I: GENERAL INTRODUCTION

1.1. Overview

Liquefied Petroleum Gas (LPG) is flammable mixtures of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and vehicles. In Rwanda, LPG is used mainly in cooking by household, restaurant, hotel, public and private institutions. Available cylinders' capacity on market are 3kg; 6kg; 12 kg; 15kg, 20kg, 25 kg, 35kg, 38 kg and 50 kg.

As from official statistics, only five per cent of Rwandan urban households use gas for cooking, an increase of four per cent from 2014. Only 1.1 per cent of rural households use gas for cooking. This means that, out of the 2,708,000 households in Rwanda, only 135,400 use cooking gas.

According to the government's seven-year programme(NST1), the number of Rwandans using wood as a source of energy will be reduced to 42 per cent by 2024 from the current 83.3 per cent. The use of LPG in cooking has increased from 724.6 tonnes in 2010 to about 3,000 tonnes in 2017 according to figures of the National institute of Statistics (NISR). The use of firewood, kerosene stove and/or electric cooker is rapidly replaced by the gas cooker which is abundant and more cost effective for domestic use.

The reason to adopt the use of LPG gas in Rwanda was that it is faster than charcoal when cooking and timesaving; more energy efficient; cheaper than charcoal for cooking purposes; more environmentally friendly than charcoal; reduce the greenhouse gases (GHG) emission by up to 70%; LPG is clean energy and there is no waste upon cooking;

Gas leakage tragedies and accidents have lead to heavy losses over the years. So it is very crucial to detect any gas leakage and prevent any accidents. Unproper handling of LPG use cause severe damages to human life. Bhopal gas tragedy in India is an example for accidents due to gas leakage. Gas leakage detection is not only important but controlling the leakage is also important.

1.2. Problem statement

Safety plays a major role in today's world and it is necessary that good safety systems are to be implemented in places of residence and work. LPG, first produced in 1910 by Dr. Walter Snelling is a mixture of Commercial Propane and Commercial Butane having saturated as well as unsaturated hydrocarbons. Because of the versatile nature of LPG, it is used for many needs such as domestic fuel, industrial fuel, automobile fuel, heating, illumination etc. and the demand for LPG is on an exponential raise day by day [1].

Butane and Propane gases, are highly inflammable in nature. The LPG is an odorless gas to human beings even if some people may have a low sense of smell. In such cases they may not be able to respond

for the gas concentration present. Leakage of LPG and fire are nowadays big problem for a wide range of cases such as domestic household, factory, kitchens in restaurants, canteens. Because gas explodes when in contact with fire [2].

1.3. Objectives of this research

Throughout this research, there is a main objective to achieve and specific objectives that will be focused on in this study:

a. General Objective

The main objective of this work is to design an Arduino based gas leakage detecting and preventing system.The hazardous gases like LPG and propane will be sensed and displayed each and every second in the LCD display. If these gases exceed the normal level, then an alarm will be generated immediately and also an alert message (SMS) will be sent to the authorized person through the GSM.

b. Specific objectives

The specific objectives for this project will be the following:

- To design a prototype system that can help in handling gas leakage and preventing damages that may occur in residential buildings, restaurants and canteens and other public and private places where gases are found.
- To display the leakage alarm on a display board and send an alarm notification on SMS to any predefined mobile number.
- To actively prevent accidents through an automated notification system. The advantage of this automated detection and alerting system over the manual method is that it offers quick response time and accurate detection of an emergency and in turn leading faster diffusion of the critical situation.

1.4. Scope of this research

The scope of this project had been performed in order to achieve the objectives of this project. Design and build a prototype of an LPG/CNG leakage detector controlled by Arduino Uno using MQ-6 gas sensor to detect the presence of gas leakage and fire sensor to detect fire in case.

Due to the increase in fuel costs, we use LPG gas in most petrol/diesel vehicles. N The use of LPG gas in cars and home is very risky. The LPG gas cylinders used at home and elsewhere are the same condition, which is mainly due to LPG gas leakage accidents. For the protection and security against LPG gas explosion problem, I hereby design the IoT based system to prevent accidents.

1.5. Application

This project has application in homes. It can also be used in industries and offices and colleges where the LPG gas cylinder is used in the canteen. This project also has applications in hotels and restaurants

1.6. Advantage of the system

The main advantage of the Arduino Uno based LPG detector system project is that it gives a remote indication to the user about the LPG leakage with the help of SMS indication and it helps to have actuation techniques to control the damages that may occur

CHAPTER II: LITERATURE REVIEW

In this chapter, a critical analysis of existing research in the field of gas accidents prevention has been made to highlight their strengths and weaknesses and a gap was identified. It provided a theoretical background to this study and helped to establish the links between what is proposed to examine and what has already been studied, it helps us to look at different systems with active and passive accidents prevention mechanisms and control actions.

Towards, the literature of this research a number of research on gas leakage security systems have been conducted. Gas leakage is a major concern with residential, commercial premises and gas-powered transportation vehicles. One of the preventive measures to avoid the danger associated with gas leakage is to install a gas leakage detector at vulnerable locations.

2.1. Systems with active accident prevention mechanism and control action

Before the development of electronic household gas detectors in the 1980s and 90s, gas presence was detected with a chemically infused paper that changed its color when exposed to the gas [1]. Since then, many technologies and devices have been developed to detect, monitor, and alert the leakage of a wide array of gases. Today, booking an LPG cylinder is now just a text message away.

Among these technologies there is the Design of a microcontroller based toxic gas detecting and alerting system. The hazardous gases like LPG and propane were sensed and displayed each and every second in the LCD display. If these gases exceed the normal level, then an alarm is generated immediately and also an alert message [2].

In addition, the design of a wireless LPG leakage monitoring system was proposed for home safety. The system detects the leakage of the LPG and alerts the consumer about the leak and as an emergency measure the system will switch on the exhaust fan and also checks the leakage. An added feature of the system is that the approximate consumption is indicated in terms of the total weight. The proposed system makes use of GSM module in order to alert about the gas leakage via an SMS [3].
Researchers moreover proposed a system that takes an automatic control action after the detection of small amount of LPG leakage. This automatic control action provides a mechanical handle for closing the valve. We are increasing the security for human by means of a relay which will shut down the electric power to the house. Also, by using GSM, we are sending an alert message to the users and a buzzer is provided for alerting the neighbors about the leakage [4].

The effort to prevent accidents also proposed to build the system using a MQ6 gas detection sensor and interface it with 8051 family microcontrollers along with GSM modem. The gas leakages are detected by gas sensor, the signal from gas sensor is applied to microcontroller and we also used the Temperature sensor LM35 and LDR also used. The microcontroller processes this signal and sends it to the GSM modem. The GSM modem now sends out an alerting SMS to the authorized people so that they may handle the issue [5].

The NodeMCU development kit was employed as the core control unit, this system provides gas and fire sensing and a buzzer was used for alerting the house occupant in case of danger issues, but the use of NodeMCU development kit as core control unit may add cost to the system. Another device that has the ability to make three different actions when LPG gas was detected was proposed, it alert the owner by making sound as a notification for quick action, send an SMS to a phone and finally provide a display on a screen[7].

As a result of sudden development witnessed in communication sector in most of developing countries, GSM-Based gas monitoring system has received huge interest. A microcontroller-based gas leakage detector system was designed after MQ6 senses the presences of the gases, an SMS will be sent to the owner's phone via GSM module controlled by the brain of the system (PIC16F877), but alarm using buzzer will be activated as a third-party environmental control of the system. Also, another GSM-Based gas detector system was developed [8] [9].

Microcontroller Based LPG Gas Leakage Detector Using GSM Module, in this system where used gas sensor, GSM module, microcontroller, if the gas concentration is increasing the gas sensors will sense the leakage of the gas and then send to the microcontroller. Then the GSM module is connected to the microcontroller which will gives the command to stop the main supply. The system is highly reliable, tamper-proof and secure. In the long run the maintenance cost is efficient. It is highly accurate [10].

Furthermore, researchers proposed an automated gas detection and accident avoider system using ARM cortex. The system automatically detects gas leakages. If the leakage is detected, then this systemautomatically switches on the exhaust fans. One exhaust is used to push the gas out of the room. While another fan is used to pull in fresh air from outside at the same time sending out an alert message to turn off the gas supply. The ARM Microcontroller have a smaller number of transistors and these are cost sensitive and high-performance devices. One of the most advanced forms of these microcontrollers is a cortex controller, it is mostly used in wireless communication technologies and

other embedded system dueto benefits such as low power consumption, etc. ARM Cortex is enhanced for low cost an energy efficientMicrocontroller.

In this proposed system it takes the input from the gas sensor and sends each data to the ARM cortex. ARM manipulates the data and sends the manipulated data to all the sensors, buzzer, LCD, exhaust fan, GSM module, which alerts us about the leakage of gas and we can prevent the leakage of gas [12].

2.2. Systems with passive accident prevention mechanism

A System was proposed which detects gas leakage and alerts through alarm and status display besides turning off the gas supply valve [13] LPG leakage monitoring and multilevel alerting system was proposed. A system using LPG gas sensor for sensing the leakage and produce the result in audio and visual formats also alerts human via Short Message Service (SMS). But it lacked an automatic prevention system [14]. A wireless gas leakage & level detection with auto renewal system was proposed. A system in which gas level is detected and auto booking is done with the gas station also giving the information to the consumer. But it did not deal with the detection and prevention issue [15].

Real time gas leakage detection using Cloud. This system was proposed in which ZigBee is used to feed real time sensor data over the cloud. The sensor monitors, detects and raises an alarm whenever a gas leak or fire broke out condition is detected. This data is made available at real time feeds over the cloud. But it lacked a self-prevention system [16].
Design and implementation of an economic gas leakage detector was proposed. A system, detecting low and high gas leakage levels and alerts the users by issuing appropriate audio-visual warning signals. The cost involved in developing the system is significantly low and is much less than the cost of gas detectors commercially available in the market [17].

An android based automatic gas detection and indication robot. A mini mobile robot which is capable of detecting a gas leakage in any hazardous places whenever there is an occurrence of gas leakage in a particular place the robot immediately read and sends the data to android mobile through wireless communication like Bluetooth. They have developed an android application for android based smart phones which can receive data from robot directly through Bluetooth. The application warns with an indication whenever there is an occurrence of gas leakage and can also control the robot movements via Bluetooth by using text commands as well as voice commands [18].

In view of the problem of gas leakage detection, alerting and prevention many systems have been proposed earlier by different authors and researchers and that has helped to improve the gas safety issue in every day to day lives but there has been limited studies on proper accident prevention apart from notification.

To bridge the gap, the addition of automaticgas cylinder closing, automatic closing of external motor valve whenever gas leakage is detected together with a disposition to stop fire is proposed in this research for a real time intervention to stop any accident and prevent any damages.

CHAPTER III: METHODOLOGY

This chapter discusses techniques used to identify, select, process, and analyze data, it will go through the system level design, hardware and software components as well as the Program Description Language (PDL).

3.1. Existing methodologies

In the existing method, different gas sensing technologies are used. The LPG gas leakage is detected by the semiconductor sensor. Nowadays LPG accidents occur very common. The main reason of these accidents is due to the leakage of LPG. This leakage of LPG starts when we forget to close the main regulator valve.This is the basis of these kinds of accidents. Already there are some sorts of remedial measures such as when the leakage is detected; message is sent to the fire station and the owner. Another remedial measureis that when the leakage is detected, exhaust fan is switched on. The first mentioned method has the disadvantage that there is no control action taken, it needs a manual control which puts human into direct risk. The second method has the disadvantage that if the wiring of the exhaust fan is not proper then it will cause immediate explosion due to the flow of AC. In all these mentioned above, there is only detection no control action is taken.

3.2. Proposed methodology

The proposed methodology takes an automatic control action after the detection of the smallest amount of gas leakage. This automated control in place ensures a mechanical action for closing the gas valve by using a Relay automatically command the dry powder fire extinguisher when fire is detected,

and Using GSM the system will send an alert message to the users and a buzzer with Red LED provided for alerting the neighbors about the gas.

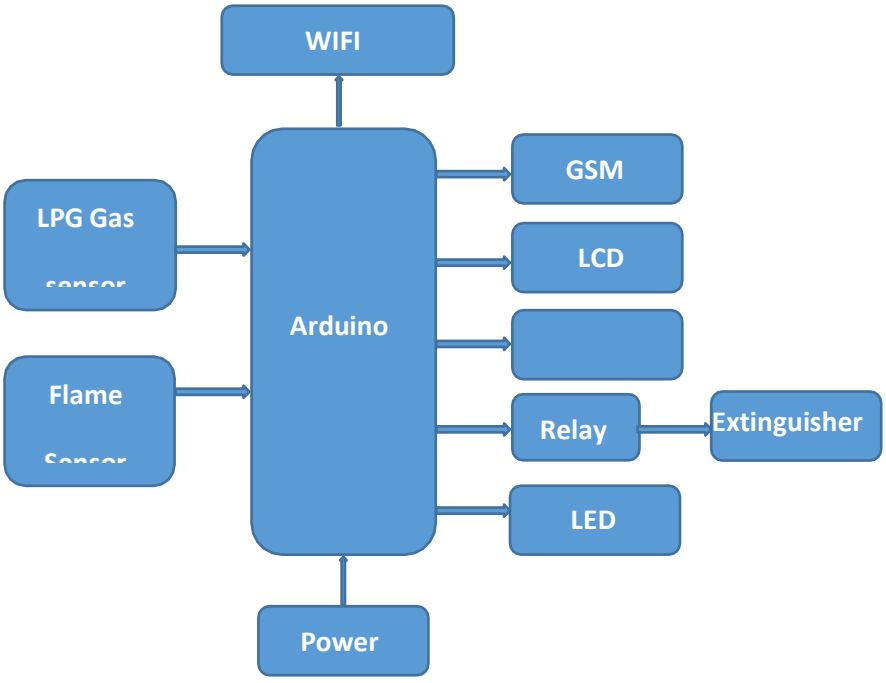


Figure 1: Architecture of the Proposed Prototype

As it appears in Figure 1, sensors are used to detect gas leakage and fire. There are some sorts of remedial measures such as when the leakage is detected, message is sent to the fire station and the house owner. Besides in case of gas leakage, electricity will be automaticallycut off and exhaust fan switched on automatically.

This will take into consideration the following:

1. The gas sensor chosen is MQ-6 which has great sensitivity to Propane, Butane and LPG, also response to natural gas.
2. The sensors used to detect the fire will be sensing both the flame and the smoke
3. These sensors will be connected directly and controlled by a microcontroller. PIC16F1938 is chosen to makes the detector much simpler.
4. The output reading from the sensors will be displayed on the LCD.
5. The PIC16F1938 also will be integrated to the GSM module by using MAX232 as the connector. Wheneverthe reading of the sensor shows a gas leakage or fire, it will automatically send an SMS alert wirelessly byusing the GSM Modem through GSM Network to the numbers as being set on the coding.

In the process of designing and implementing the systems, I followed the process depicted in Figure 2, However, the last stage of implementation was not done as the system is developed as a prototype. Real implementation will be undertaken in the future once necessary resources are obtained to produce actual systems to be sold.

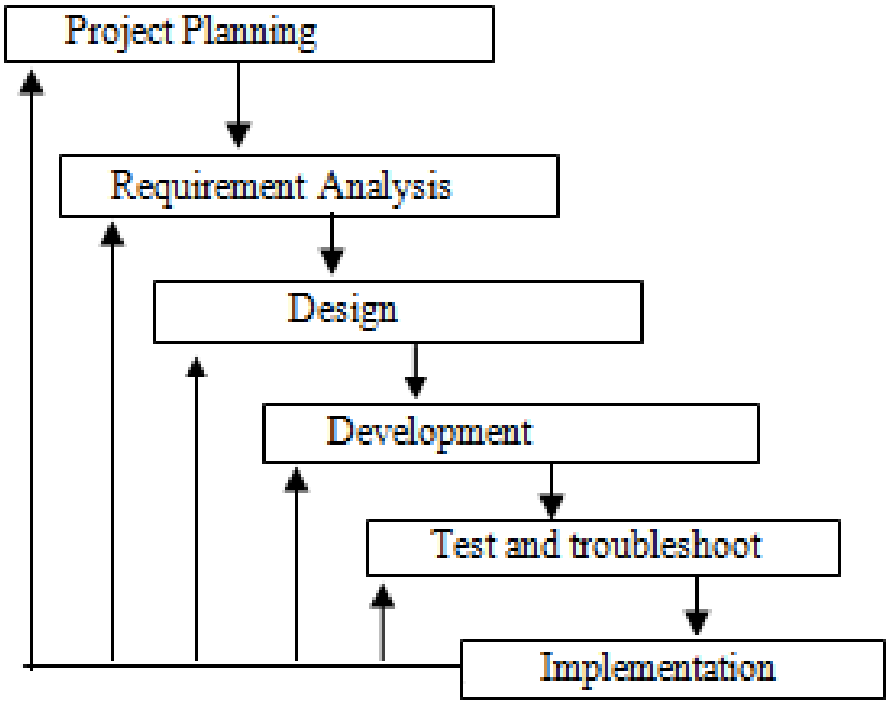


Figure 2: Workflow of the project

3.3. System Architecture

The three-layer IoT Architecture has been selected for the solution as shown in Figure 3. In this architecture the system is made up of three layers; the perception layer, the network layer and the application layer. The system components are grouped to the appropriate layers as follows;

The perception layer – This is the physical layer, which has the LPG gas and flame sensors for sensing and collecting information from the environment. The sensors sense the environment for any gas leakagesand fires.

The network layer – This layer contains the Microcontroller and the network and communication devices. A GSM module and a WIFI module is used for communication in case any anomalies are detected.

The application layer – This is where the application service and actuation action take place. An LCD,LED and buzzer are used to notify users of gas leakages. An extinguisher is used to automatically take action in case of a fire.

Application Layer	LCD, LED and buzzer are used for notifications. An extinguisher is used to automatically extinguish fire.
Network Layer	Arduino for data processing, A GSM and a WIFI module is used for communication.
Perception Layer	LPG gas and flame sensors for sensing and collecting information from the environment. A mobile App used tomonitor current conditions.

Figure3: System architecture

3.5. System Hardware Components

The system is made up of the following hardware components;

a) Arduino Uno

Arduino is an open-source physical computing platform based on a microcontroller board and an integrated development environment to program the board. Arduino obtains several inputs such as switchesor sensors and controls several outputs such as lights, motors and others. Arduino software

is compatible with the Windows OS, Macintosh and Linux Oss unlike most microcontroller systems that are limited to Windows.

It is the most useful part of the system. All the input and output devices are controlled by Arduino. At the same time, it reads and manipulates the input from the sensor. Figure 4 shows the Arduino pinout.

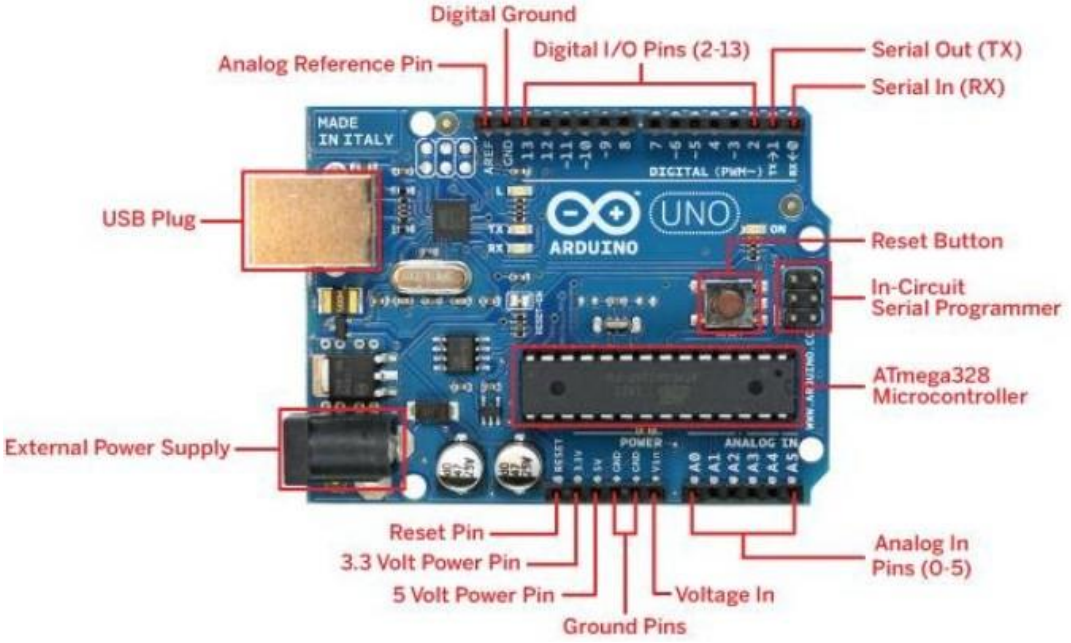
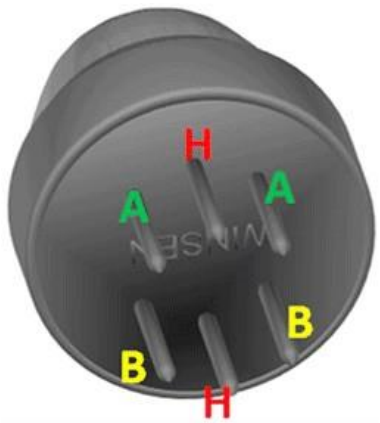


Figure 4. Arduino Pinout

b) LPG Sensor (MQ6 Gas Sensor):

This sensor detects the LPG gas molecules in the air. And gives respective voltage output to the Arduino. Gas sensor MQ-6 is SnO2, has lower conductivity in clean air. When the target combustible gas occurs, the sensor's conductivity is higher along with the gas concentration increasing. MQ-6 gas sensor has great sensitivity to Propane, Butane and LPG, also response to Natural gas. The sensor can be used to detect different combustible gas, especially Methane, it is cheap and suitable for different application.



Pin No.	Pin Name
1	Vcc(+5V)
2	Ground
3	Digital Out
4	Analog out

Figure 5: MQ6 gas sensor

Connection to Arduino	
MQ6	**ARDUINO**
VCC	+5v
GRND	GRND
Digital Out	-
Analogue Out	A0

c) Fire sensor:

A flame(fire) sensor module that consists of a flame sensor (IR receiver), resistor, capacitor, potentiometer, and comparator LM393 in an integrated circuit. It can detect infrared light with a wavelengthranging from 700nm to 1000nm.The far-infrared flame probe converts the light detected in the form of infrared light into current changes. Sensitivity is adjusted through the onboard variable resistor with a detection angle of 60 degrees. Working voltage is between 3.3v and 5.2v DC, with a digital output to indicate the presence of a signal. Sensing is conditioned by an LM393 comparator.

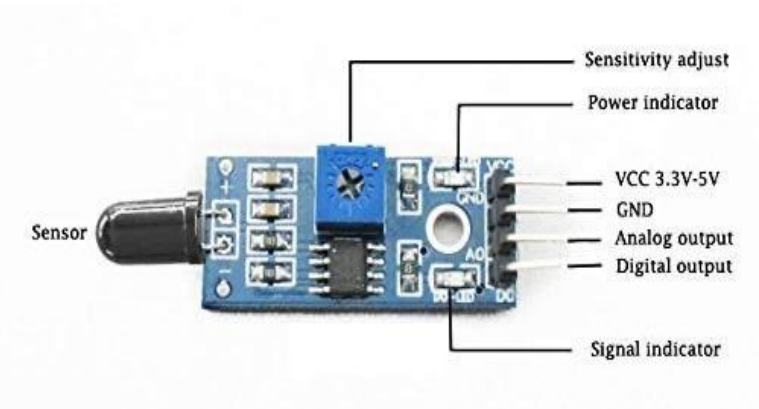


Figure 6: Flame sensor

Connection to Arduino	
Flame sensor	**ARDUINO**
VCC	+5v
GRND	GRND
Digital Out	D5
Analogue Out	

d) GSM Modem:

User receives SMS indication with the help of GSM modem connected to the Arduino Uno board. GSMrefers to Global System for Mobile. It is mainly used for communication purpose. In this project, the GSMsystem is used to alert the users. When the gas leakage is detected, the system stops the leakage and alertsthe surroundings. Then, the information about the leakage has to be informed to the user. For this purpose,GSM is used. Using GSM, a warning SMS is sent to the user. The type of GSM module used in this project

is GSM module SIM900. The method of communication is asynchronous serial communication. Thecorresponding code has to be loaded into the microcontroller, to which GSM is connected

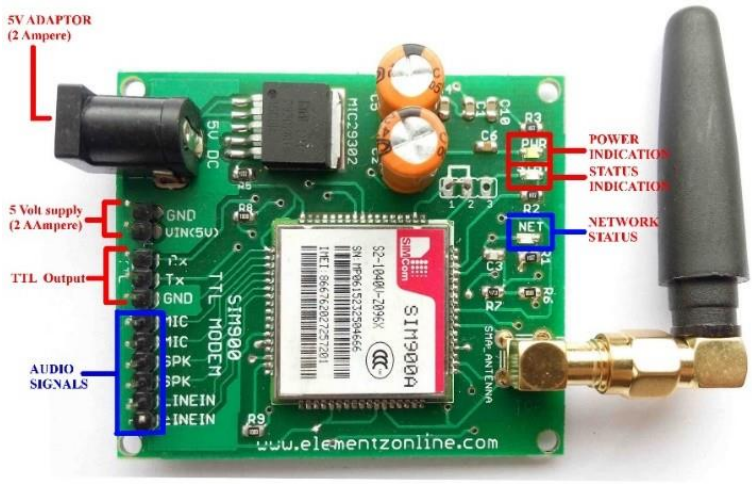


Figure 7. GSM Module

Connection to Arduino	
GSM	**ARDUINO**
VCC	
GRND	GRND
Tx	Rx
Rx	Tx

e) Buzzer:

The buzzer is a sounding device that can convert audio signals into sound signals. A piezoelectric buzzeris connected to the system using a transistor circuit. This buzzer gives a warning signal to the user when gas leakage or fire is detected.

Figure 8: Buzzer

Connection to Arduino	
Buzzer	**ARDUINO**
Data	D6
GRND	GRND

f) ESP-8266

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP / IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

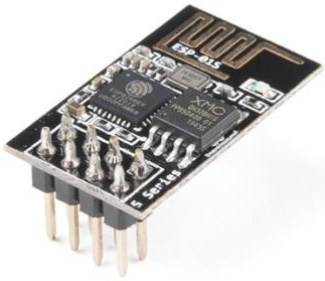


Figure 9: ESP 8266 Wi-Fi module

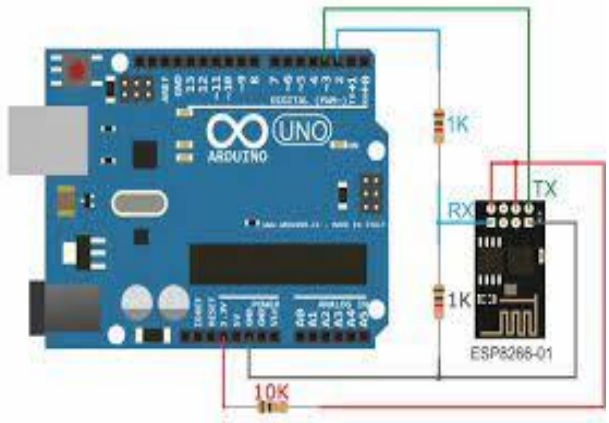


Figure 10. Connection of ESP-8266 to Arduino

g) Stepper Motor

A stepper motor is used to automatically sprinkle dry powder. The motor is connected to the dry powder extinguisher via a relay module

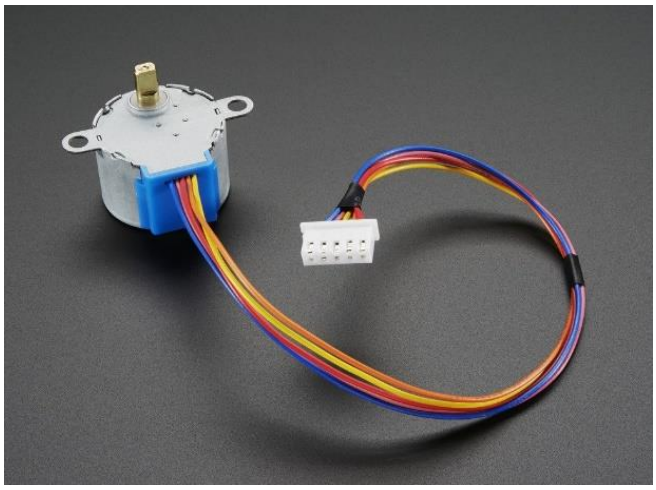


Figure 11: Stepper motor

h) Dry powder extinguisher

The dry powder extinguisher is used for fires caused by flammable liquids including petrol and paint as well as flammable gases including acetylene and liquid petroleum gas. Any fires that involve electrical equipment up to 1000 V may also be dealt with the help of this fire extinguisher.

Figure 12: Dry powder fire extinguisher

i) LED

A light-emitting diode is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons

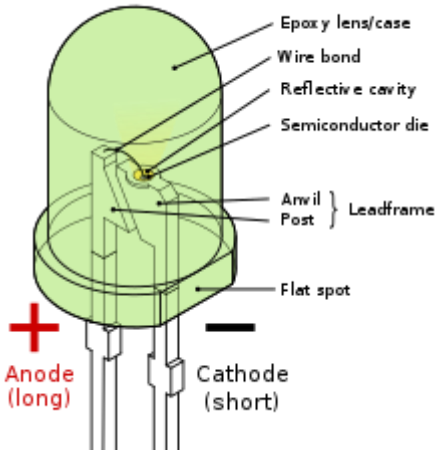


Figure 13: LED

j) LCD

An LCD screen is a module for electronic displays. Liquid crystal is used to produce visible images. TheLCD comes in various shapes and sizes for example 16×2 LCD can display 2 lines with a maximum of 16characters per line. In this LCD each character is displayed in a 5×7-pixel matrix.

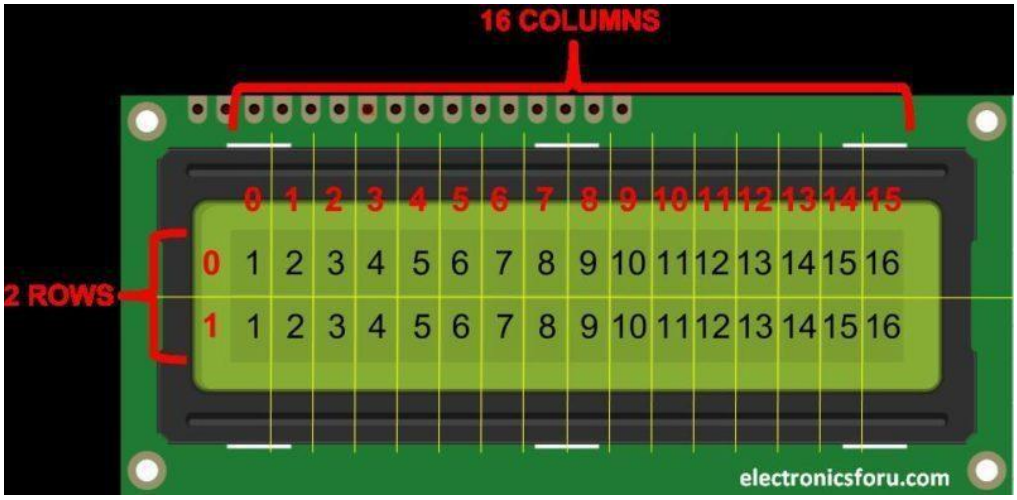


Figure 14: 16X2 LCD Pinout diagram

Connection to Arduino	
LCD	**ARDUINO**
VCC	+5V
GRND	GRND
SDA	SDA
SCL	SCL

3.5. Software Components

The software that will be used in the coding and control of the system, include the following

a) Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows,macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards

b) Blynk

Blynk is a Platform with iOS and Android apps to control Arduino, Raspberry Pi and the likes over theInternet. It's a digital dashboard where you can build a graphic interface for your project by simply draggingand dropping widgets.

3.6. System PDL

Program description language (PDL) is free format English like text and was used to describe the flow of control and data in the system. The program is initiated when device is turned ON with the initializationof variables and a display of welcome messages. The system the continuously check for any leakages and incase detected sends alerts appropriately. The system also monitors any fire outbreaks and sends alerts andactuate the extinguisher as needed.

BEGIN

Initialize Variables

DOFOREVER CALL
WELCOMECALL
MONITOR

ENDDO
END

BEGIN/WELCOME

Display Device Location
Display Welcome

Wait 5 Seconds
Clear LCD

BEGIN/ MONITOR

Sense LPG gas Sense fire
flame

IF leakage detected

Send leakage alert Display LCD notification
Switch ON LED

Switch ON Buzzer

ELSEIF flame detected

Send fire alert

Display LCD notificationSwitch ON LED

Switch ON Buzzer

ENDIF END/

CHAPTER IV: RESULTS ANALYSIS AND INTERPRETATION

In this section different results for the system are presented and interpreted, the first section gives the prototype for the solution. This is followed by different results from the prototype and mobile application.

4.1 System Prototype

Figure 5.1 shows the system prototype. The sensing module is made up of the flame sensor for detecting fire and LPG gas sensor for detecting gas leakages. The processing module is an Arduino microcontroller. Outputs and notifications are shown through a buzzer, LCD and LED with actuation being done via a relay to a stepper motor and a dry powder fire extinguisher. For communication a Wi-Fi module is used to send data to the cloud platform connected to a mobile app. A GSM is used to send SMS to uses incase leakages or fire detection. All the components of the system were tested and they worked effectively and as expected.

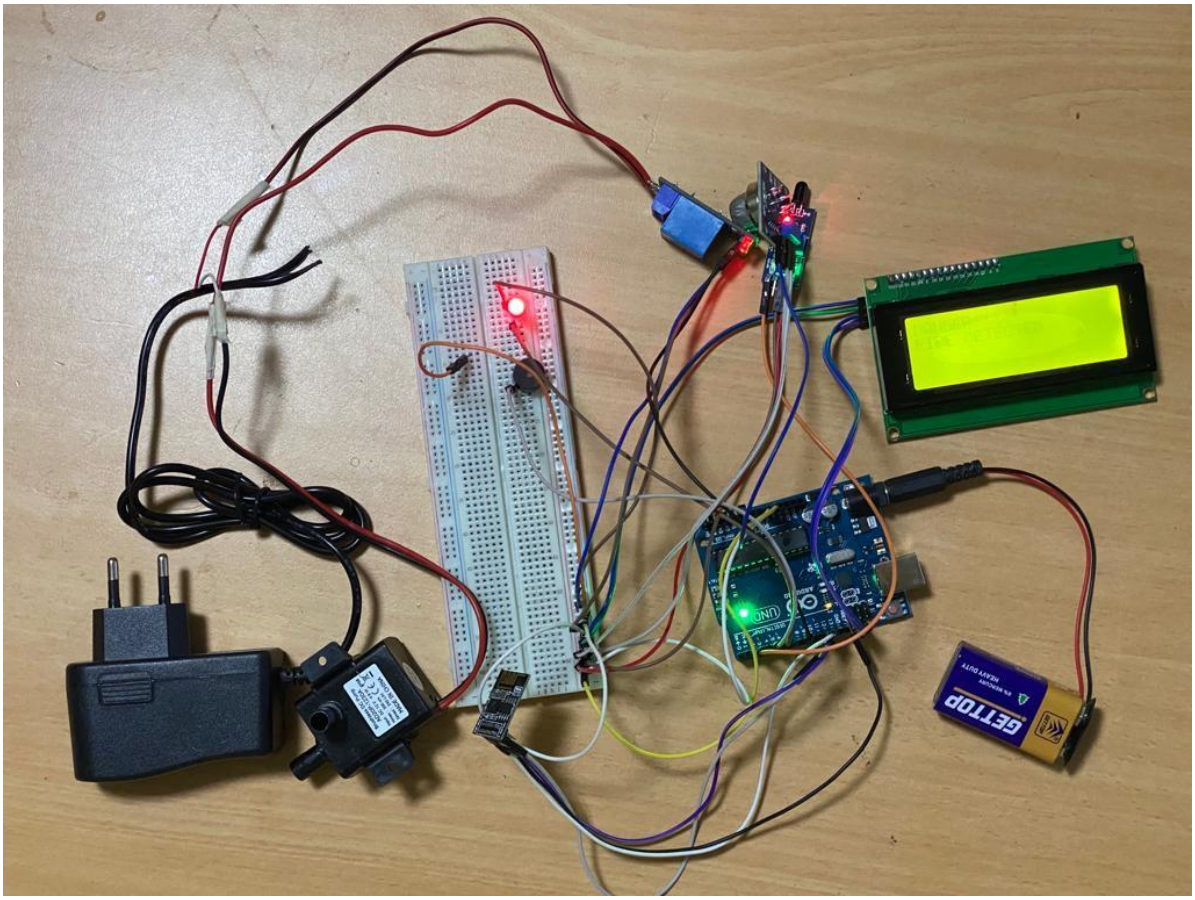


Figure 15: System Prototype

4.2 Monitoring Results

The collected data from the sensor was sent via the Wi-Fi module to the cloud with the users getting real-time updates on a mobile app.

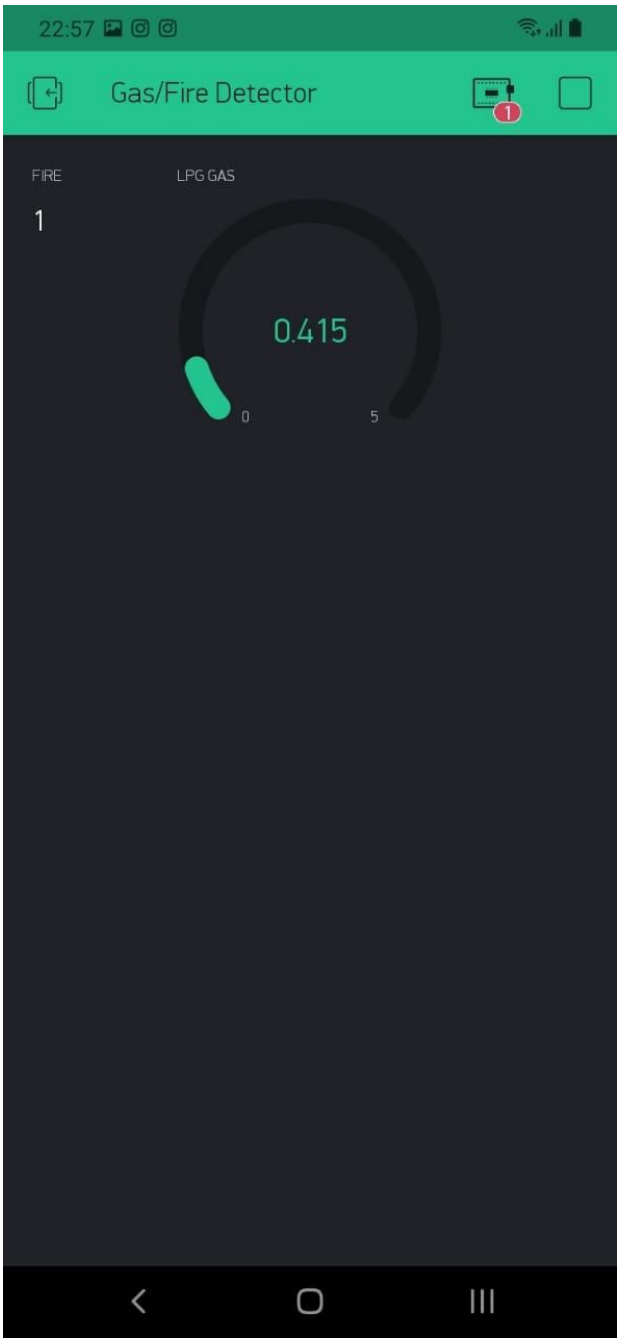


Figure 16: LP Gas Monitor and fire monitor APP displayNotification of Results and Actuation

The system functionality was tasted against the required thresholds and notifications were successfully sentto the users as needed. The extinguisher was also actuated as required and water sprinkled to quench fires.

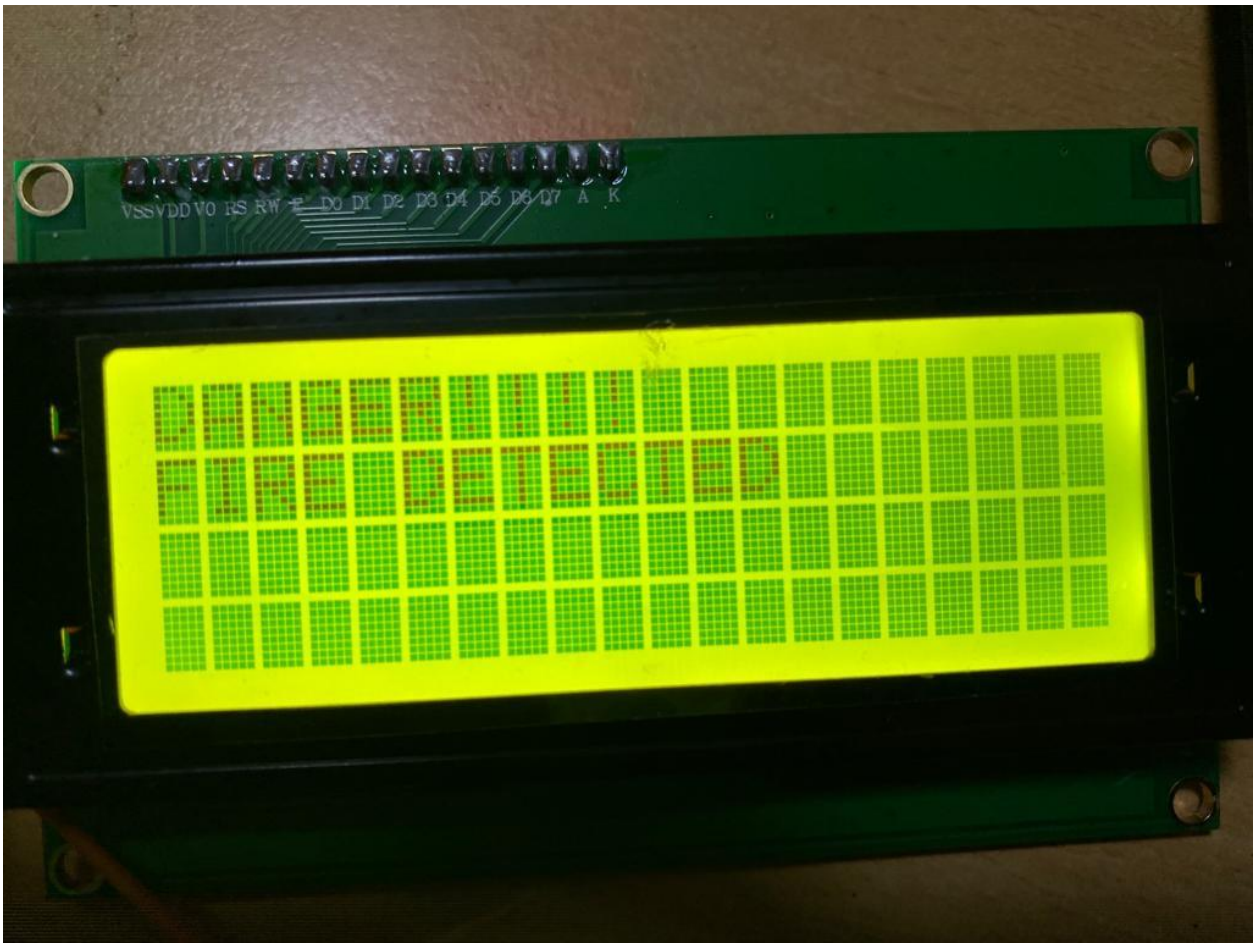


Figure 17. LCD Display on fire detection

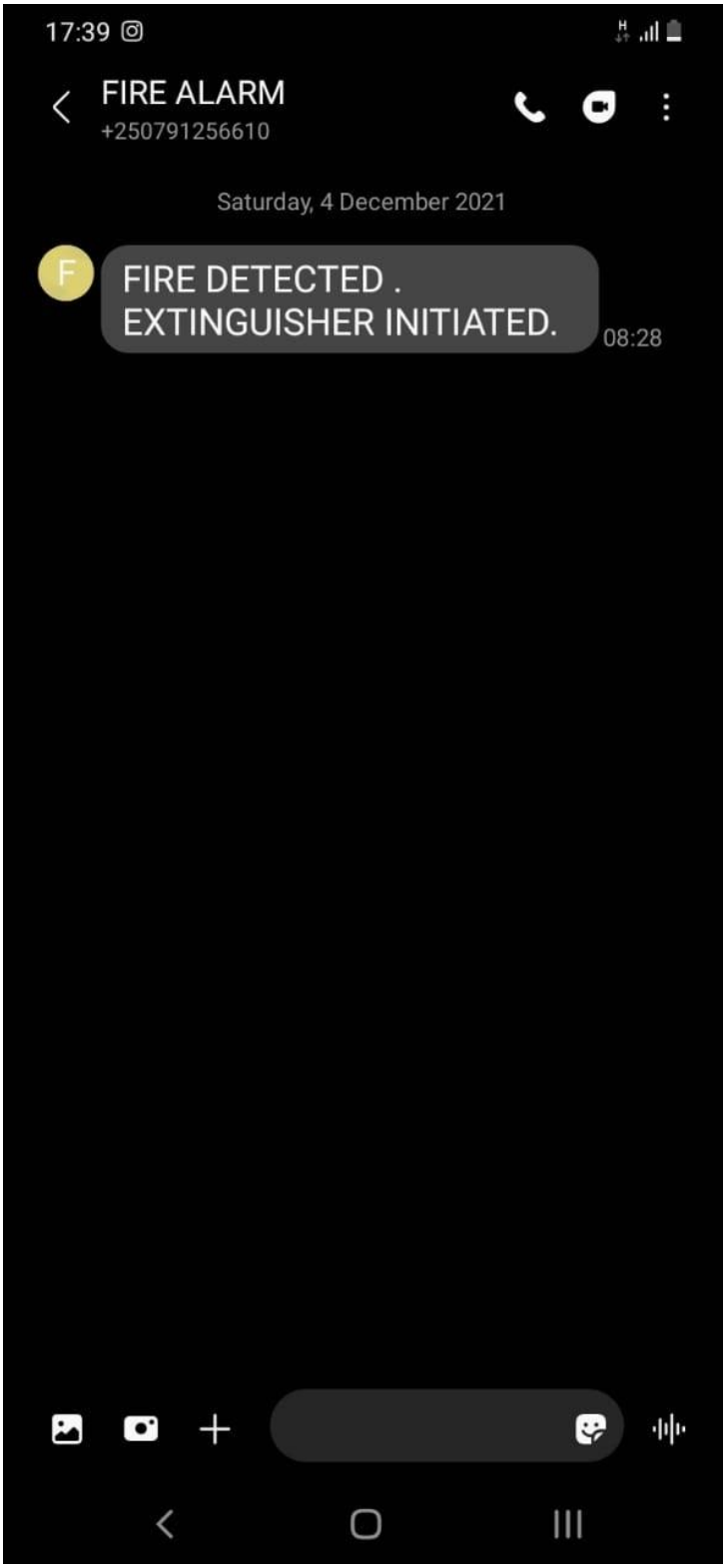


Figure 18. SMS on fire actuation notification

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

Conclusion

This Arduino based LPG /CNG Gas Accidents Prevention and Reporting with GSM project detects the LPG gas leakage. If the LPG gas level crosses the threshold level, then it sends SMS to the user using the GSM modem. The LPG detector system turns on the buzzer to indicate to the person nearby to the system, at the same time Relay is turned on. Arduino has a built-in Analog to Digital converter so there is no need to connect any external ADC IC. The LPG sensor is directly connected to the analog inputpins of the Arduino Uno board.

This project proves really helpful in cases when there is nobody in the house that has an LPG gas cylinder in it. Due to some negligence, there might be LPG gas leakage which can lead to measuring accidents. GSM based Arduino LPG detector can avoid such situations by sending an alert SMS to the owner and byturning on Buzzer at the same time.

The whole system consists of fire and gas sensors for detection purpose. If system detects a gas leakage the system first turns off the gas supply using external motor valve to avoid more gas leakage, when fire is detected, it automatically triggers the dry powder extinguisher to stop fire, the system shuts off gas supplythus preventing the fire from spreading further and avoiding any dangers of explosions.The system starts an exhaust fan when gas leakage is detected, sends information to the authorized user through an SMS using GSM modem. The system starts the exhaust fan in order to suck out the smoke so that any person in the room can easily escape [1] [19].

Nowadays, several gas leakage control systems have been put in place and each address or focused on a particular way of providing solution to the common problem. To contribute to this long disturbing problem, a careful analysis was carried out to identify the little gray area in the previously proposed designs. This prototype enables it to address the delay in response time by automatic control before the intervention of a person despite being alerted using SMS. This idea reduces heavily the reliance on the action of a person and increase the window of opportunity to avoid disaster [6] [10].

The use of LPG gas as a source of fuel in increasing as many households have preferred to use the same over the years. From the study there have been reported cases of fires that result from unattended gas leakages. The harm and damages that result from such accidents are costly and, in some cases, fatal. There is therefore a need to monitor LPG gas leaks and incase of fire automatically extinguish the same. The use of latest IoT technologies provide capabilities of making this a reality and was explored in this study.

I successfully designed and prototyped an LPG gas monitoring, fire detection and extinguishing system. The results show that it is indeed possible to apply IoT in solving the above-mentioned problem. The use of this system will indeed lead to a reduction of accidents and losses that originate from LPG gas leakages. I recommend the implementation of this solution in all households that use LPG gasses and even in other industrial settings.

Future works will involve exploring option to automatically shut down the gas pipes in case of leakages and add a GPS modem to this system.

Recommendations

To Researchers

Through this research the number of those aiming at active gas accidents prevention mechanisms and control actions is limited, I recommend researchers to further make more research about various ways to actively attend accidents that results in gas leakage and suggest different ways that will highlight the use of artificial intelligence and machine learning to solve the problem in a real time

To Regulatory bodies

The gas leakage accidents cause severe damages when they are not properly handled and prevented. Much efforts and best practices would be of paramount importance if regulatory bodies such as RURA (Rwanda) are too much concerned about and find ways to support researchers to carry out many researches in this field.

APPENDIX

Arduino codes

```
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>
SoftwareSerial mySerial(10, 9);//(Tx,Rx)

//SoftwareSerial SIM900A(10,11);
LiquidCrystal_I2C lcd(0x27, 16, 2);
int buzzer = 5;
//int pump = 12;
int LED = 7 ;
float lpg_value;
//int Relaypin= 3;
int RELAY_PIN = 6;  // the Arduino pin, which connects to the IN pin of relay
int numdata;
boolean started=false;
char smsbuffer[160];
char n[20];

void setup()
{
   mySerial.begin(115200);  // Setting the baud rate of GSM Module Â
// Open serial communications and wait for port to open:
  Serial.begin(115200);
 // SIM900A.begin(115200);   // Setting the baud rate of GSM Module
  lcd.init();   // initializing the LCD
  lcd.backlight(); // Enable or Turn On the backlight
  // initialize digital pin A5 as an output.
  pinMode(RELAY_PIN, OUTPUT);
  pinMode(buzzer, OUTPUT) ;
  pinMode(LED, OUTPUT) ;
  digitalWrite(RELAY_PIN, HIGH); // turn on pump 5 seconds
  while (!Serial)
  {
  ; // wait for serial port to connect. Needed for native USB port only
  }
}
void loop()
{
  if (Serial.available())
  {
    //Serial.write(Serial.read());
    int flame_detected=Serial.parseInt();
    lpg_value=Serial.parseFloat();
    lpg_value=lpg_value/1000;
    //flame_detected = 1;
    if (flame_detected == 1)
    {
```

```
  SendMessage();
  digitalWrite(buzzer, HIGH);
  Serial.println("Flame detected");
//  digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds
  delay(5000);
  digitalWrite(buzzer, LOW);


  lcd.setCursor(0,0);
  lcd.print("DANGER!!!!");
  lcd.setCursor(0,1);
  lcd.println("FIRE DETECTED");
  digitalWrite(LED, HIGH);
   lcd.setCursor(0,3);
   lcd.print("LPG GAS ");lcd.print(lpg_value);
   lcd.clear();
   delay(4000);
   digitalWrite(RELAY_PIN, HIGH);
   delay(4000);
   digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds

  }
  else
  {
    Serial.println("No flame detected");
  //  digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds
    lcd.setCursor(0,0);
    lcd.print("SAFE");
    lcd.setCursor(0,1);
    lcd.print("NO FIRE DETECTED");
    lcd.setCursor(0,3);
    lcd.print("LPG GAS ");lcd.print(lpg_value);
    delay(1000);
   // lcd.clear();
    }
  if(lpg_value >=200)
  {
    digitalWrite(RELAY_PIN, HIGH);
  SendMessage2();
  lcd.clear();
 digitalWrite(buzzer, HIGH);
    digitalWrite(LED, HIGH);
    lcd.clear();
       lcd.setCursor(0,1);
    lcd.println("WARNING!!!");
    lcd.setCursor(0,2);
    lcd.println("LPG GAS HIGH");
    lcd.setCursor(0,3);
    lcd.print("LPG GAS ");lcd.print(lpg_value);
   // turn on pump 5 seconds
   delay(1000);
   digitalWrite(RELAY_PIN, LOW);
```

```
      SendMessage2();
      lcd.clear();
     digitalWrite(buzzer, LOW);
       digitalWrite(LED, LOW);
         // lcd.clear();


       }
       else
       {
       SendMessage2();
//     digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds
       Serial.println("LPG value low");
       lcd.print("SAFE");
       lcd.setCursor(0,1);
       lcd.print("NO FIRE DETECTED");
       lcd.setCursor(0,2);
       lcd.println("LPG GAS LOW");
       lcd.setCursor(0,3);
       lcd.print("LPG GAS ");lcd.print(lpg_value);
       digitalWrite(buzzer, LOW);
////    digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds
//      delay(4000);

    //   lcd.clear();
       }
       }
       Serial.println("-------------------------------------------");
       lcd.setCursor(0,2);
       lcd.println("CONNECTING....");
       lcd.setCursor(0,3);
       lcd.print("LPG GAS =");
       lcd.print(lpg_value);
//       digitalWrite(buzzer, LOW);
//        digitalWrite(RELAY_PIN, LOW); // turn on pump 5 seconds
     delay(4000);
       lcd.clear();

      SendMessage2();
}
void SendMessage()
{
  mySerial.println("AT+CMGF=1"); //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"0784996607\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println("FIRE DETECTED EXTINGUISHER INITIATED !");// The SMS
      text you want to send
  delay(100);
 mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
}
```

```
void SendMessage2()
{
  mySerial.println("AT+CMGF=1"); //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"0788408534\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println(" ALERT!!LPG GAS LEAKAGE LEVEL IS GOING HIGHER !");//
      The SMS text you want to send
  delay(100);
 mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
}
```

Node MCU_Codes

```
// Template ID, Device Name and Auth Token are provided by the Blynk.Cloud
// See the Device Info tab, or Template settings
#define BLYNK_TEMPLATE_ID           "TMPLxxxxxx"
#define BLYNK_DEVICE_NAME           "Device"
#define BLYNK_AUTH_TOKEN            "8fvtyUYn8FUxZCg3dwoMkF7lYI79lkdY"
// Comment this out to disable prints and save space
#define BLYNK_PRINT Serial
#include <SoftwareSerial.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Wire.h>
#include <ESP8266WiFi.h>
#include <ESP8266WebServer.h>
#include <ESP8266HTTPClient.h>
#include <Adafruit_MLX90614.h>
#include <ESP8266WiFiMulti.h>
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>
ESP8266WiFiMulti WiFiMulti;
WiFiClient client;
const char* host = "catine.vrt.rw/";

// https://www.instructables.com/Interface-LCD-Using-NodeMCU/
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3F, 16, 4);
        int buzzer = D2 ;
int LED = D7 ;
int flame_sensor = D1 ;
int flame_detected ;
#define SERVER_IP "catine.vrt.rw/sms.php"
//
//char auth[] = BLYNK_AUTH_TOKEN;
// Your WiFi credentials.
// Set password to "" for open networks.
```

```
//char ssid[] = "Retbin Inc";//"JADOGENTIL";
//char pass[] = "kibuye@36";//jado2021";
String str;
float sensorVoltage;
float sensorValue;
#ifndef STASSID
#define STASSID "Retbin Inc"
#define STAPSK  "kibuye@36"
#endif
void setup()
{
// Debug console
Serial.begin(115200);
//BLYN VERSION 0.6
Blynk.begin(auth, ssid, pass);
// You can also specify server:
//Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
//Blynk.begin(auth, ssid, pass, IPAddress(192,168,1,100), 8080);
// pinMode(buzzer, OUTPUT) ;
// pinMode(LED, OUTPUT) ;
//attachInterrupt(digitalPinToInterrupt(interrupt_pin),interrupt_routine,RISING);
pinMode(flame_sensor, INPUT) ;
Serial.println(" Flame detected? , LPG (Voltage)");
Serial1.begin(115200);
Wire.begin(2,0);
lcd.begin();   // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.print(" Hello Makers "); // Start Printing
WiFi.begin(STASSID, STAPSK);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
Serial.println("");
Serial.print("Connected! IP address: ");
Serial.println(WiFi.localIP());
}
}

void loop()
{

int value=0;
flame_detected = digitalRead(flame_sensor) ;

delay(100);
sensorValue = analogRead(A0);
sensorVoltage = sensorValue/1024*5.0;
delay(100);
// Serial.print("sensor voltage = ");
Serial.print(sensorVoltage);
//Serial.println(" V");
Serial.print(",");
```

```
delay(100);
//flame_detected=1;
if ((flame_detected ==HIGH) || (sensorValue >= 4000) )
{
value=1;
Serial1.print(value);
Serial.print(value);
Serial.println(",Flame detected");
//    Blynk.virtualWrite(V2, "WARNING. FIRE ");
displayInfo();
digitalWrite(buzzer, HIGH);
digitalWrite(LED, HIGH);
//digitalWrite(LED, LOW);
}
else
{
value=0;
Serial1.print(value);
Serial.print(value);
Serial.println(",No flame detected");
Blynk.virtualWrite(V2, "No fire");
digitalWrite(buzzer, LOW);
digitalWrite(LED, LOW);
}
if(sensorVoltage<1.4)
{   displayInfo();
//    Blynk.virtualWrite(V1, "LPG LOW");
}
else
{
Blynk.virtualWrite(V1, "LPG HIGH");
}
Serial1.print(flame_detected);
Serial1.println(sensorValue);
str =String("coming from ESP8266: ")+String("LPG=
      ")+String(sensorVoltage)+String("detected flame= ")+String(flame_detected);
Serial1.println(str);
delay(1000);
digitalWrite(buzzer, LOW);
//  Blynk.run();
//You can inject your own code or combine it with other sketches.
// Check other examples on how to communicate with Blynk. Remember
// to avoid delay() function!
// Blynk.virtualWrite(V0, sensorVoltage);
//digitalWrite(buzzer, LOW);
delay(5000);
displayInfo();
}
void displayInfo()
{
WiFiClient client;
HTTPClient http;
```

```
Serial.print("[HTTP] begin...\n");
// configure traged server and url
http.begin(client, "http://" SERVER_IP ""); //HTTP
http.addHeader("Content-Type", "application/json");
Serial.print("[HTTP] POST...\n");
// start connection and send HTTP header and body
int httpCode = http.POST("/sms.php");
// httpCode will be negative on error
if (httpCode > 0) {
// HTTP header has been send and Server response header has been handled
Serial.printf("[HTTP] POST... code: %d\n", httpCode);
// file found at server
if (httpCode == HTTP_CODE_OK) {
const String& payload = http.getString();
Serial.println("received payload:\n<<");
Serial.println(payload);
Serial.println(">>");
}
} else {
Serial.printf("[HTTP] POST... failed, error: %s\n", http.errorToString(httpCode).c_str());
}

http.end();
```

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