Sudan University of Science and Technology

College of Engineering

School of Electronic Engineering

Design of IoT Based Gas Leakage Detection and Safety System

A Research Submitted in Partial fulfillment for the requirements of the Degree of B.Eng. (Honors) in Electronics Engineering (Industrial)

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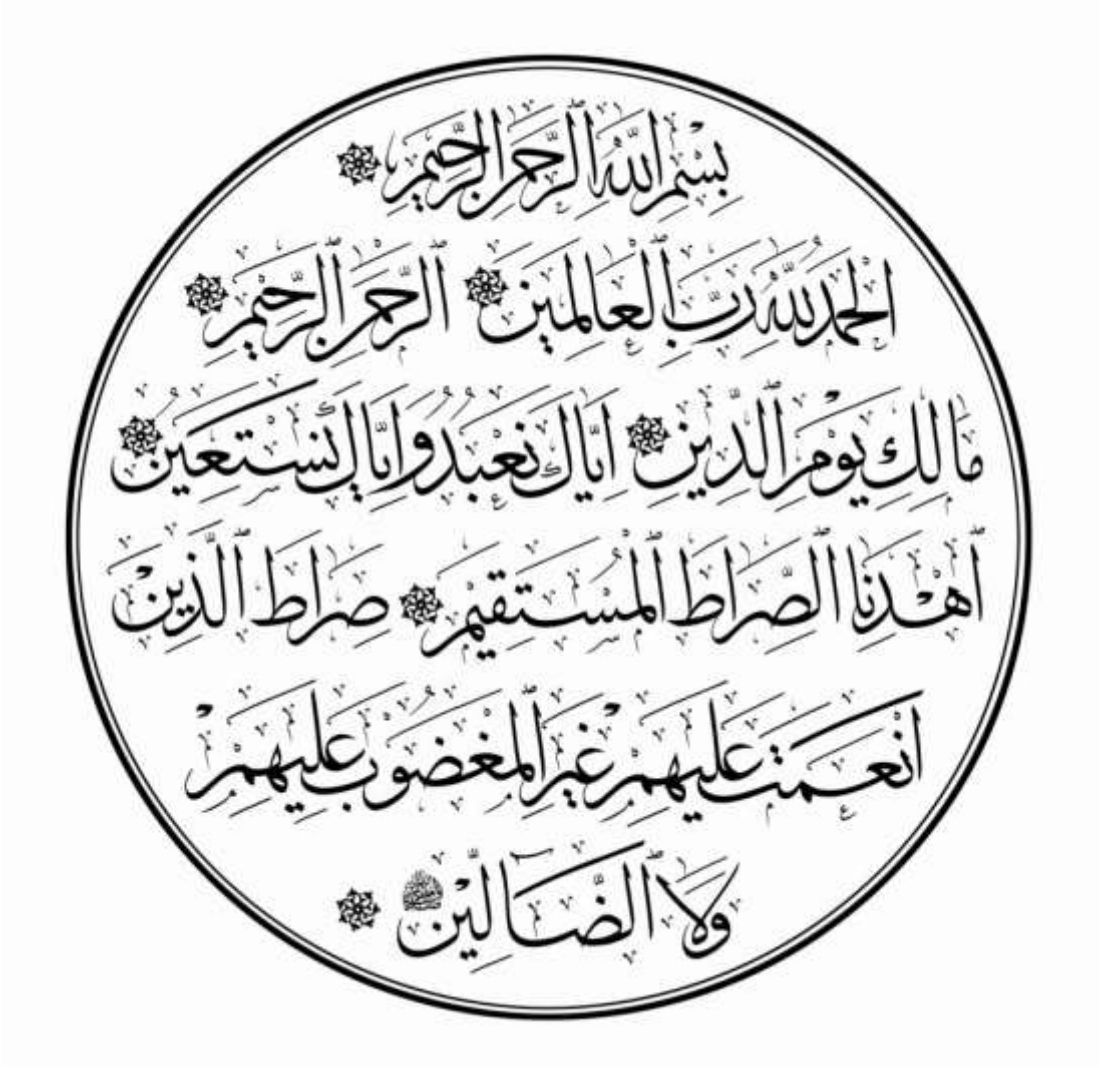
استهلال


بسم الله الرحمن الرحيم
الحمد لله رب العالمين الرحمن الرحيم
مالك يوم الدين إياك نعبد وإياك نستعين
اهدنا الصراط المستقيم صراط الذين
أنعمت عليهم غير المغضوب عليهم
ولا الضالين

DEDICATION

As well as everything that we do, we would be honored to dedicate this work to our parents for their emotional support, our brothers, our sisters and our friends, our college, especially our friend Iqan Haidar, whose has been a constant source of inspiration for us. Without their love and support this project would not have been made possible.

ACKNOWLEDGEMENT

Thanking Allah before and after... First and foremost; the greatest thanking to our teachers for their continuous support... and for their great efforts, they were the best guide and monitor... Finally; thanking our colleagues and workers at the College of Engineering for their cooperation...

ABSTRACT

The gas and fire detection system plays an important role in saving lives and properties and maintaining and monitoring a safe environment and situation. This project discusses the effective method to use the microcontroller (Arduino) to control the other components to provide a gas and fire safety system. From the project done, the system is giving quick response to current situation. System can detect gas and flame sensed by the detectors. When the sensors from each level triggered individually, the gas valve turn off, the ventilation fan, the alarm system operates and it shows in the control panel liquid crystal display alert, a message will be send to the person in charge of the factory in case of gas leakage, and make a call in case of fire detection, finally the factory power is shut down.

المستخلص

إن لأنظمة اكتشاف الحرائق و الغازات المتسربة دور مهم في الحفاظ على الأرواح والممتلكات و الحفاظ على بيئة آمنة و مراقبتها. هذا المشروع يناقش ألية تحكم الأردوينو ببعض العناصر لاكتشاف الحرائق و الغازات المتسربة، هذا النظام ذو استجابة سريعة لحالات الحرائق و الغازات المتسربة عن طريق استخدام حساسات حرائق و غازات، عندما تستشعر هذه الحساسات يقوم النظام بإغلاق مفتاح تأمين الغاز، و تشغيل مراوح شفط الهواء لتقليل تركيز الغاز المتسرب أو دخان الحرائق، و من ثم تشغيل نظام الإنذار الذي يتضمن شاشة تعرض الحالات الطارئة. في حالة تسرب الغاز يتلقى المسؤول رسالة نصية تنبيهية، أما في حالة الحرائق يتلقى مكالمة هاتفية.

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CHAPTER ONE

INTRODUCTION

Preface

Gas leakage leads to various accidents resulting in both material loss and human injuries. The risk of explosion, firing and suffocation are based on their physical properties such toxicity, flammability, etc. The number of deaths due to explosion of gas cylinders and gas pipelines has been increasing in recent years. The reason for such explosion is due to substandard cylinders, old valves, worn out regulators and lack of awareness in handling gas cylinders or leakage in gas pipelines due to creaks or the effect of heat. Flammable gases are used as fuel in many applications like homes, hostels, industries, automobiles, vehicles. The serious problem of this gas's leakage is that they are heavier than air; these gases do not disperse easily. It may lead to suffocation when inhaled and may lead to explosion. Due to the explosion of gases, the number of deaths has been increased in recent years. To avoid this problem there is a need for a system to detect the gas leakage. The situation should be taken before any fire/blast could happen because of its highly sensitive and flammable nature it can cause great disaster if any fire source is exposed to the gas so special countermeasure should be taken for the gas leakage. Gas leak detection is the process of identifying potentially hazardous gas leaks by means of various sensors. This paper presents a gas leakage detection and alert system to avoid fire accidents and to provide safety. The infamous Bhopal gas tragedy of 1984, which claimed the lives of thousands, is one of the major accidents due to gas

leakage[1]. And another instance, the HPCL refinery disaster destroyed the lives of many families.

Critical Systems

A critical system is a system which must be highly reliable and retain this reliability as they evolve without incurring prohibitive costs, and whose failure could threaten human life, the system's environment or the existence of the organization which operates the system.

Safety Critical

Is a system whose failure or malfunction may result in death or serious injury to people, loss or severe damage to equipment/property, environmental harm, a safety-critical system can be a control system for a chemical manufacturing plant or aircraft.

Business Critical

A system whose failure may result in the failure of some goal-directed activity and is essential to the survival of a business or organization, an example of a mission-critical system is a navigational system for a spacecraft.

Mission Critical

A mission critical system also known as mission essential equipment and mission critical application is any system that is essential to the survival of an organization and the operation of the organization is affected if the system fails or is interrupted in any way, an examples of mission critical systems include control systems for aircraft, electricity grid systems, and emergency communications systems.

Security Critical

Safety critical systems (SCS) are systems designed with the intent of curbing the effects of an accident from a hazardous event. This can be implemented in the aviation industry, the medical profession.

Problem Statement

The gas and fire safety system in Saria batteries factory which uses different toxic gases that can result in a hazardous work environment if a gas leakage due to creaks in pipelines or old valves in gas cylinders occurred, it can also lead to explosions when exposed to heat or sparks, which could result in great losses both material and human lives.

Proposed Solution

A gas detection and monitoring system based on IoT using MQ-2 and MQ-7 sensors and Arduino microcontroller, allowing remote monitoring of the system, and notifying the person in charge when the gas exceeds a threshold level or a fire is detected through SMS or a phone call.

The Objectives

1- activate the safety system to reduce the leakage gas and fire accident by implementing gas concentration detection and fire detection

2- make the work environment healthier by reducing the toxic gas

Methodology

To build system that is able to detect gas leakage, Fire detection and alerting its owner to take precautions. We start building the hardware part which consist of Flame Sensor, Gas sensors (MQ-2 and MQ-7) and temperature sensor, All these sensors are collecting the environment data as Input, the feedback from this data is shown in the actuators which are gas valve, electrical panel, fire fighting system, ventilation fan, alarm lamp, liquid crystal display and GSM900 Module, these actuators will turn on/off depending on the sensor data. The interface GSM Module SIM900 is able to connect with a cellular network. The internet of things part consist of WI-FI Module (Nodemcu-ESP8266) and Thingsboard cloud in this part we send sensor data to be stored in the cloud server so we can get it back when we need it .

Thesis layout:

The Chapters of the Research are Organized as Follows:

Chapter one gives a general overview for the system, this chapter also includes the problem statement, objectives and the methodology which was followed to solve the research problem. Chapter Two gives a summary of the background and the related literature up to the state-of-the-art regarding the problem and its possible solutions. Chapter Three shows the methodology and simulation setting up. Chapter Four involves the results which are analyzed and interpreted to evaluate the proposed algorithms and the system performance. Finally, Chapter Five the thesis is concluded in the conclusion along with suggestions for further future research.

CHAPTER TWO

BACKGROUND AND RELATED WORK

2.1 Background

An estimated average of 4,200 home structure fires per year started with the ignition of natural gas. These fires caused an average of 40 deaths per year. US Local fire departments responded to an average of 125,000 natural gas or LPG-Gas leaks per year that did not result in fires in or at home properties in 2012-2016. Since 2007, these incidents have generally been increasing. Also, gas leak can cause various health issues such as natural gas poisoning which is caused by High levels of natural gas exposure, which is characterized by fatigue, severe headaches, memory problems, loss of concentration, nausea, loss of consciousness, and suffocation. Early identification of gas leakage can prevent hazardous results, a hazard can be material, or an activity, or a procedure that can cause harm to human, or environment, or incur economical loss. After studying the related works for similar topics, the proposed system was designed. An MQ-2 and MQ-7 sensors detects the gas level and if the sensor value is greater than the threshold value then it will alarm the owner through GSM signal and turns on an alarm to alert nearby people and display the gas level on LCD to alert the users. It will turn on an exhaust ventilation fan to transfer the gas to an open space which will eventually dissolve into normal air pressure very quickly, and a relay will cut off the main power supply and the valve is turned off to prevent further leakage. To avoid any accident we find many kind of safety system.

2.2 Safety Critical System

Safety-critical systems are those systems whose failure could result in loss of life, significant property damage or damage to the environment. There are many well-known examples in application areas such as medical devices, aircraft flight control, weapons and nuclear systems. Many modern information systems are becoming safety-critical in a general sense because financial loss and even loss of life can result from their failure. Future safety-critical systems will be more common and more powerful. From a software perspective, developing safety-critical systems in the numbers required and with adequate dependability is going to require significant advances in areas such as specification, architecture, verification and the software process. The very visible problems that have arisen in the area of information system security suggest that security is a major challenge too. For examples: Circuit breaker, emergency services dispatch system, electricity exaggeration transmission and distribution, fire alarm and fire sinker[2].

Types of Safety Critical System:

2.2.1 Process Safety System or Process Shutdown System (PSD)

PSD Is defined as the automatic isolation and the activation of all part of a process, during a PSD the process remain pressurized. Basically PSD consist of field mounted sensors. Valves and trip relays, a system logic unit for processing of incoming signals, alarm and MHI units. The system is able to process all input signals and activating output in accordance with the applicable cause and effect matrix chart

Typical Action from PSD Systems:

1. Shutdown the whole process.
2. Shutdown part of the process.
3. Depressurize/Blow down parts of the process.

2.2.2 Safety Shutdown System

The safety shutdown system (SSS) shall shut down the facilities to a safe state in case of an emergency situation, thus protecting personnel, the environment and the asset. The safety shutdown system shall manage all inputs and outputs relative to emergency shutdown (ESD) functions (environment and personnel protection). This system might also be fed by signals from the main fire and gas system. it has two types:

1) Emergency Shutdown (ESD)

ESD Is designed to minimize the consequences of emergency situations, such as outbreak of fire in gas filled areas or areas which may otherwise be hazardous.

An emergency shutdown system for a process control system includes an emergency shutdown (ESD) valve and an associated valve actuator. An emergency shutdown (ESD) controller provides output signals to the ESD valve in the event of a failure in the process control system, a solenoid valve responds to the ESD controller to vent the actuator to a fail state, a digital valve controller (DVC) test strokes the ESD valve. An impedance booster device enables the dc powering of the solenoid valve and the DVC over a two wire line while still permitting digital communication over the same two wire line.

Typical Actions from an Emergency Shutdown System:

- Shutdown of part systems and equipment.
- Isolate electrical equipment.
- Prevent escalation of events.
- Depressurize / Blow down.
- Emergency ventilation control.
- Close watertight doors and fire doors.
- Centralized Project Development for Both Safety and Process needs.

2) Emergency Depressurization (EDP) System

Depressurization of any equipment must reduce its pressure to a certain amount and at a given time. This differs with the type of depressing: high rate or low rate depressurization.

2.3 Alarm systems

Alarm systems used in factories are part of the safety systems, the alarm System consist of:

2.3.1 Alarm Control Panel

It is a digital control unit receives the signals from the detectors. It converter this signal into an alarm, and sometimes an alarm and lights, by using bells or horns with or without lights, such as Fire Alarm Main Control Panel which is an electronic device that controls all devices associated from receiving signals from all types of detectors to sounding

the necessary warning sirens and carrying out the tasks assigned to it. Shown figure (2-1):

Figure 2-1: Alarm Control Panel

2.3.2 Detectors

They are detectors and sensors connected to the control panel, to detect the fire and gas and send a signal to the control panel. There are many types of sensors or detectors used in the alarm systems such as:

2.3.2.1 Gas Detectors

It is a device that detects the presence of gases in an area, often as part of a safety system. It works when there is a dropout of gases in the building, it detects is there any gases in the building, and therefore sends a signal to the control panel, one of the common gas sensor detection is MQ sensors.MQ gas sensors are a family of sensors which are used to detect a wide variety of gases like alcohol, smoke, methane, LPG, hydrogen, NH3, Benzene, Propane etc. These sensors are made up of electrode which is coated with a sensing material, and it is heated to make it more reactive and sensitive. We use in our project MQ-2, MQ-7 gas sensors. shown Table (2-1):

Table 2-1: Gas Sensors

Sensor	Detects	Heater Voltage
MQ-2	Methane, Butane, LPG, smoke	5V
MQ-3	Alcohol, Ethanol, smoke	5V
MQ-4	Methane, CNG Gas	5V
MQ-5	Natural gas, LPG	5V
MQ-6	LPG, butane gas	5V
MQ-7	Carbon Monoxide	Alternating 5V and 1.4V
MQ-8	Hydrogen Gas	5V
MQ-9	Carbon Monoxide, flammable gasses.	Alternating 5V and 1.4V
MQ131	Ozone	6V
MQ135	Air Quality (Benzene, Alcohol, smoke)	5V
MQ136	Hydrogen Sulfide gas	5V
MQ137	Ammonia	5V

Sensor	Detects	Heater Voltage
MQ138	Benzene, Toluene, Alcohol, Acetone, Propane, Formaldehyde gas, Hydrogen	5V
MQ214	Methane, Natural gas	6V
MQ216	Natural gas, Coal gas	5V
MQ303A	Alcohol, Ethanol, smoke	0.9V
MQ306A	LPG, butane gas	0.9V
MQ307A	Carbon Monoxide	Alternating 0.2V and 0.9V.
MQ309A	Carbon Monoxide, flammable gasses	Alternating 0.2V and 0.9V
MG811	Carbon Dioxide (CO2)	6V
AQ-104	Air quality	

2.3.2.1.1Gas Sensor (MQ-2)

MQ-2 gas sensor is an electronic sensor used for sensing the concentration of gases in the air such as LPG, propane, methane, hydrogen, alcohol, smoke and carbon monoxide, it is also known as Chemi-resistor. It contains a sensing material whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas[3]. Shown figure (2-2):

Figure 2-1: Gas Sensor (MQ-2)

2.3.2.1.2.Gas Sensor (MQ-7)

We use MQ-7 for sensing the carbon monoxide (CO) concentrations in the air. The MQ-7 can detect CO-gas concentrations anywhere from 10 to 500ppm It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V)[4]. Shown figure (2-3):

Figure 2-2: Gas Sensor (MQ-7)

2.3.2.2 Beam Detectors

They are used in the high places or the opening places such as: places without roofs and the opening places for marketing. It consists of a sender and receiver, the sender sends rays to the receiver, when there is a fire the smoke cut this rays and the sensor will work. Shown figure (2-4):

Figure 2-4: Beam Detectors

2.3.4 Alarm Unit

Used to make a sound to inform the workers in the faculty or people in the building there is emergency situation, there are many elements used in the alarm such as: Horns, Bells, Sirens and LED indicator. Shown figure (2-5):

Figure 2-5: Alarm Unit

2.4.1 Fire Sprinklers System

It is an important part in the safety system in the fire protection, it consist of a water supply and distribution system along the pipelines, it has many types like wet pipe, wet pipe antifreeze, dry pipe. Shown figure (2-6):

Figure 2-6: Fire Sprinklers System

2.4.2 Temperature Sensor

1. We use DHT11 (Temperature and humidity sensor) in our system the sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1% , operating voltage from 3.5V to 5.5V and operating current from 0.3mA (measuring) to 60uA. Shown figure (2-7):

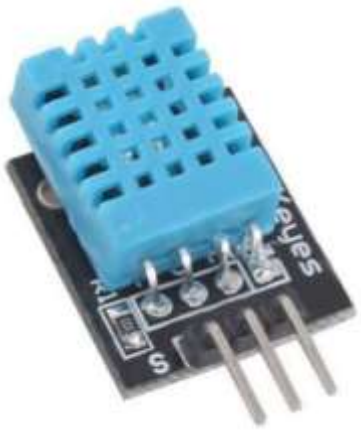

Figure 2-7: Temperature Sensor

2.4.3 Flame Sensor

This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice. The flame detection response can depend on its fitting. It is used in alarm systems, natural gas lines and propane & a fire suppression system. The response of these sensors is faster as well as more accurate compare with a heat or smoke detector because of its mechanism while detecting the flame. Shown figure (2-8):

Figure 2-8: Flame Sensor

2.4.4 Liquid Crystal Display (LCD)

Liquid Crystal Display is a type of flat panel display which uses liquid crystals in its primary form of operation. LCDs allowed displays to be much thinner than cathode ray tube (CRT) technology. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it. Where an LED emits light, the liquid crystals in an LCD produce an image using a backlight. Shown figure (2-9):

Figure 2-9: Liquid Crystal Display (LCD)

2.4.5 Wireless Module (SIM900)

SIM900 Modem is built with Dual Band GSM/GPRS based SIM900 modem from SIMCOM. It operates from 3.4V to 4.5V supply range. It works on frequencies 850/ 900/ 1800 MHz. SIM900 can search these bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 19200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable the user to connect with internet via GPRS. SIM900 is an ultra-compact and reliable wireless module. Shown figure (2-10):

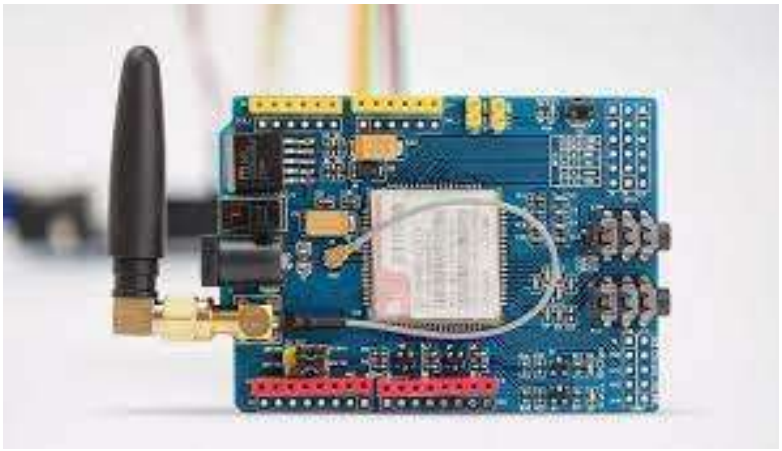

Figure 2-10: Wireless Module (SIM900)

2.4.6 Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino mega was chosen because it is easy to use and has 16 analog input pins because the sensors provide analog data and the factory environment is analog, and because it has more pins compared to Arduino UNO, and it is better at executing codes used for connecting to the cloud. Shown figure (2-11):

Figure 2-11: Arduino Mega

2.4.7 WiFi Module (MODMCU ESP8266)

The NodeMCU (Node MicroController Unit) is open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK .NODMCU has 4 ground pin and 4 power pin one is Vin to supply the nodmcu directly and the other three pins is output to feed external component , has two control pin (enable and reset) has I2C pins ,GPOI pin ,UART pin ,PWM pin ,SPI pin, ADC pin , and SIDO pin [5]. Shown figure (2-12):

Figure 2-12: WiFi Module (MODMCU ESP8266)

2.4.8 Relay

Relay works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energizes the electromagnetic field which produces the temporary magnetic field, this magnetic field moves the relay armature for opening or closing the connections, resulting in the control of the pump. Shown figures (2-13/2-14):

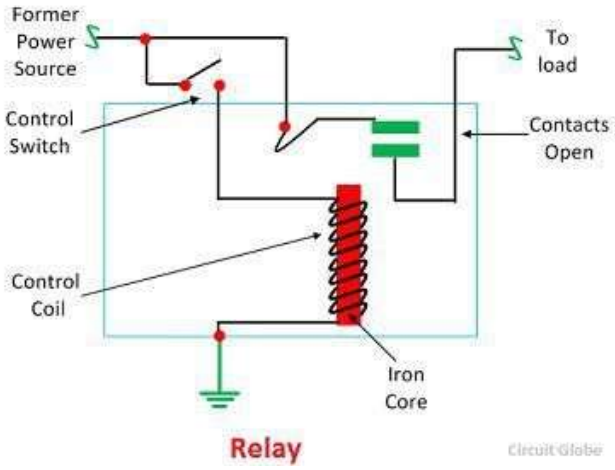

Figure 2-13: Relay Diagram

Figure 2-14: Relay

2.4.8.1 Solid State Relay

Solid State Relays are semiconductor equivalents of the electromechanical relay and can be used to control electrical loads

without the use of moving parts, but instead uses the electrical and optical properties of solid state semiconductors to perform its input to output isolation and switching functions. Solid state relays can be designed to switch both AC and DC currents by using an SCR, TRIAC[6]. Shown figure (2-15):

Figure 2-15: Solid State Relay

2.4.9 Solenoid Valve

Is an electrically controlled valve, the valve features a solenoid, which is an electric coil with a movable ferromagnetic core (plunger) in its center. In the rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts an upwards force on the plunger opening the orifice. It will shut-down the gas valve when it receive command signal from the Arduino[7]. Shown figure (2-16):

Figure 2-16: Solenoid Valve

2.4.10 Ventilation Fan

Purpose of the ventilation fan is to reduce the concentration of gas when gas leak and smoke when a fire accident happened. Industrial fans provide air and gas movement, replacing stale and contaminated air with fresh air, they are essential in some factory settings where they reduce high heat levels and prevent air stagnation when air conditioners are too expensive or aren't an option. Industrial fans also help remove smoke and help regulate gaseous fumes in chemical industries. Shown figure (2-17):

Figure 2-17: Ventilation Fan

2.4.11 Buzzer

A buzzer or beeper is an audio signaling device; it is generally used as sound alarms. It generates sound in a frequency range of 1 to 7 kHz as an audio indication. In this frequency range, the hearing threshold is at maximum. Shown figure (2-18):

Figure 2-18: Buzzer

2.4.12 Three Phase AC Contactor

A three-phase contactor is an electronic device used to turn power on or off at a three-phase load. These devices are used when the voltage requirements of the load exceed the power-handling capability of a mechanical relay, they do not use a physical switch for switching. A contactor uses a low-voltage signal to control the high-voltage circuit[8]. Shown figures (2-19/2-20):

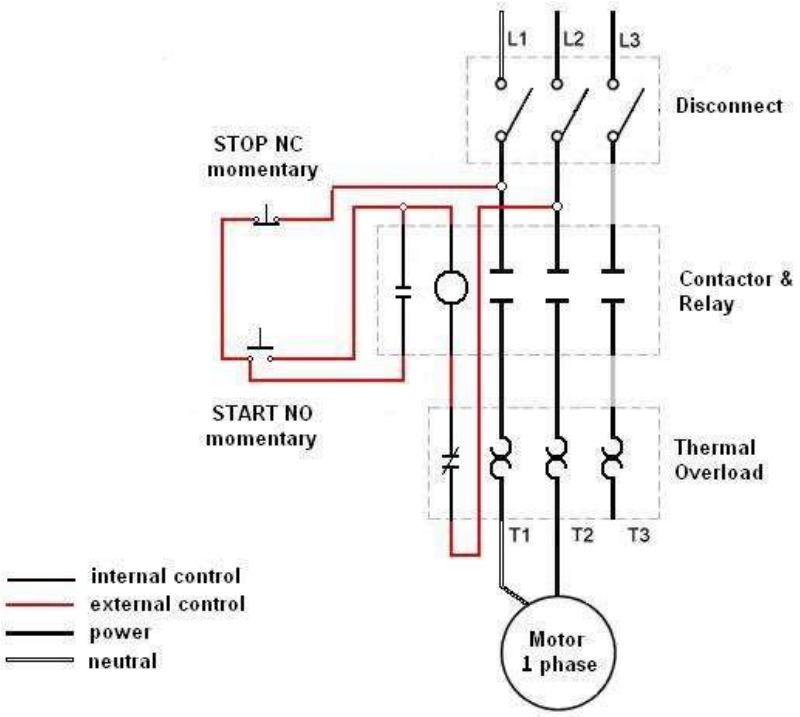

Figure 2-19: Three Phase AC Contactor Diagram

Figure 2-20: Three Phase AC Contactor

2.5 Internet of Things (IoT)

The Internet of things refers to a type of network to connect anything with the Internet based on stipulated protocols through information sensing equipment to conduct information exchange and communications in order to achieve smart recognition, positioning, tracing, monitoring, and administration. Internet of things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. The IoT improve the safety of the factory by monitoring Possible Risks by analyzing data and using it to develop occupational health and safety strategies for employees and increase understanding of working environments with the help of connected sensors[9]. Shown figure (2-21):

Figure 2-21: Internet of Things (IoT) System

2.6 The Cloud

"The cloud" refers to servers that are accessed over the Internet, and the software and databases that run on those servers. Cloud servers are located in data centers all over the world. By using cloud computing, users and companies do not have to manage physical servers themselves or run software applications on their own machines[10]. Shown figure (2-22):

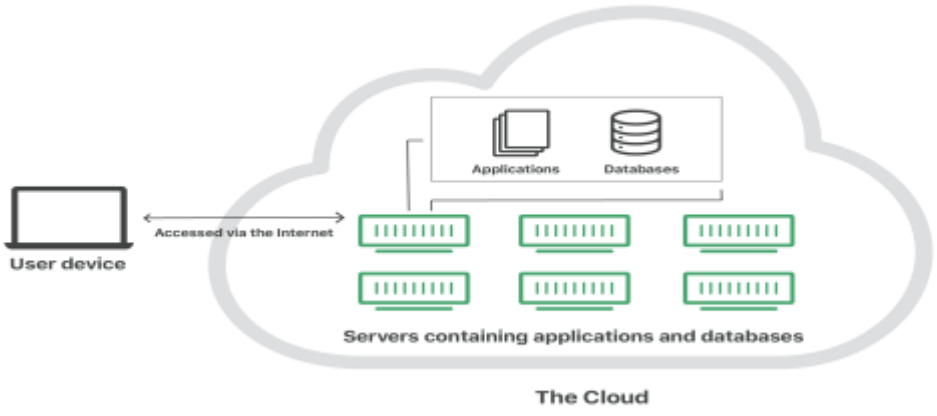

Figure 2-22: The Cloud

The cloud enables users to access the same files and applications from almost any device, because the computing and storage takes place on servers in a data center, instead of locally on the user device.

The Main Service Models of Cloud Computing:

Software-as-a-Service (SaaS): Instead of users installing an application on their device, SaaS applications are hosted on cloud servers, and users access them over the Internet. Examples of SaaS applications include Sales-force, Mail-chimp, and Slack.

Platform-as-a-Service (PaaS): In this model, companies don't pay for hosted applications; instead they pay for the things they need to build their own applications. PaaS vendors offer everything necessary for building an application, including development tools, infrastructure, and operating systems, over the Internet. PaaS examples include Heroku and Microsoft Azure.

Infrastructure-as-a-Service (IaaS): In this model, a company rents the servers and storage they need from a cloud provider. They then use that cloud infrastructure to build their applications. IaaS providers include Digital-ocean, Google Compute Engine, and Open Stack.

In Recent Years a Fourth Model has Emerged:

Function-as-a-Service (FaaS):FaaS, also known as server less computing , breaks cloud applications down into even smaller components that only run when they are needed. Shown figure (2-23):

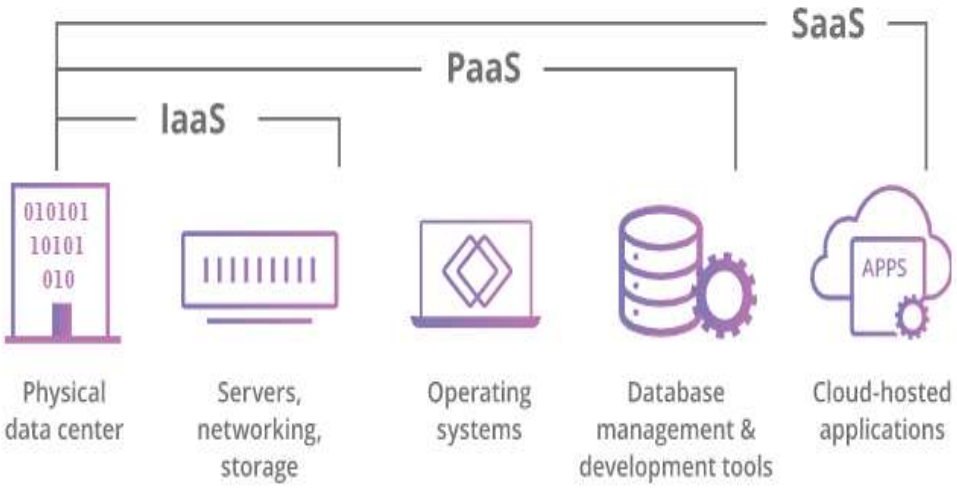

Figure 2-23: Models of Cloud

2.6.1 Things-board Cloud

Things-Board is an open-source IoT platform that enables rapid development, management and scaling of IoT projects. It enables device connectivity via industry standard IoT protocols - MQTT, CoAP and HTTP and supports both cloud and on-premises deployments. Things-Board combines scalability, fault-tolerance and performance so we will never lose our data[11]. Shown figure (2-24):

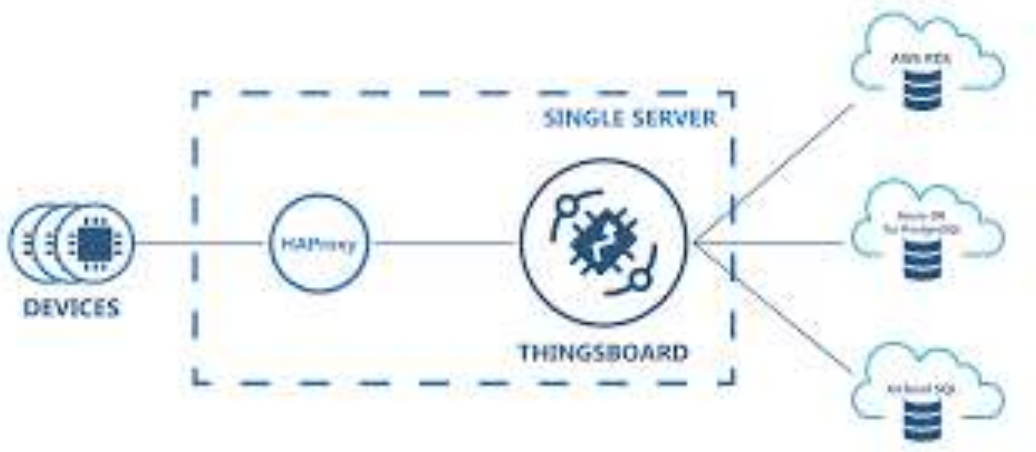

Figure 2-24: Things-board Cloud

2.7 Related Work

Many similar projects already exist and they have their own characteristics and functionality. They all have so many advantages as well as disadvantages. We can see various descriptions of them below here.[12]Manish Verma used Raspberry pi 3 model attached with embedded system with required input and output gas level with the help of gas sensors. This resulted in a more efficient in operation because it is connected to a common web page specially built to notify or email the responsible authority automatically so reduces the stress of constant monitoring. The choice of using a real time gas leakage monitoring and sensing the output levels of gas has been clearly observed by the help of this system.

This project[12] implements a model which sends an email to the user in case there is a leakage. The model detects the leakage of Liquid Petroleum, Gas, & Benzene, this cost-effective project uses MQ-6 and MQ-135 sensors for detecting the aforementioned gases using Arduino - UNO, WIFI Module ESP8266 and Thing-speak cloud. The real-time information of the above-mentioned gases are uploaded in the cloud and displayed in the form of a graph to the user. The prototype of this model generates an email to the concerned person using IFTTT web service. An LED is also used as a visual alarm at the site of leakage.

The authors in[13] developed a system to monitor and control the gas leakage concentration. MQ-6 gas sensor is used for sensing the level of gas concentration in a closed volume. To monitor the consequences of environmental changes an IoT platform hosted by “Things-speak” platform has been introduced. Both robust and cloud-forwarded controls have been applied to prevent uncontrolled leakage of those gases and

auto-ignition. This type of system can be directly applied to the engine chamber/ fuel chamber of the modern marine vessels using dual fuel power cycle with LPG/LNG as secondary fuel-flamer. The results from the experiments clearly indicate satisfactory actuation speed and accuracy. The trials performed by the authors showed about 99% efficiency of signal transmission and actuation.

The authors of this paper[14] presented a project that deals with monitoring LPG leakage along with administrative alert by giving buzzer sound, switching on specified relay(s) and sending an alert message to administrator(s) to decide about the precaution measures. For this purpose, gas leakage concentration is sensed by gas sensor (MQ-6) which sends the data (analog) to the controller (NodeMCU) where the analog value is subjected to a sequential conversion to predict the probable intensity of gas inside the control volume and on crossing a reference threshold value (set by administrator/operator) the controller it switches „ON‟ the relay(s) and buzzer(s) alerting to the administrator/operator of the plant (Industry/Home) including an extra control-option through manual control utilizing the IoT server to prevent accidents from the leakage.

This gas detection and alert system[15] will not only alert us of the leakage but will also mechanically turn off the knob of the gas cylinder to seize any leakage of gas. Moreover, this system informs the concerned person by emailing and dropping a message on their mobile. This gives a larger degree of safety to any gas setup in any circumstances. The project is determined by using a lighter to collect leaked gas around the gas sensor after sensing procedure if sensor value is greater than the threshold value then microcontroller will perform its programmed tasks:

1.Immediately turn off the regulator knob to stop further leakage

2.Within 2-4sec the relay will cut off the main power supply.

3.Buzzer starts beeping and a message is displayed on LCD to alert the users and nearby people.

4.Wi-Fi module will send SMS/e-mail using the cloud to the users.

5.The exhaust fan will fan out all enclosed gas from the environment. When reset button of MCU pressed the system will get refreshed

As a control framework, the authors of this paper[16] use Raspberry pi, MQ gas sensors, and an alert circuit. With the guide of Things-speak cloud benefits, the yield of the data gathered by the sensors is stored into the cloud utilizing the Distributed computing (IoT). The technique for distinguishing conceivably unsafe gas spills by sensors and directing the bot with the guide of catches is UMV Gas spill discovery. Ordinarily, these gadgets utilize a hear-able bell to caution people that a hurtful gas has been recognized. Utilizing the MQ sensors interconnected to the Raspberry pi, this recognizable proof can be cultivated. A voltage is delivered in it at whatever point the framework recognizes gas and is provided as a contribution to the raspberry pi. At the point when the gas has been discovered, the ringer sounds. This information is saved in the cloud utilizing IoT. By means of prearranging a python code and downloading the vital sensor libraries, the whole activity of the gadget can be refined.

In this paper[17], we built an IoT (Internet of Things) based framework that helps to prevent accident-related to LPG leakage. The device is an intelligent piece of home computerization framework, as at the point whenever gas spillage is detected it alarms the customer through GSM signal phone call and SMS. All the while, it sounds the buzzers to alert nearby people and it turns on the exhaust fan to transfer the gas in an open space which will eventually dissolve into normal air pressure very quickly. The device is capable of identifying the gas and fire separately so that it can send accurate information directly to the user via GSM module as quickly as possible. The algorithm is designed to detect and produce results as quickly as accurately possible to prevent any accident/blast from happening.

When a gas leakage occurs in an underwater structure[18], the high-pressure gas jetted from the leak point will form bubbles in the nearby waters, and the leak point will produce radiation noise with a sound source level much higher than the environmental background and certain characteristics. Active sonar detection technology uses image sonar to detect whether there is a bubble group in the target area to determine whether there is a leakage and the passive sonar detection technology uses whether the radiation noise intensity is stronger than the background noise to determine whether there is a leakage. Compared with other detection methods, the sonar detection technology is an external inspection method. It does not need to install the measuring equipment on the measured object in advance, and only needs to deploy the sonar array in the detection area, which has the advantages of easy expansion and easy installation. In addition, compared to active sonar, passive sonar does not generate acoustic signals to interfere with other

acoustic equipment used in the oil production, and passive sonar systems have lower power consumption and longer lifespan.

This paper[19] presents the design and development of a wireless gas leakage monitoring system by using Arduino and Zigbee. In this project, the monitoring system is developed by using LabVIEW GUI. It is used to display the level of gas concentration in a place through another remote PC, and via internet server. Hence, it provides benefit to monitor the condition of a room in a safe distance. Traditionally, the gas pipeline leakage monitoring system is realized by communication cable system, therefore the cost of installation and maintenance are very expensive and difficult as mentioned by jDing . In order to overcome these restrictions, wireless sensor network is chosen as the best choice in the situation above. Some papers proposed different types of wireless sensor network such as radio frequency (RF) transceiver router and coordinator, general packet radio service (GPRS) network and Zigbee Nowadays, Zigbee is widely used in the gas leakage monitoring application field for the real-time monitoring of the potential risk areas. For the autonomous control system is as a preventive way to stop the situation becoming worst by shutting down the process automatically. A. Shrivastava has proposed the system by using stepper motor to turn off the main power and the gas supply. Whereas in this model, the relay switch is used to turn off the main power, and the electronic gas valve is used to turn off the gas supply. At the end, when the gas leakage is successfully stopped then the whole system will return to initial stage with the help of reset button.

CHAPTER THREE

METHODOLOGY

In this chapter we will discuss the problem solution and the system components and discuss about each component and its use in the system.

3.1 Overview

The design of the system consist of three parts, first part is to sense the gas concentration, fire and temperature measurement. The second part is to monitor the factory environment using an application, the third part is to control the system through Arduino mega and relays for the run-on and run-off of the panel and water pump and automatic valve.

The proposed system working method start by receiving signals from the sensors and in the case of a gas leak or fire accident the Arduino determines the situation based on the sensors data, if there was gas leak the system will turn off the gas valve using solenoid valve and turn on the ventilation fans to reduce the gas concentration by using a mechanical relay and send a SMS to the managers informing them , when contacting the gas and an alarm will start to notify people in the factory, the alarming part consist of a buzzer and LCD that inform the worker there is gas leak. And in the case of fire detection the system will turn off the gas valve and turn on the fire-fighting system and ventilation fans to reduce the smoke and call the managers to inform them there is a fire and the factory power will shut-down and the alarm system will be activated. All the sensors data that received by Arduino will be saved on

the cloud or database and used to monitor the system through the application that act like human machine interface (HMI),we can save this data in the cloud by connecting Arduino to the internet by using ESP8266. And we use SIM900 to send SMS or make a call to inform the manager the emergency situation. The system block diagram is shown in figure (3-1):

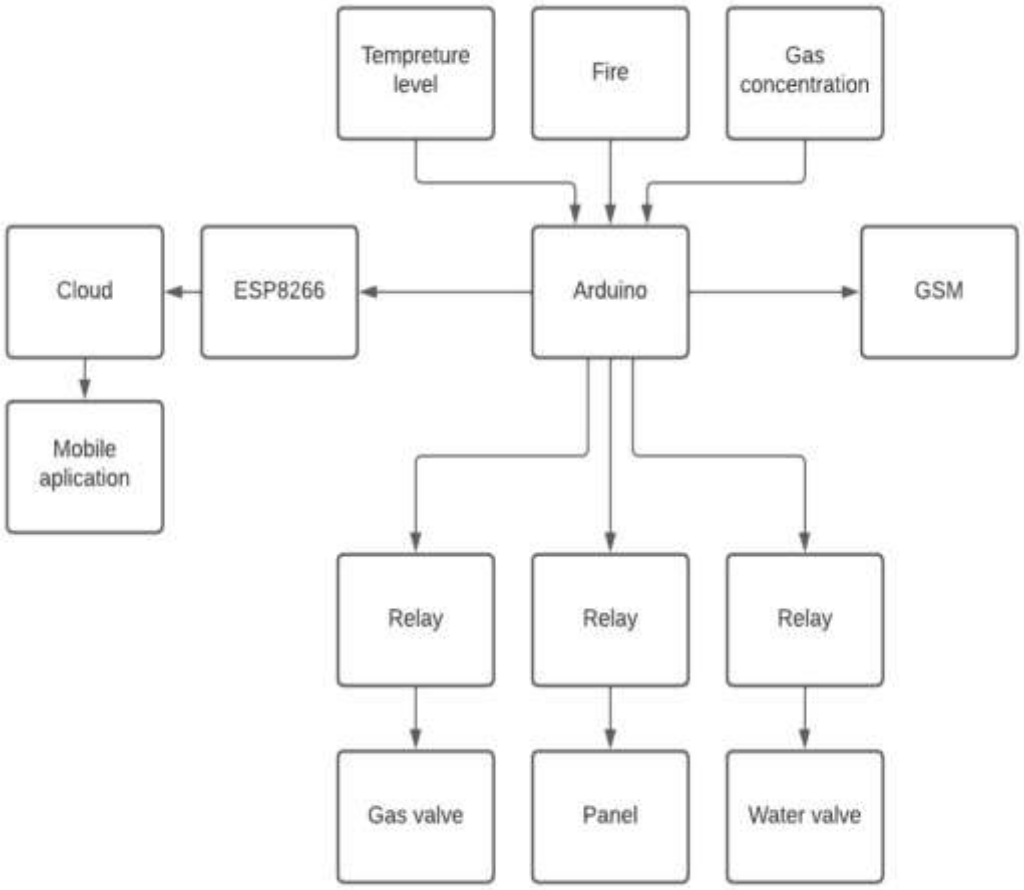

Figure 3-3: System Block Diagram

3.2 Simulation

The following figure (3-2) illustrates the system circuit for IoT gas and fire detection which has been designed using the Proteus program , We Considering that the factory is divided into two part each part has LPG gas sensor (MQ-2), CO gas sensor (MQ-7), flame sensor and

temperature sensor ,so when the system detect any gas or fire in any part in the factory it will decide the right action using the actuators.

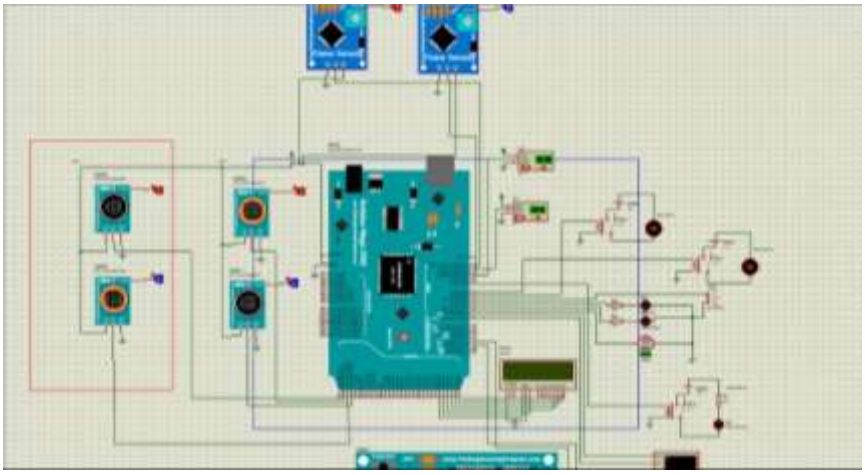

Figure 3-2: Simulation System

3.3 System Interfacing

3.3.1 Interfacing Gas Sensor (MQ-2, MQ-7) with Arduino

The gas sensors are connected to the Arduino Mega which is supplied by 5 DC voltage from the regulator by wiring VCC and GND pins of gas sensors to VCC and GND pins of Arduino and then the signal pin of gas sensors are connected to the analog pin in the Arduino (53) for the first MQ-2 and pin (52) for the second MQ-2 and pin (51) for the first MQ-7 and pin (50) for the second MQ-7.

3.3.2 Interfacing Flame and Temperature Sensors with Arduino

The Arduino Mega is supplied by 5 DC voltage from the regulator, then the gas sensors are connected to the Arduino by wiring VCC and GND pins of gas sensors to VCC and GND pins of Arduino and then the signal pin of gas sensors are connected to the analog pin in the Arduino (13) for flame one and pin (11) for flame two and pin (12) for temperature one and pin (10) for temperature two.

3.3.3 Interfacing the First Relay Circuit with Arduino

This circuit controls the gas valve, the circuit construction from relay RL1, it has five pins. Two are connected to the Arduino pin (6) and ground (control pins), the third pin is connected to the gas valve negative point and the fourth pin is connected to the power supply which feed the gas valve positive point by 5 DC voltage and the fifth pin configuring the mode relay if it is close or open.

3.3.4 Interfacing the Second Relay Circuit with Arduino

The second relay is used to control the LED which is used in the simulation to represent the electricity panel, the circuit construction from relay RL2, it has five pins. Two are connected to the Arduino pin (8) and ground (control pins), the third pin is connected to the LED negative point and the fourth pin is connected to the power supply which feed the LED positive point by 5 DC voltage and the fifth pin configuring the mode relay if It is close or open.

3.3.5 Interfacing the Third Relay Circuit with Arduino

This circuit controls the motor which represent the fire-fighting system, which is controlled by the relay RL3, it has five pins. Two are connected to the Arduino pin (7) and ground (control pins), the third pin is connected to the motor negative point and the fourth pin is connected to the power supply which feed the motor positive point by 5 DC voltage and the fifth pin configuring the mode relay if it close or open.

3.3.6 Interfacing the Liquid Crystal Display (LCD) with Arduino

The VSS pin of the LCD is connected to the ground, while the VDD pin is fed by 5 DC voltage, the VEE pin is connected to the monitor with variable screen-lighting control resistance, the RW pin is

connected to the ground, the RS pin is connected to the seventh digital pin of Arduino, the E (enable) is connected to sixth digital pin of Arduino, the data legs (D4-D7) are connected with pins (25 -22) of Arduino.

3.3.7 Interfacing the Ventilation Fan with Arduino

The ventilation fan positive input is connected to the Arduino pin (2) and the negative pin is connected to the ground, it will be active when it receives a signal from Arduino to reduce the gas concentration or smoke.

3.3.8 Interfacing the Buzzer with Arduino

It is connected to the Arduino pin (5) and the other side is connected to the ground, it will be active when it receives a signal from Arduino to alarm the people in the factory.

3.3.9 Interfacing the Light Emitting Diode (LED) (Red, Green) with Arduino

It is connected with a 450 ohm resistance and the resistance is connected with Arduino pin (4) for the red LED and Arduino pin (3) for the green LED, the other side of LED is connected with the ground when the red LED receive a signal from the Arduino that mean the system is in the emergency mode and when the green LED is active that mean the system in the safe mode.

3.3.10 Interfacing the Wireless Module (GSM900) with Arduino

The GSM900 TX pin is connected to the Arduino through RX pin and its RX pin is connected to the TX pin in Arduino, a virtual terminal

RX and TX are connected to the TX and RX pins of the GSM900 respectively to display the messages from the GSM.

3.4 System Operation

First of all, all the hardware unit of the system was tested and it was ensured that they were in a good working condition. Then all units, gas valve, electrical panel, fire-fighting system, buzzer, ventilation fan, gas sensors, flame sensors, temperature sensors, LCD and LEDs, were connected to each other on the board with the Arduino Mega using wires, the sensors were connected to 5v from the Arduino, the actuators were connected to a 12v external power supply and the AC contractor is connected to a 24v external power supply, the system response is divided into two parts: normal mode “no gas or fire detected” and emergency mode “gas or fire detected”. In the normal situation the green LED light up, and the LCD screen displays the phrase ‘safe’ the gas valve relay and electricity panel relay are normal close, the fire-fighting system relay is normal open and the ventilation fan is close. In the emergency mode if one of the gas sensors is sensing (LPG or CO) gas the sensor sends the signal by analog signal pin to the Arduino, then the Arduino receives and read the signal and compare it with the threshold value, if it is higher than threshold value the Arduino send a high digital signal that will change the gas valve relay from normal close to open to turn off the valve, and send a high digital signal to the ventilation fan, buzzer and red LED to be active. and if one of the flame sensors is active then the sensor sends the signal by digital signal pin to the Arduino, then the Arduino receive and read the signal if it is equal to zero the Arduino send a high digital signal that will change the fire-fighting system relay from normal open to close, and change the gas valve relay from normal close to open to turn off the valve, and send a high digital signal to the

ventilation fan, buzzer and red LED to be active then send a high digital signal that will change the solid state relay from normal close to open to turn off the AC contactor to shut-down the factory power. Second part is the software, the code used to program the system, after importing the required libraries and declaring the variables, the values from the sensors are read using specific functions like DigitalRead and AnalogRead, and then stored in the variables, next the sensor value is tested using an IF statement and if value is above the predefined value then the Arduino will send controlling signal to the actuators accordingly, if a gas leakage is detected a SMS is sent using sendSMS function, and in the case of fire a call is made using callfunction function.

3.5 System Work Flow

Figure 3-3: System Work Flow

CHAPTER FOUR

SYSTEM RESULT

4.1 System Operating Condition

4.1.1 Fire is Detected

If both of the flame sensor or one of them detected a fire ,the sensor will send signal to the Arduino so the Arduino sends a signal to: the first relay to operate the fire-fighting system, to the second relay to close the gas valve, to the fan to reduce the smoke, to the alarming part (buzzer and LED),to the LCD to display the case, to the GSM to make a warning call to the manager, and to the electrical panel to shut-down the factory power. The Fire Detection is shown in figure (4-1):

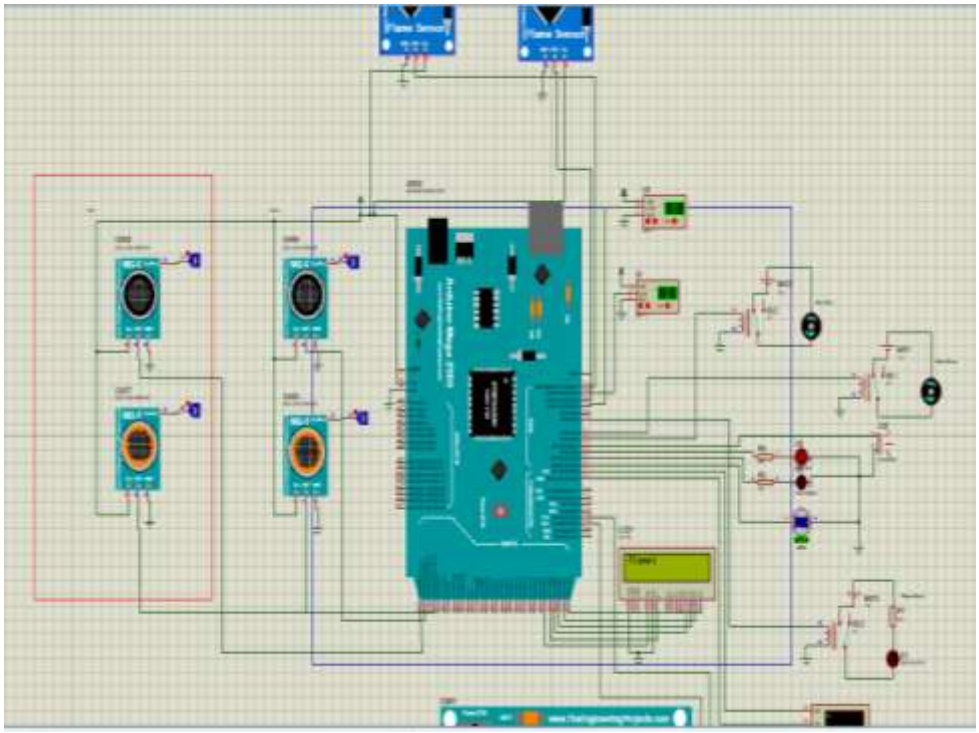

Figure 4-1: Fire Detection

4.1.2 Gas is Detected

We have 4 gas sensors two of them are MQ-2 and the other two are MQ7- when these sensors detect gas then it will send signal to the Arduino and therefore the Arduino sends a signal to: the second relay to close the gas valve, to the fire-fighting system to reduce the concentration of the gas, to the alarming part (buzzer and LED), to the LCD to display the case, and to the GSM to send a warning message to the manager. The Gas Detection is shown in figure (4-2):

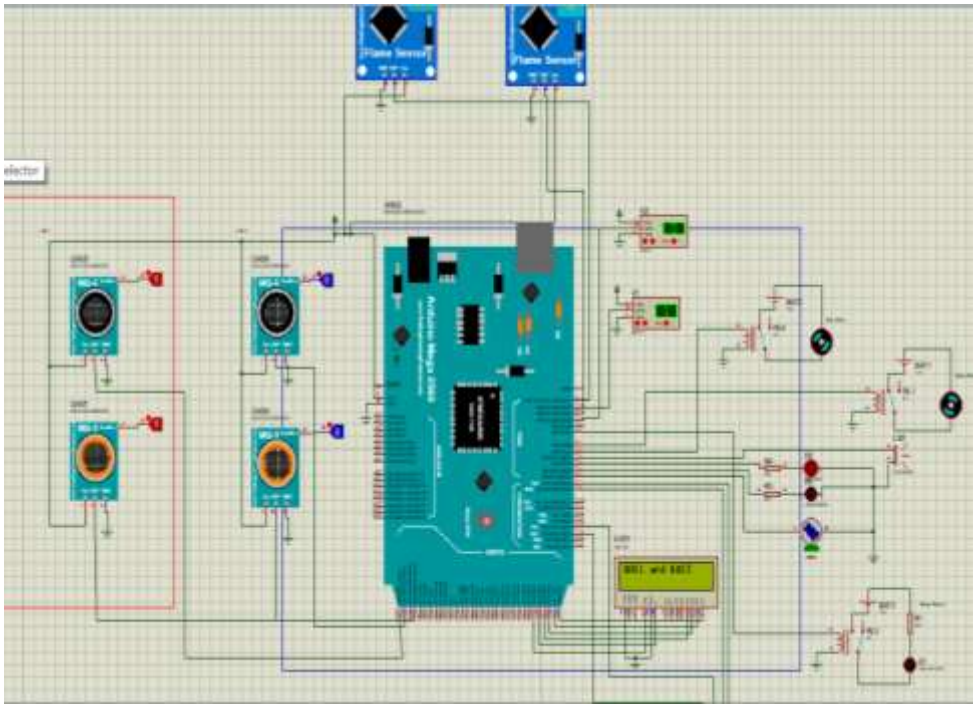

Figure 4-2: Gas Detection

4.1.3 Fire and Gas is Detected

Any one of the flame senor with any one of the gas sensor are active then the sensor will send signal to the Arduino then the Arduino sends a signal to: the first relay to operate the fire-fighting system, to the second relay to close the gas valve, to the ventilation fan to reduce the concentration of the gas, to the alarming part (buzzer and LED), to the

LCD to display the case, and to the GSM to send a warning message and call the manager. The Fire andGas Detection is shown in figure (4-3):

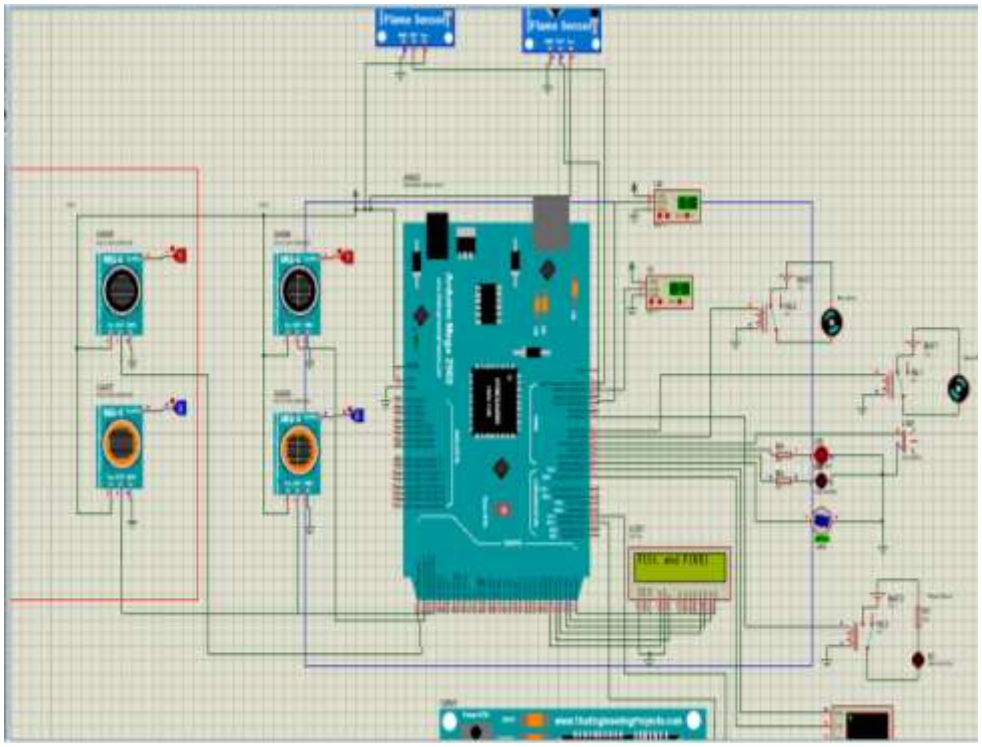

Figure 4-3: Fire and Gas Detection

4.1.4 No Detection

The system is in the normal mode the sensor voltage is less than the threshold so the electricity panel and gas valve are active and the fan, water pump and alarming unit are off. The Normal Mode is shown in figure (4-4):

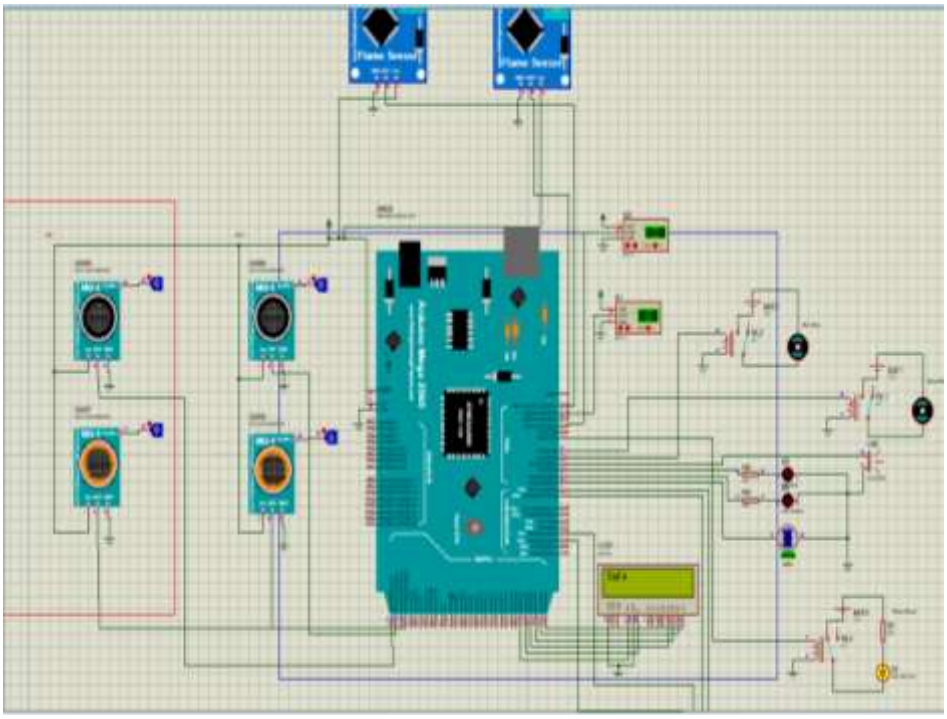

Figure 4-4: No Detection

4.2 Results

4.2.1 Case One

In this case any one of gas sensor is higher than the threshold the sim900 will send a message to the manager phone and the LCD will display which gas sensor is detect the gas. Shown figures (4-5/4-6):

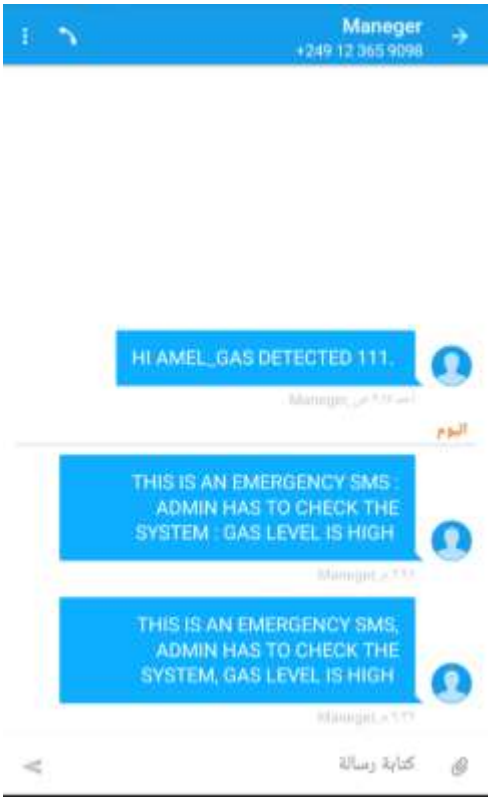

Figure 4-5: SMS Gas Alarm

Figure 4-6: Liquid Crystal Display (LCD) Gas Alarm

4.2.2 Case Two

In this case one or both of flame sensors are higher than the threshold the sim900 will make a call to the manager number and the LCD will display which flame sensor is detect the fire. Shown figures (4-7/4-8):

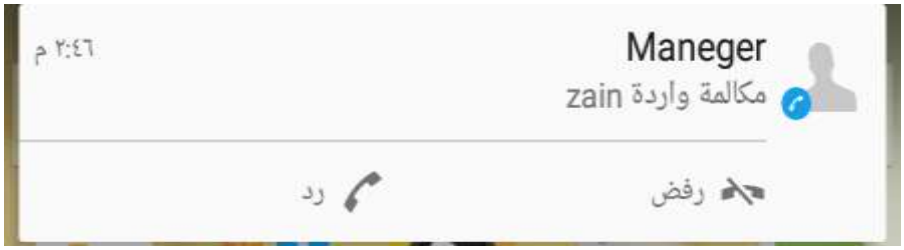

Figure 4-7: GSM Call Alarm

Figure 4-8: Liquid Crystal Display (LCD) Fire Alarm

4.2.3 Case Three

In this case any one or two or three or all of gas sensor with the flame sensor is higher than the threshold the sim900 will send a message and make a call to manager phone and the LCD will display which flame and gas sensor is detect the fire and the gas. Shown figure (4-9):

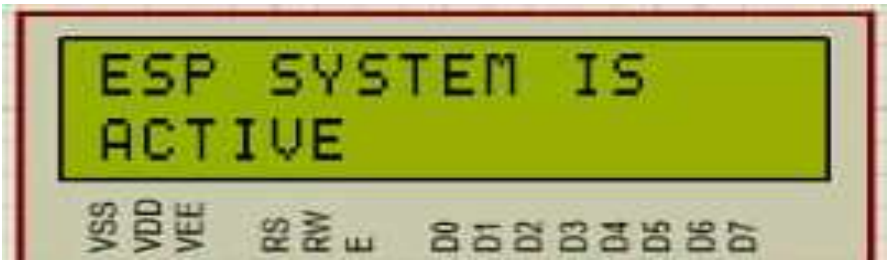

Figure 4-9: Fire and Gas Alarm

4.2.4 Case Four

In case the factory temperature is high than the normal the sensor will send signal to Arduino to activate the cooling fan. Shown figure (4-10):

Figure 4-10: Cool Temperature

CHAPETER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this thesis, the aim is to design a gas and fire alarm and control system with a Low cost with effective usage and make it more users friendly and easy to operate. So gas, temperature and flame sensors and Arduino are used to save lives and reduce percentage of any accident. The program embedded in the Arduino Mega works according to the need A step by step approach in designing Arduino based system for gas and temperature measurement has been followed. According to the study and analysis of various parts of the system a design has been carried out the results obtained from the measurement has shown that the system performs well under all conditions and the attempt has been done

5.2 Recommendation

From the outcomes of the research, the following recommendations can be made:

1. Predicting the occurrence of a gas leak or fire based on AI which learning form data we storage in our cloud

2. In case the system breakdown , by using NODEMCU WI-FI module and GSM we can send a message to the manager that the system breakdown and the sensors have no read.

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APPENDIX

```
#include<SoftwareSerial.h>   //allow serial communication

#include <Wire.h>

#include <LiquidCrystal.h>    // Liquid Crystal display

SoftwareSerial SIM900(34, 35);    // Configure software serial port

char msg;

char call;

const int rs = 27, en = 26, d4 = 25, d5 = 24, d6 = 23, d7 = 22;

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

#include "dht.h"

dht DHT;

#include <MQ2.h>

#define dht2 DHT;

void setup() {

SIM900.begin(19200);

Serial.begin(9600);

delay(1000);

lcd.begin(16, 2);

lcd.print("Safe");

}

void loop() {

DHT.read11(dht_apin);

float TEMP1=DHT.temperature;   // read temperature from first sensor
```

```
DHT.read11(dht_apin2);
float TEMP2=DHT.temperature;   // read temperature from second sensor


   // display the data in the serial monitor
   Serial.println("( LAB 1 )");
   Serial.print("TEMP in LAB 1 = ");
   Serial.print(TEMP1);
   Serial.println("C  ");
   Serial.print("MQ2 Gas Value in LAB 1: ");
   Serial.println(GAS_Value1);
   Serial.print("MQ7 Gas Value in LAB 1: ");
   Serial.println(GAS7_Value1);
   Serial.print("Fire Sensor 1 state: ");
   Serial.println(digitalRead(40));
   Serial.println("( LAB 2 )");
   Serial.print("TEMP in LAB 12 = ");
   Serial.print(TEMP2);
   Serial.println("C  ");
   Serial.print("MQ2 Gas Value in LAB 2: ");
   Serial.println(GAS_Value2);
   Serial.print("MQ7 Gas Value in LAB 12: ");
   Serial.println(GAS7_Value2);
   Serial.print("Fire Sensor 1 state: ");
   Serial.println(digitalRead(41));
```

```
if(GAS_Value1 >= 400){    // if the gas value exceeds the threshold value perform the following actions
  lcd.setCursor(0,0);
  lcd.print("GAS1 DETECTED");
  lcd.setCursor(0,1);
  lcd.print("IN LAB 1");
    Serial.println(" ");
    Serial.println("MQ2 GAS in LAB 1");
    Serial.println(GAS_Value1);
    Serial.println(" ");
    digitalWrite(ALARM,HIGH);
    digitalWrite(relay,LOW);
    digitalWrite(motor1pin1, HIGH);
    digitalWrite(motor1pin2, LOW);
    sendSMS();
    delay(1000);
  }
  if(GAS7_Value1 >= 300){
  lcd.setCursor(0,0);
  lcd.print("GAS7 DETECTED");
  lcd.setCursor(0,1);
  lcd.print("IN LAB 1");
    Serial.println(" ");
    Serial.println("MQ7 GAS in LAB 1");
```

```
  Serial.println(GAS_Value1);
  Serial.println(" ");
  digitalWrite(ALARM,HIGH);
  digitalWrite(relay,LOW);
  digitalWrite(motor1pin1, HIGH);
  digitalWrite(motor1pin2, LOW);
  sendSMS();
  delay(1000);
 }
if(FLAME_LAB_1 == LOW){
lcd.setCursor(0,0);
lcd.print("FIRE DETECTED");
lcd.setCursor(0,1);
lcd.print("IN LAB 1");
  Serial.println(" ");
  Serial.println("MQ7 GAS in LAB 1");
  Serial.println(GAS_Value1);
  Serial.println(" ");
  digitalWrite(ALARM,HIGH);
  digitalWrite(relay,LOW);
  digitalWrite(motor1pin1, HIGH);
  digitalWrite(motor1pin2, LOW);
  digitalWrite(motor2pin1, HIGH);
  digitalWrite(motor2pin2, LOW);
```

```
    callfunction();
    delay(1000);
}
  else{
   digitalWrite(ALARM,LOW);
    digitalWrite(motor1pin1,LOW);
    digitalWrite(motor1pin2, LOW);
    digitalWrite(motor2pin1,LOW);
    digitalWrite(motor2pin2, LOW);
    digitalWrite(relay,HIGH);
    delay(5000);
   delay(3000);
  }
}
// SMS function
void sendSMS() {
 SIM900.print("AT+CMGF=1\r");
 delay(100);
 SIM900.println("AT+CMGS=\"+249117763141\"");
 delay(100);
 SIM900.println("GAS DETECTED.");
 delay(100);
 SIM900.println((char)26);
 delay(100);
```

```
  SIM900.println();
  delay(5000);
}
// Calling function
void callfunction() {
  SIM900.println("ATD + +249909598273;");
  delay(100);
  SIM900.println();
   delay(20000);
  SIM900.println("ATH");    // AT command to hang up
}
```