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DESIGN AND IMPLEMENTATION OF FIRE PREVENTION AND CONTROL SYSTEM USING ATMEGA328P MICROCONTROLLER

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Abstract

The design and implementation of a fire prevention and control system using ATmega328P was successfully designed and implemented to curb the frequent fire outbreak in Africa. The system was designed to trigger alarm ON whenever gas leakage or smoke is detected and as well triggers ON fire extinguishing fan ON to suck the gas away from the premise. The Liquid Crystal Display (LCD) as well indicates the system performance measure of the premises at any point in time. The Arduino UNO is used as the main controller of the system and the buzzer for notification when there is danger. The system will detect the leakage using a gas sensor MQ-5 and use the buzzer for alarm to alert the public/authorities that there is danger in the premises. The system uses two indicator LED Lights; the Green LED light indicates that there was no gas leakage detected in the premises whereas the Red LED light indicate that there was gas leakage detected and needs immediate intervention. This designed and implemented device has 15% performance efficiency compared to the existing ones and will be of a very good help to African countries as it has the ability to prevent fire outbreak in promises.

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Introduction:-

Safety is one of the crucial aspects of life and it should be taken care of first before any other activities. One of the disastrous outbreak that many have experienced in life is fire outbreak and its control is always difficult. fire is the state of combustion in which inflammable material burns, producing heat, flames, and often smoke. Fire outbreak is a sudden and unplanned increase of fire in an enclosed or open arena. Fire outbreak is also described assudden unplanned eruption or an outburst of flame, light and heat which is produced when something burns. This fire outbreak can be caused by many factors such faulty home appliances, bad house wiring, careless use of gas cooker and container, careless use of candle, explosion of gas cylinder or tanker, use of cell phones at filling or gas station, smoking and so on.

However, such fire outbreak sometimes escalates to highest level simply because safe measures weren't put in place or there is less or no monitoring at all. Hence, several projects have been built in the past to ensure that the issue of abrupt fire outbreaks in schools and other places were eradicated or curbed to the barest minimum.
Many researchers have placed some curbing measures to ensure that such incident were reduced to ensure lives and properties weren't lost in this process. In 1999, R.A Carter presented a fire safety and security system in schools which had the security and smoke detection alarm system combined with an automatic sprinkler system [1].In 2005 some group of researcher researched about School Safety Interventions: Best Practices and Programs where they involved school social workers because of their influence to stop school violence [2].In 2006, researchers also proposed an efficient monitoring system for early fire automatic detection using the Arduino mega and other main components used to design a fire alarm. The system had the ability to remotely send an alert to the authorities by using a GSM module whenever a fire is detected [3]. The quest to eradicate fire outbreak by researchers kept on evolving and in 2010 they came up with a fire fighting robot that had to control fire through a robotic vehicle. Moreover, With the advancement in the field of Robotics, human intervention is becoming less every day and robots are used widely for purpose of safety [4].A WiFi Based Home Automation System that supports a wide range of home automation devices like power management components, and security components like fire detectors were designed to still curb fire outbreak in our various home and offices [5].In 2013, the development of Fire Alarm System using Raspberry Pi and Arduino Uno that could detect the presence of smoke in the air due to fire and captures images via a camera installed inside a room when a fire occurs [6].

A Local Data Fusion Algorithm for Fire Detection through Mobile Robot was developed where a local data fusion algorithm based on luminosity, temperature and flame for fire detection was presented. The data fusion approach was embedded in a low-cost mobile robot [7].

An Intelligent Fire Detection and Mitigation System Safe from Fire (SFF) was developed and implemented. The developed system has the ability of taking in input signals from various sensors placed in different position of the monitored area and fuzzy logic was integrated on it to identify fire breakout locations and severity [8].

A controlled Robot for Fire Detection and Extinguish to Closed Areas Based on Arduino was design and implemented for effective fire outbreak control.The basic idea of fire detection and treatment robot was based on detection of the fire by the wireless camera and flame sensor and control the fire outbreak by sending a programmable command to the mobile phone through Bluetooth connection to turn ON water pump to extinguish the fire [9].

An IOT fire detection system using temperature sensor (flame sensor) and Arduino device was developed to detect fire outbreak and measure the amount of heat intensity as well as the specific location of the house, offices was designed in 2019 by [10]. This developed device help to detect and measure the specific location at where the fire outbreak happened and proffer solution to it immediately by signaling the specific and designed authority on the happenings.

An early fire detection system based on fuzzy logic using multisensory was developed and implemented by [11] in 2020. The system consisted of a multisensory to detect fire, smoke and temperature in the room. The multisensory used in the design were: KY-026 sensor as fire detection sensor, MQ-9 sensor as smoke detection sensor and DS18b20 sensor as temperature detector sensor were combined together for effective and efficient fire outbreak detection [11].

A fire detection model based on power-aware scheduling for IoT-sensors in smart cities with partial coverage was developed [12]. In the proposed model, the sleep scheduling approach used for saving sensors energy. The approach was anticipated to significantly help in saving consumed energy and retrieve the excess to avoid wastage and use it to fight fire outbreak [12].

In Uganda, a number of school dormitories have been prone to fire outbreak that has taken many lives which would have been curtailed if all the necessary fire outbreak proactive measures were taken. The fire outbreak incident of April 2008 in a girls' dormitory at Buddo Junior School took lives of 20 pupils which would have been secured. Another bad scenario of fire outbreak in Uganda that killed not less than 30 people happened at Bishop Ruhindi High School in Rukungiri District, Bukoyo Secondary School in Iganga District,St Mary's College in Buikwe District,Kawempe Muslim SS, Merryland High School, Kibibi Junior School, Light College Katikamu, Moyo SS

and St Leo's Junior School and finally at St John Bosco Primary School, Katende were a live was lost. Furthermore, In November 12, 2018, a school in Rakai district caught fire and killed 10SS3 students and left 50 students critically injured [13].

It is also very important to note that there is a need to install solar photovoltaic panels in the monitoring environment in case of power failure. There many review work done in the field of photovoltaic installation, fabrications and optimizations that will help in installation of solar photovoltaics in the designated zone of monitoring to avoid fire outbreak [14-18]. There is also study in the development and fabrications of photovoltaic panels that will help the research to know how to develop, optimize, fabricate and install a sizable solar panel in the monitoring environment with less cost [16] [19-25]

There are other designs and implementations of microcontroller and Arduino based research works that explicitly highlighted on the Arduino connections with ATmega322P microcontroller for smart surveillance security system, automated hybrid smart door control system, an improved automatic DC motor speed control systems using microcontroller, An industrial heat detector and cooling system using raspberry Pi [18][19] [26-28]. These extensive review in this areas will guide me in the interconnections of the microcotroller and the arduino.

From these extensive and comprehensive review, it was observed that the peculiarity of the fire outbreak in Uganda, East African is lack of preventive measure and carelessness. It was on this background that this research proposed the design and implementation of a fire outbreak prevention and control system using Atmega328p microcontroller. This design will be able to detects gas leakage, smoke from flammable materials, notify the authorities/students on the happening and automatically set fire extinguisher ON to sucks away gas/smoke or extinguish the fire.

Material and Methods

This section of this research detailed the sequentially step by step used in designing and implementation of the proposed system. This section will explain the components involved and its circuit connections.

Figure 2:- Flowchart of the Proposed Design.

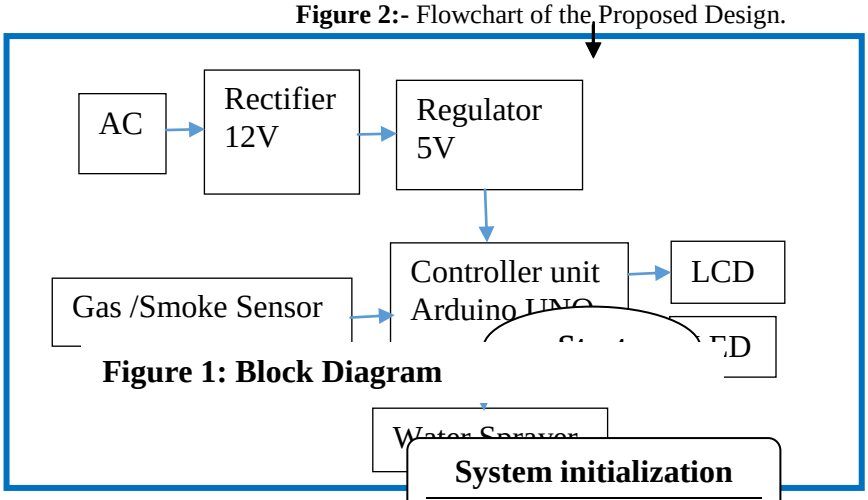
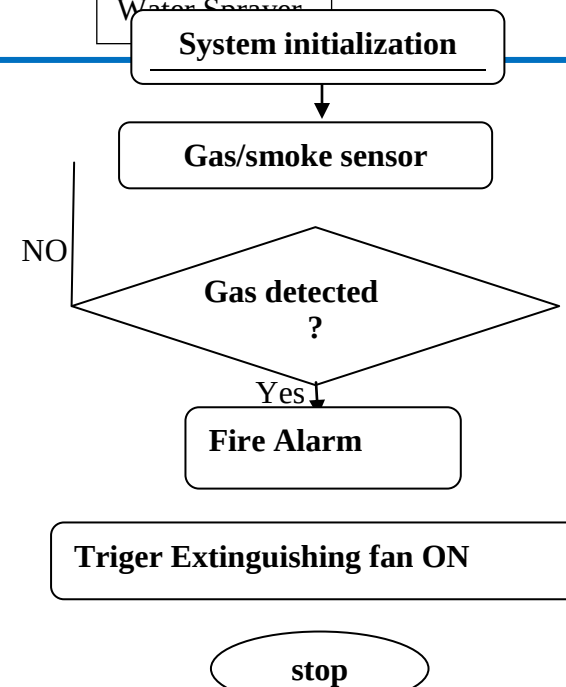


Figure 1: Block Diagram



The block diagram consists of the ATMEGA328P as the project controller, MQ2 for detecting gases and smoke, the automatic fire extinguisher(water sprayer) that put off the gas away from the premises where there is leakage, and liquid crystal display(LCD)for displaying status of the environment, a buzzer for alarming and LED indicator which shows RED and GREEN light. The Green display showed that there is no gas leakage or smoke detected whereas the red light indicates that there is gas leakage or smoke detected as in block diagram in figure 1.

The flowchart in figure 2 shows the systematic working system of the fire prevention and control system using atmega328p microcontroller. The system will initialize and it will check if there is gas leakage or smoke detected using MQ2 sensor, if there is none detected, it will keep checking but if detected it will command the ATMEGA328P to trigger the alarm through the buzzer and the fire extinguishers will automatically trigger ON. The buzzer alarm will alert those inside the vicinity to be aware of the happenings and exit doors will be automatically opened for people inside to exit for safety.

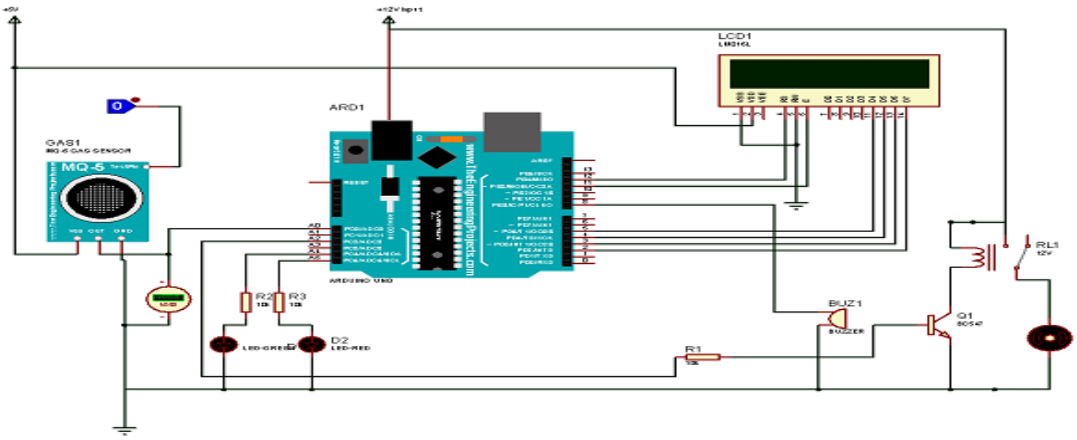


Figure 3:- Circuit diagram.

The circuit of the fire prevention and control system using atmega328p microcontroller is connected as shown in figure 3. This comprises of all the components that made up the circuit. The hardware components were discussed below:

ATMEGA328P

ATmega-328 is basically an Advanced Virtual RISC (AVR) micro-controller that supports up to eight (8) bits data. ATmega328P has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM) and 2KB Static Random-Access Memory (SRAM). This ATMEGA328P was used in this research design because of its good features which make it the most popular device in today's market. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable Serial USART, programming lock for software security, throughput of up to 20 MIPS etc. one good feature of **ATmega328P** is that it is compactible in Arduino Uno. The **Arduino bootloader needs to be installed** into the chip (Or buy a chip with boot loader – ATMega328P-PU) [9]

Figure 4 is the diagram of ATmega328P and Arduino Uno device for the effective and efficient connection of the circuit.

Figure 4:- ATmega328P Microchips and Arduino Uno Device.

Crystal Oscillators.

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a constant frequency as shown in figure 5. This will act as an external clock source that operates at 16MHZ interfaced to the Atmega328p. It also works hand in hand with the 22pf ceramic capacitors which prevent debouncing in timers.

Figure 5:- Crystal oscillator.

Pull-up Resistor.

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines. A pull-up resistor connects unused input pins (AND NAND gates) to the DC supply voltage, (Vcc) to keep the given input HIGH. To disable the continuous reset of the Atmega328p, a pull-up resistor should be connected to its reset pin. A pull-up resistor is as shown in figure 6.

Figure 6:- Resistor.

Liquid-Crystal Display (LCD)

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers to display readable images. This module was used to display the status of the whole things that the fire prevention and control system using atmega328p microcontroller does and the actions. The LCD is as shown in figure 7.

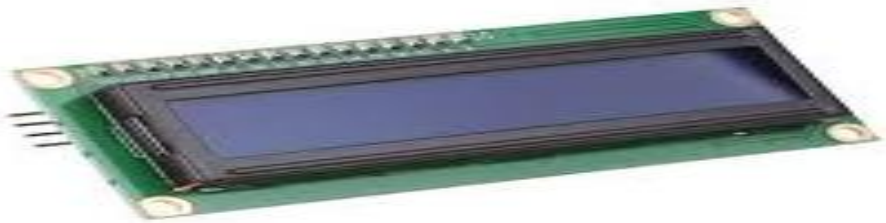


Figure 7:- Liquid-Crystal Display (LCD).

Implementation Techniques

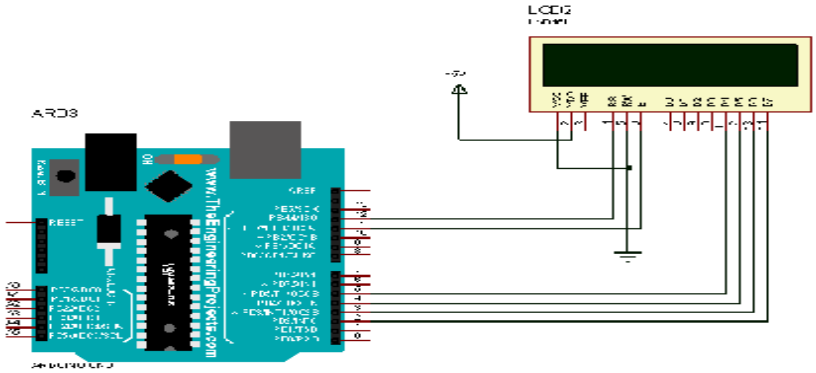


Figure 8:- Interfacing Arduino to LCD.

Figure 8 showed the systematic connection of the pins between the LCD and the Arduino microcontroller.The written codes in c language has been embedded in the Arduino Uno and a hex file were also created.

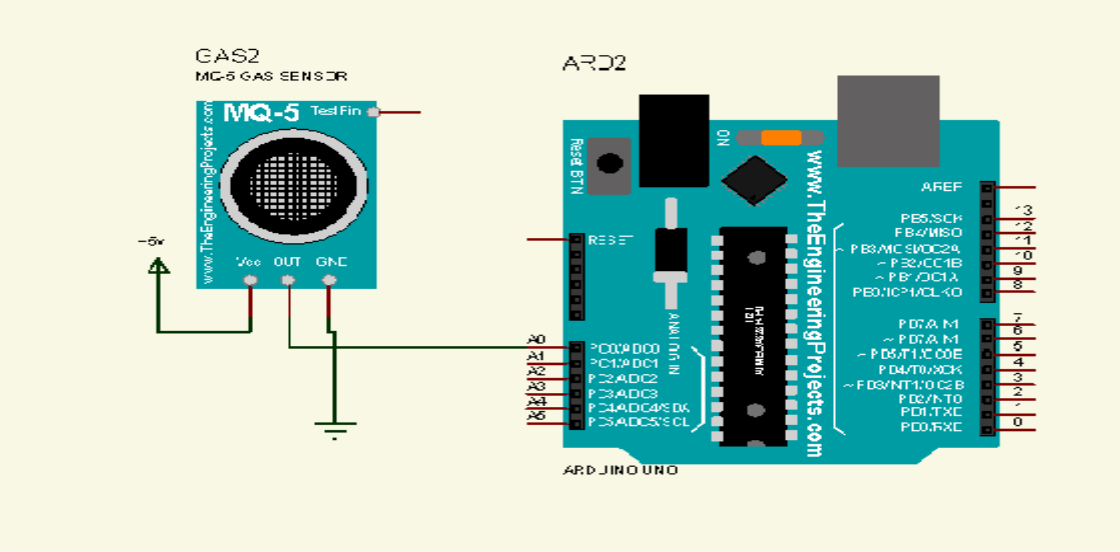


Figure 9:- Interfacing the MQ-5 sensor to Arduino.

The ground of the buzzer is connected to the ground of the Arduino. The Vcc of the Buzzer is connected to digital pin 8 of the Arduino and The Do pin of the MQ-5 sensor is connected to the digital pin of the Arduino pin 7. In addition, the +5 volt of Arduino is connected to the Vcc of the sensor. Then finally, the ground of the Arduino is connected to the ground of the sensor. The interfacing of the buzzer, Arduino and MQ-5 sensor is as shown in figure 9.

Result:-

From the design, implementation and connections of the circuits in figure 8 and 9 and the full circuit diagram shown in figure 3, the results below were gotten during simulation and physical implementation of the system.

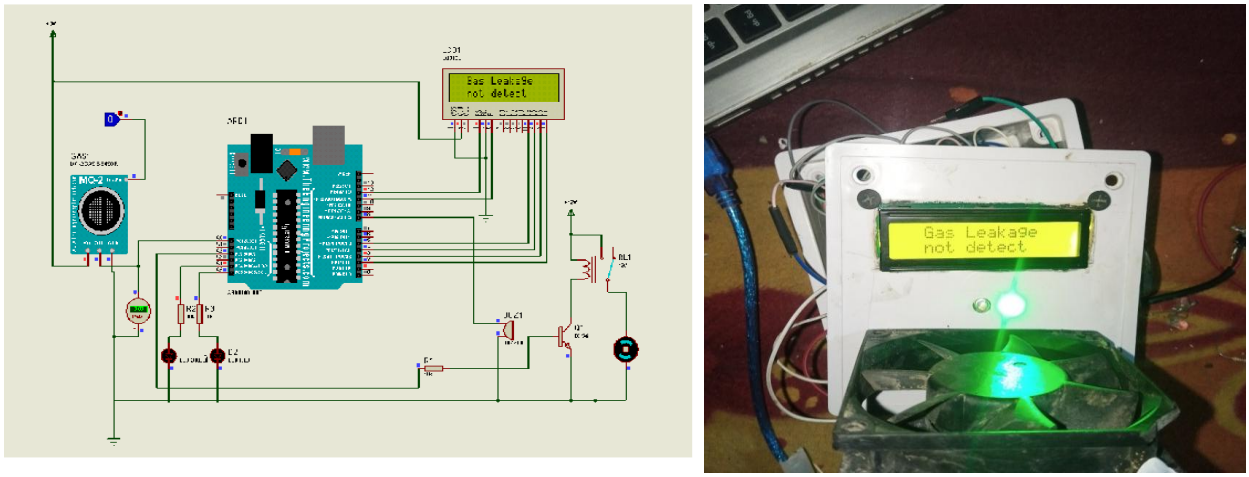


Figure 10:- Implementation and simulation results showing no Gas leakage/ smoke Detected and green LED.

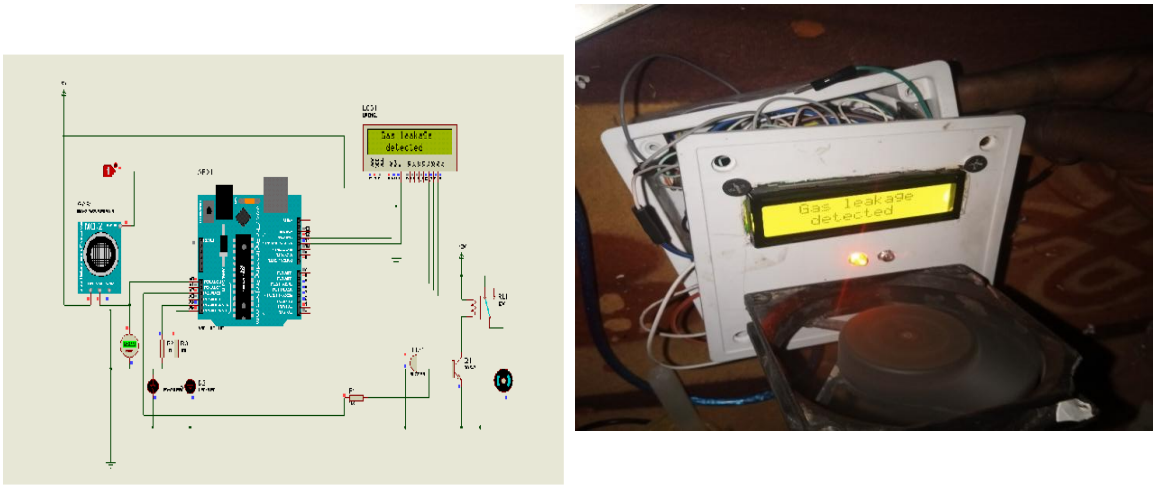


Figure 11:- Simulation result showing gas leakage detected.

From figure 10 it was observed that the simulation and implemented results showed that there is no gas leakage/smoke in the environment. The green light is ON indicating that there is no fire outbreak danger or signs in the environment. It also indicated that the designed and implemented system is working effectively as it has the ability to indicate that there is no fire outbreak signs in the environment and never triggered the alarm ON.

The simulation and implemented fire prevention and control system using atmega328p microcontroller is working effectively as it showed that there is danger in the environment by triggering the RED light ON as shown in figure 11. The system showed that there is gas leakage within the environment and triggered the RED light ON signaling the authority that there is danger. The RED light will be on for 30 seconds before triggering the ALARM ON.

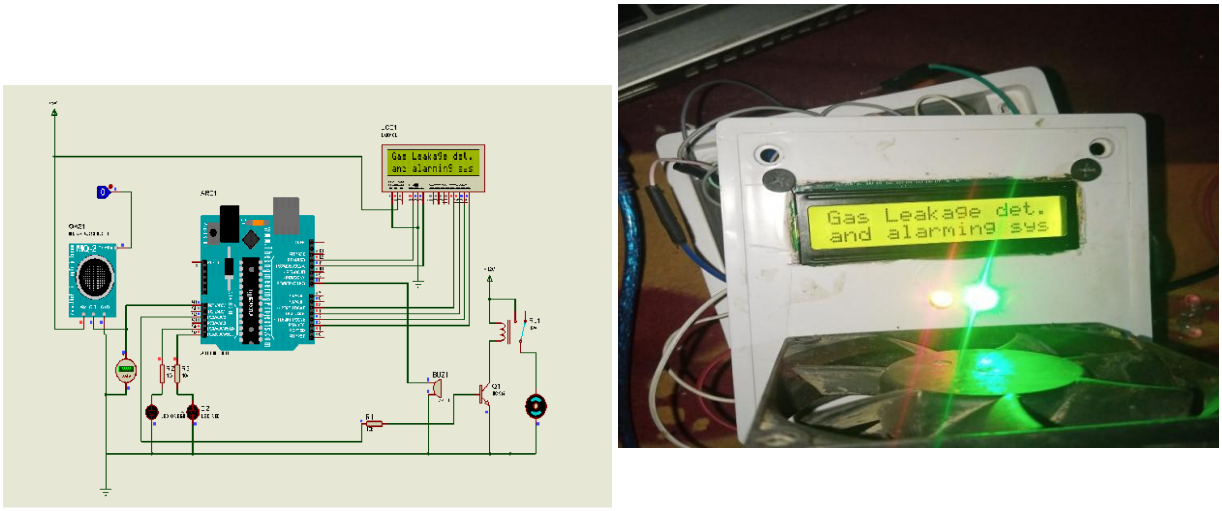


Figure 12:- Implementation and simulation results showing Gas leakage/smoke Detected and Red LED Light and Alarming system ON.

Figure 12, showed the fully designed and implemented fire prevention and control system using atmega328p microcontroller when there is danger and alarm triggered ON. The system detected gas leakage in the environment and the Alarm was trigged ON after 20 seconds of the detection calling the attention of the authorities in charge. If there is no human intervention after 40 seconds, the designed system will measure and detect the range at which the gas is coming from and the fire extinguisher fan automatically triggers ON and starts sucking away the gas at that particular location that the leakage was detected. This designed and implemented system prevents and controls fire outbreak from occurring and whenever fire outbreak occurs it will be easily controlled before it escalates as the alarm and preventive mechanism were set aside to avoid disastrous occurrence.

Conclusion:-

The fire prevention and control system using atmega328p microcontroller was designed and implemented successfully. The designed and implemented fire prevention and control system using ATmega microcontroller has the ability of preventing fire outbreak by sounding an alarm when there is gas detected in the environment using MQ-4 sensor. At the same time, the location will be detected and the fire extinguishing fan will be activated to suck away the gasses present in the particular environment. The red LED will also be powered on as a sign that there is a presence of gas in the environment. The alarm that was triggered ON by the buzzer and the RED light will not turn off until the fan sucks away the gas in the environment. Therefore, with the help of the fire extinguishing fan and the alarm that calls the attention of the public/authorities, it will be very difficult to have a fire outbreak and even if it happens it will not be disastrous as preventive and control methods are already in place.

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