DESIGN AND IMPLEMENTATION OF AN AUTOMATIC FIRE ALARM SYSTEM USING GSM MODULE

Olaniyan O. M, Jayeoba M., Kazeem S.

Department of Computer Engineering, Federal University, Ekiti

Corresponding Author: Olaniyan O. M., olatayo.olaniyan@fuoye.edu.ng

ABSTRACT: A great threat to lives and properties is fire disaster ever since the genesis of human existence. Statistically, over 70% of total loss of properties and about 20% of total loss of lives every year in Nigeria is due to fire disaster. Electric short circuit in faulty electrical wiring, leakage of flammable materials, insufficient fire defense materials, violation of fire safety and most especially, lack of adequate awareness etc. are the major causes of such percentage. Although conventionally, some factories and recent buildings have now incorporated fire extinguishing systems which are not enough to take prompt action during fire to save properties and ultimately save lives. This project is based on the design and implementation of an automatic wireless-based fire monitoring, detection and alarm system using GSM module. Designing a system to alleviate and to detect fire accidents in advance (before its outbreak) by alerting residents of a building and the fire department would really help to combat fire outbreak issues in the nation. The system is able to detect an erupting fire, alert occupants of the building, notify the concerned recipient, extinguish the source of the fire before the occurrence of such hazard, thereby proffering an eventual prevention of fire outbreaks and its fatalities, hence, saving lives and properties. This project basically takes the advantage of the dominating wireless communication network, using a GSM module to alert the concerned occupants remotely via text messages when the sensors sense dangerous gas leakage, heat and fire in order to alleviate the rate at which peoples lose lives and properties due to fire hazards in Nigeria.

KEYWORDS*:* Fire, Sensor, Control Panel, Power supply.

I. INTRODUCTION

A great threat to lives and properties is fire disaster ever since the genesis of human existence. Statistically, over 70% of total loss of properties and about 20% of total loss of lives every year in Nigeria is due to fire disaster (Fire Industry Association, 2015). Electric short circuit in faulty electrical wiring, leakage of flammable materials, insufficient fire defense materials, violation of fire safety and most especially, lack of adequate awareness etc. are the major causes of such percentage.

Although conventionally, some factories and recent buildings have now incorporated fire extinguishing systems such as fire alarm, water supply system, fire extinguishers etc. which are not enough to take prompt action during fire to save properties and ultimately save lives. It is thoughtful that an automatic fire detection and mitigation system, in such scenario, will provide real-time surveillance, monitoring, and automated notification. Wireless sensor networks (WSNs) are widely deployed in environmental monitoring, structural health monitoring and industrial monitoring in recent years. For such applications, WSN provides low cost solutions. Though WSNs devices have limited computation, radio communication capabilities and sensing, their low power consumptions, small magnitude, and low cost makes them suitable for communication between detectors in fire alarm system.

This paper therefore presents the design and implementation of a system that detect fire-outbreaks in advance automatically, and further send notifications to concerned recipients over a wireless network for significant lives and cost saving.

II. BLOCK DIAGRAM

This system's architecture is based on the Wireless Network and comprises of both software and hardware resources. The three major sections of the system are: Sensor Interface, Control, Panel / Transmission, and Displaying / Alert / Notification as shown below.

III. SYSTEM COMPOSITION – EXPERIMENTAL SETUP

At the core of the system is the enclosed environment being monitored, which can also be referred to as the "subject" in this case. The subject is primarily monitored by flame, gas and temperature sensors which are embedded on a CPU, and triggered by the presence of fire symptoms, ranging from flame, to smoke, or heat.

The information collected by the sensor about the environment will then be sent to the Control Panel which is a microcontroller (Arduino). The

microcontroller comprises of CPU that does the logical processing of the received information as the two hardware components are directly connected together on the hardware part of this project. So, when the sensor receives an input that it is configured for, it sends signal to the microcontroller where the decision of whether to launch a transmission process in order to send an alarm via the Wireless Notification Medium to the building occupants or Fire Emergency Services or not (depending on the configuration) is made.

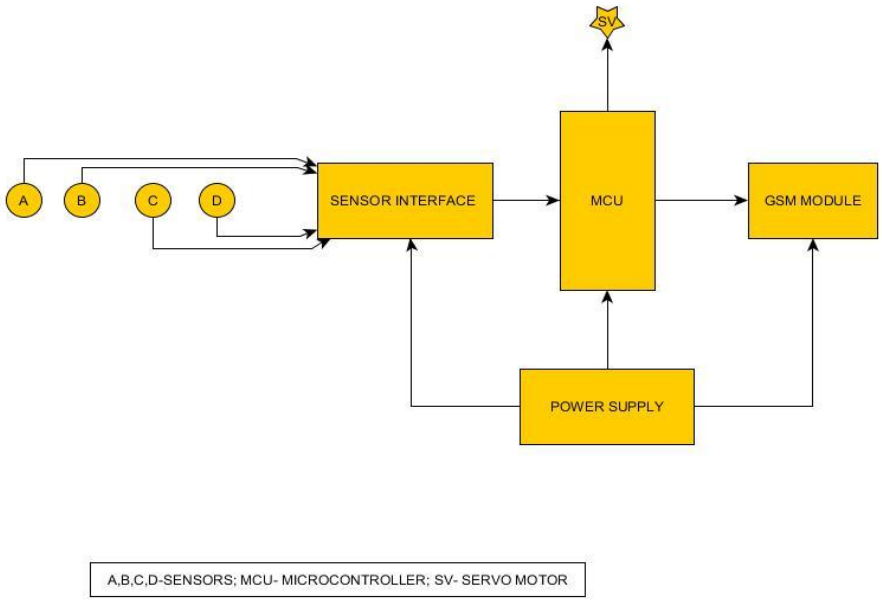

Fig. 1: Architecture of the Automatic Fire Alarm System using Module

The materials used in this project include the following:

i. Lipo battery
ii. Sim808 GSM module
iii. MQ-2 Gas Sensor
iv. LM35 Temperature Sensor
v. ATMega328 (mini) Microcontroller
vi. Flame Sensor
vii. Resistors
viii. Capacitors
ix. LEDs
x. Piezoelectric buzzer
xi. USB Ports
xii. Connecting wires, soldering lead, hot melt sticks, Veroboard, cable wires, etc.

IV. SENSING INTERFACE

A. Flame Sensor

A flame sensor is a designed sensor with the intent of detecting and responding to the presence of flame or fire in the environment where it is used. When used with a microcontroller, it can be configured to response to a particular level of fire or flame as the needs may be. For example, a fuel line can be deactivated (such as a propane or a natural gas line), a fire suppression system can be activated, an industrial alarm can be sounded for fire awareness etc. depending on its area of application. Based on its mechanism, it is faster and more accurate than other high temperature detectors such as heat detectors.

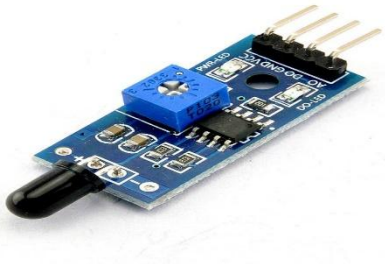

Fig. 2: Flame Sensor

B. MQ-2 Sensor

Ideally, LPG sensor is a sensor to detect the presence leakage LPG gas in a domain where it is used such as in our home, a gas service station, a storage tank and even in vehicle which uses LPG gas as its fuel. When interfaced with a microcontroller, an alarm can be sounded when there is gas leakage or to provide a visual indication of the LPG concentration via either LCD (Liquid crystal display) or seven-segment displays. The higher is the rise in the gas concentration, the higher the sensor's conductivity when the target combustible gas exists. The sensor can detect smoke in the range of 300-10,000 ppm, giving an analog output voltage of between 0v to 5v depending on the quantity of

smoke detected ([CBG13]). The sensitive material used is SnO2, whose conductivity is lower in clean air. Its conductivity increases as the concentration of combustible gases increases, hence generating a corresponding analog voltage at the output.

Fig. 3: Gas sensor

C. Temperature Sensor

The LM35 is an I.C (integrated circuit) based sensor that can be used to measure temperature with an output voltage proportional to the temperature (in °C) and a scale factor of .01V/°C.. It is more accurate than thermistor when measuring temperature. The sensor circuitry is sealed to prevent the influence of oxidation. The LM35 produces a higher output voltage when compares to thermocouples and may not require extra output voltage amplification.

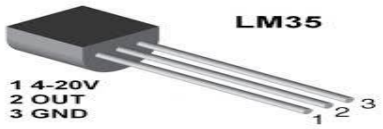

Fig. 4: Temperature Sensor

The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4°C at room temperature and +/-0.8°C over a range of 0°C to +100°C. LM35 draws a very small current (60 micro amps) from its supply and thus, less susceptible to self- heating. TO-92 plastic transistor-like package, T0-46 metal can transistor-like package and 8-lead surface mount SO-8 small outline package are different packages that LM35 appears. This project uses the To-92 small transistor package type.

V. CONTROL PANEL – ATMEGA MICRO CONTROLLER

At the control panel, Arduino microcontroller is programmed with C programming language for processing and controlling signals provided by sensors. The Arduino platform provides an integrated development environment (IDE) which includes support for C, C++ and Java programming languages. Using various 8-bit Atmel AVR microcontrollers or 32-bit Atmel ARM processors, the Arduino Microcontroller provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers.

By considering its several advantages such as simple user experience, economical nature, combined with its open source and extensible nature; Arduino board is chosen for the control panel of this project.

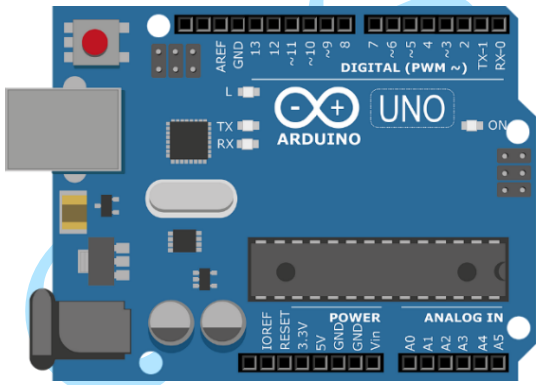

Fig. 5: A typical Arduino Board

The ATmega32 provides the following features: 32 kilobytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024 bytes EEPROM, 2 kilobyte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for boundary-scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes.

VI. TRANSMISSION AND NOTIFICATION SYSTEM – GPRS MODULE WIRELESS NETWORK

GSM / GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM / GPRS module consists of a GSM / GPRS

modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer. The MODEM is the heart of such modules.

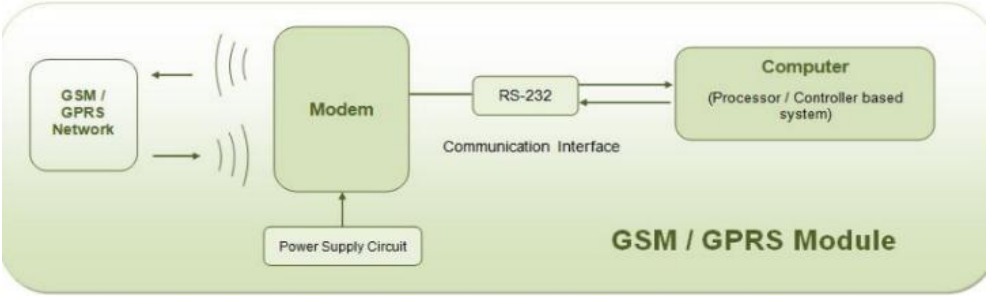

Fig. 6a: GSM/GPRS Module Architecture

For establishing communication between the cellular network and the computer, wireless MODEMs are devices that generate, transmit or decode data from a cellular network. In this project, microcontroller is the computer used to communicate with the cellular network. MODEMS are manufactured for specific cellular network (GSM / UMTS / CDMA) or specific cellular data standard (GSM / UMTS / GPRS / EDGE / HSDPA) or technology (GPS / SIM). Wireless MODEMs like other MODEM devices use serial communication to interface with and need Hayes compatible AT commands for communication with the computer ([SP13]).

GSM / GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. To activate communication with the network, a SIM (Subscriber Identity Module) card is required just like mobile phones. Also, they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

The MODEM needs AT commands, for interacting with processor or controller, which are communicated through serial communication. These commands are sent by the controller/processor. The MODEM sends back a result after it receives a command. Different AT commands supported by the MODEM can be sent by the processor / controller / computer to interact with the GSM and GPRS cellular network.

The GSM/GPRS module comprises of GSM/GPRS modem with standard communication interfaces like RS-232 (Serial Port), USB etc., so that it can be easily interfaced with a computer or a microprocessor / microcontroller-based system. The power supply circuit is also built in the module that can be activated by using a suitable adaptor ([BYJ6).

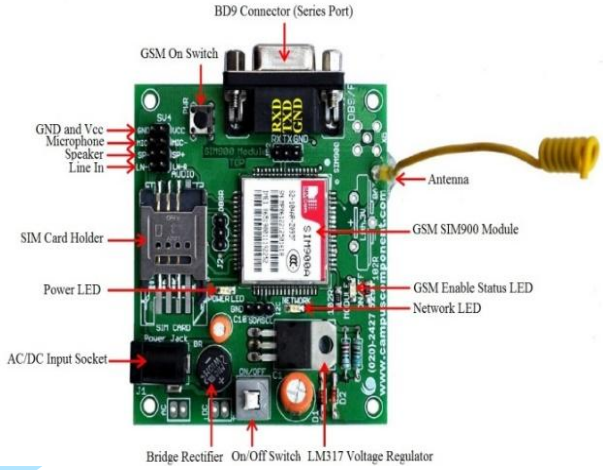

Fig. 6b: SIM808 GSM Module ([SP13])

VII. POWER SUPPLY

A Lithium Ion Battery which can be charged by an ordinary 5V cell phone charger through an on-board USB charging port is used to power this device. Using a rechargeable battery gives the device a major advantage which is that even when there is no electrical power, the device can still operate. Below is a simple block diagram of the power supply unit:

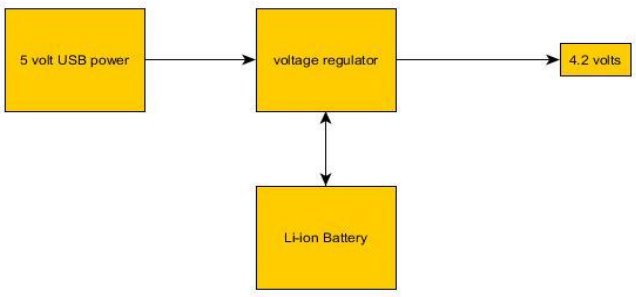

Fig. 7: Power Supply Unit

Fig. 8: Lithium Ion Battery

A Lithium-ion battery is made up of an anode, cathode, separator, electrolyte, and two current collectors (positive and negative). The anode and cathode store the lithium. The electrolyte carries positively charged lithium ions from the anode to the cathode and vice versa through the separator. The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered (cell phone, computer, etc.) to the negative current collector. The separator blocks the flow of electrons inside the battery. While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other. When plugging in the device, the opposite happens: Lithium ions are released by the cathode and received by the anode.

VIII. CIRCUIT DIAGRAM

It contains units M1, M2, M3, M4, U1 as Gas sensor, Temperature sensor, Flame sensor, GSM module and Arduino ATMEGA328P respectively.

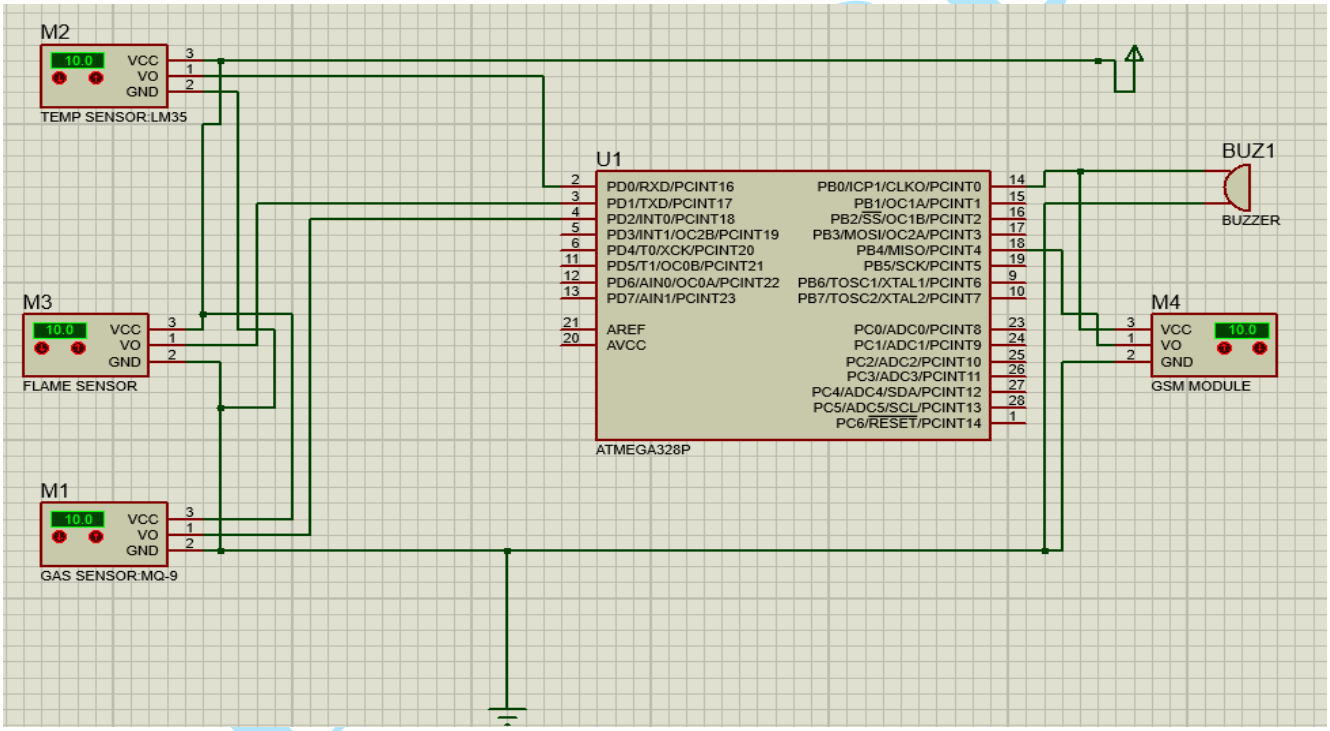

Fig. 9: Circuit Diagram Obtained Using Proteus

The diagram above is the schematic diagram of the project; the ATMEGA328 being the heart of the system initializes all the sensors after a time out of a few seconds upon powered up and begins calibration of the sensors; it then goes into the active monitoring mode, analyzing sensor data for a potential fire or emergency situation.

When there is a fire/smoke/pollution incident, the microcontroller initializes the SIM808 module and waits for it to acquire the network, then forwards the programmed SMS to the assigned Response Center numbers, repeating the message once just in case there is a network issue. After this sequence, it reverts to the active monitoring mode.

IX. CONCLUSION

This design system is able to detect an erupting fire, alert occupants of the building, notify the concerned recipient, and extinguish the source of the fire before the occurrence of such hazard, thereby proffering an eventual prevention of fire outbreaks and its fatalities, hence, saving lives and properties. During the implementation of this project, the problems and weaknesses of earlier similar systems were reviewed

in detail with the sole aim of having a better and more desired product quality. This design was implemented as a hardware, of which the major components include Arduino microcontroller, phone device, and Wireless Adapter and flame sensor. The result from this has proven that the system is scalable, accurate and energy efficient therefore, it is useful in homes and industrial environments to help reduce the risk of death and injuries caused by fire, and furthermore to avoid the losses that need to be borne by the victims.

This system is of significant benefit as an automatic notification system in situations of erupting fire. A major advantage of this system is that it explores the weaknesses of earlier similar systems by measuring simultaneously three physical environmental quantities which are the most probable symptoms of fire as a means of intensifying fire outbreak prevention measures. Furthermore, the simultaneous measure of these three quantities, help to reduce the probability of false-positive alerts. The cost of implementing this system is relatively low since the components used are relatively cheap and are easily available in the market.

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