Development of A GSM - Based Fire Detector System

Oke A.O, Falohun A.S and Adetunji A.B

Abstract- Fire outage is one of the phenomena that still pose a serious challenge to the security of lives and properties. Fire, being an important process that affects ecological systems across the globe has both positive and negative effects. It has been used by humans for cooking, generating heat, signalling and propulsion purposes. However soil erosion, atmospheric pollution and hazard to life and property are majorly the negative effects. Although the use of wildland fire, controlled burns, and provision of fire fighting services is put in place to prevent the outbreak, it is only evident in most developed countries. Fire accident creates serious health and safety hazard in developing countries, which also resulted into catastrophic situation. Associated with it is unnecessary injury or complete loss of lives in one hand, partial or complete damage to expensive and valuable properties on the other hand. This huge loss is inestimably enormous; hence this paper proposes the development of a GSM -based fire detector system. A cost effective system that detects fire or smoke and sends alert information to a mobile phone for quick and immediate action thereby, avoiding unnecessary and costly industrial and domestic breakdown.

Keywords: Fire detector, Smoke detector, Wireless sensor, Mobile phone, UART translator.

I. INTRODUCTION

Nigeria, like any developing country, is witnessing an era of rapid economic and social development. This development brings with it, new technologies, new materials, power sources and telecommunication equipment. Modern industries are springing up housing volatile materials and highly sophisticated equipment that increase the menace of fire. Concern for safety of lives and properties calls for an efficient and dependable fire protection system. This has enhanced the application of new technologies in the fire field. Sensors are able to consider certain dynamic and static variables such as humidity, the type of fuel, slope of the land, the direction and the speed of the wind, smoke , to mention a few.

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They allow us to determine the direction and possible evolution of the flame front. The sensor-based systems can be very useful to detect a fire and to take decisions to eradicate it [7]. A sensor is able to transform physical or chemical readings gathered from the environment into signals that can be measured by a system.

The reports of most of the panel of enquiries on fire accidents in Nigeria, oral interview of some fire experts and personal experience confirmed the fact that electrical fault is a major source of fire accident. Hence, realization that a fire protection system capable of automatically switching off electrical power supply to the affected area in addition to the traditional role of raising an alarm and triggering a sprinkler or other automatic fire lighting system is going to be more efficient and efficacious (by producing quicker result) than the existing systems which leaves that important role unaddressed.

II. METHODOLOGY

The fire alert design was built around techniques for digitalizing analogue signals obtained from transducers used to monitor (i.e. sense) temperature of the room and the light intensity of the room. The room temperature to be monitored, being analogue, is measured through the use of a thermistor, while the light intensity of the room is detected using Light Dependent Resistor (LDR) [9]. The LDR's resistance increases with reduced light intensity causing the voltage input into the inverting input of the comparator used to be higher than the reference voltage set at the non-inverting input of the comparator which makes the comparator to output a LOW. The thermistor resistance decrease with increase in temperature and this would cause a decrease in the voltage input to the non-inverting input of the comparator thereby causing the voltage reference set at the inverting input to be greater. In this state the comparator outputs a LOW, to indicate high temperature (i.e. fire). The two LOW outputs were ORed and coupled to the astable stage of the circuitry; the lamp and the buzzer were energized to sensitize everyone in the room or the building.

A. Power Supply Stage

The power supply employed in this design is a linear power supply that provides a regulated dc voltage (5V) used to power the whole circuit. A step down transformer was used to step down the input voltage of 220VAC to 18VAC. The 18VAC was rectified into direct current through the bridge rectifier. And since the ICs used in this design belong to the TTL (Transistor- Transistor Logic) logic family, they require a logic voltage level not more than 5.25Vdc. Hence, a voltage regulator IC, 7805, was used to regulate the dc voltage supply to the required 5V. Filtering capacitors were employed to filter away ac ripples from the power supply to ensure a ripple free power supply and ultimately a noiseless power supply.

The power supply also features a battery back up to ensure uninterrupted power to the circuit in the event of power failure as shown in Fig. I. When mains supply is present, diode, D1 is reversed biased, the rectified input voltage gets directly into the IC voltage regulator. But when mains supply is cut off, diode D1, conducts and power is supplied to the circuit thereby providing uninterrupted supply.

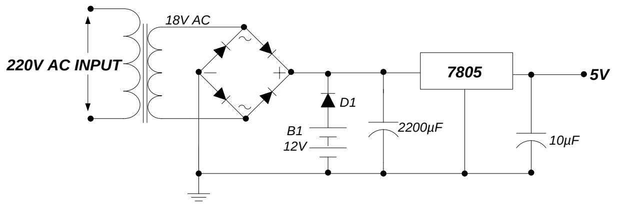

Fig 1: Power supply stage with battery backup.

B. *Power Supply Calculations*

Given:

Secondary Voltage of Transformer $= 18V$

This implies, R.M.S. Secondary Voltage$= 18V$

Maximum Voltage across secondary, $V_m = 18 \times \sqrt{2} = 25.46V$

Peak Inverse Voltage PIV $= V_m \ = 25.46V$

At any instant in the bridge rectifier, two diodes in series are conducting. Therefore, total circuit resistance $= 2r_f + R_L$

Where, $\mathrm{r_f} = \mathrm{Forward Resistance of each diode}$

$\mathrm{R_L} \ = \mathrm{Load Resistance of the circuit}$

From Data Sheet, Diodes $D_1 - D_4$ have a maximum forward voltage drop,$V_f$of $0.7V$ for silicon type and $0.3V$ for germanium type.

Maximum load current, $I_m \ = \frac{V_m}{2r_f+R_L}$ (1)

Mean load current, $I_{dc} \ = \frac{2I_m}{\pi}$ (2)

Power dissipated in each diode $= \ {I^2}_{r.m.s} \times r_f$ (3)

Ripple factor $= \frac{r.m.s.\ value of a.c component}{value of d.c.\ component} \ = \frac{I_{ac}}{I_{dc}}$ (4)

Where,

$I_{rms} = \frac{I_m}{\sqrt{2}}$: $I_{dc} = \frac{2I_m}{\pi}$

$\therefore$ Ripplefactor (forfullwavebridge)

$$= \sqrt{\left\{\left(\frac{\mathrm{I_m}/\sqrt{2}}{2\mathrm{I_m}/\pi}\right)^2 - 1\right\}} = 0.48$$

C. *Smoke Detector Stage*

The smoke detector stage employed optoelectronic means to detect if there is smoke in the room or not. The smoke detector stage was designed as embedded in a smoke chamber (a channel where smoke is outlet). When the visibility in the channel becomes poor then smoke is obviously present in the channel.

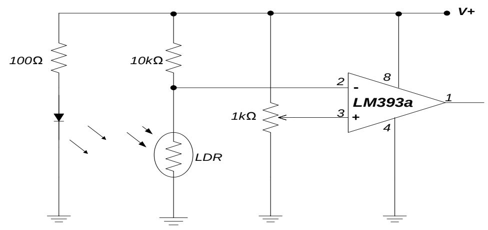

Fig. II: Smoke detector stage

The Light Dependent Resistor (LDR) is the smoke detector or light transducer in this design. As the light intensity reduces (i.e. presence of smoke), the resistance of the LDR increases. In the dark, the voltage input into the inverting input of the comparator used gets higher than the reference voltage set at the non-inverting input of the comparator which makes the comparator to output a LOW. But in bright light, the voltage input into the inverting input of the comparator used gets lower than the reference voltage set at the non-inverting input of the comparator which makes the comparator to output a HIGH.

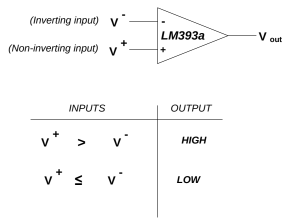

Fig. III: Operation of the comparator

D. *Fire Detector Stage*

The fire detector stage uses a thermistor to monitor the room temperature. The thermistor is a solid state device that has its resistance changing with temperature. The resistance change with temperature is nonlinear, and therefore temperature must be calibrated with respect to resistance. The thermistor resistance decrease with increase in temperature and this would cause a decrease in the voltage input to the non-inverting input of the comparator thereby causing the voltage reference set at the inverting input to be greater. In this state the comparator outputs a LOW, to indicate high temperature (i.e. fire). But when the temperature in the room is normal, the input voltage at the non-inverting input of the comparator is greater than the voltage at the inverting input and thus, the comparator outputs a HIGH.

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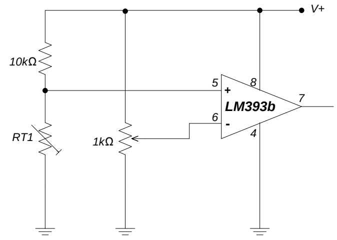

Fig. IV: Fire detector stage

III. INTERFACING THE MICROCONTROLLER TO A MOBILE PHONE

Microcontroller can be interfaced with many different input and output devices. Basic codes are provided for the microcontroller which requires programming in an assembly language code.

A. *Input Device Interfacing*

There are number of switches available, the majority of which have two contacts which are either open (OFF) or closed (ON) in other words it can be in logical level ‘0’ or ‘1’ i.e. high logical state or low level. With ionization chamber, the smoke and fire detection input pin to the microcontroller must be at '0' level, which is the default setting. Sensor is connected to the microcontroller pin input with some software calibrating. The smoke or fire sensor is not linear and so the readings will not change in exactly the same way as with a potentiometer. The resistance changes in value according to its heat. In general there is a larger resistance at linear temperatures. This can be compensated – for in the software by using a smaller range at higher temperatures.

B. *Output Device*

This process of interfacing the microcontroller through USB to communicate with the mobile phone is carried out in order to receive a message from installed mobile phone in the system to another phone numbers processed during the programming. There are various different protocols that can be used for USB communication, and it is important that the mobile phone and the microcontroller use the same settings.

IV. USING THE UART TRANSLATOR

UART stands for Universal Asynchronous Receiver/Transmitter and is the name given to the USB protocol. The USB port was initially developed for connecting a modem to a PC and has other lines that facilitate its connection to the mobile phones. Other lines found on the serial ports are for hand-shaking between the two devices if the data-flow is hardware controlled, as found in the USB to the phone, if data flow is software controlled, the technique is called XON/OFF i.e. 0 and 1 where some set of streams represent the status of the two devices involved in the communication. In this design, XON/OFF approach was used and required on three lines.

1. Receive data (RD); mobile phone receives information sent from the microcontroller.
2. Transmit data (TD); mobile phone send information to another mobile phone.
3. Signal ground-‘ground reference’.

V. RESULT AND TESTING

A. *Transmitter Construction Assemblage*

The various components used in the design were locally sourced from local electronic stores. After gathering all the components needed for this project, the components were assembled according to the circuit diagram on a Ferro-board and were soldered for firmness. The Plate 1 shows the picture of the circuit designed while Table 1, the list of materials used.

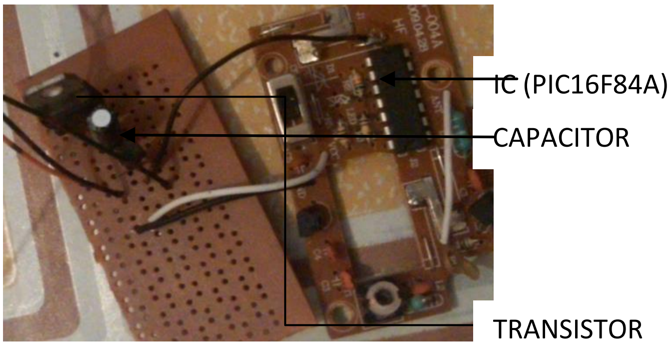

Plate 1: Design Schematic of the transmıtter unıt

Table I: The list of the materials used in the construction of the circuit

COMPONENT	VALUE
Integrated circuit	7805, TX-2B
Resistors	160K,z390,220k,1.5k, 100,33k
Capacitors	230p, 47uF, 68p, 203p, 151p, 103p
Inductors	2.2Uh, 6.8Uh, 10uh
Diodes Zener	3v
Misc	crystal, antenna
Transistor	c945

B. *Receiver Construction Assemblage*

Plate 2 is the picture of the circuitry showing the construction of the receiver assemblage

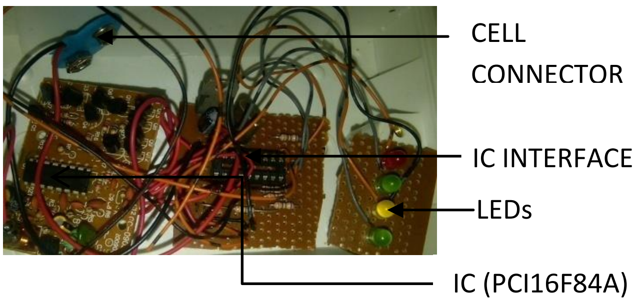

Plate 2 Receiver Node circuit Design

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C. Casing

After assembling the whole circuit and soldering, the circuit was cased in a plastic type double pattress seat, with a white colour and dimension 2 cm x 4 cm x 8 cm. The top part of the case was drilled and the antenna was passed through the hole. The circuit was fixed with the base of the circuit using the bolt and nut. The smoke sensor was attached to the lid of the casing and was held firm with the use of bolt and nut also. Connecting wires from the smoke sensor to the transmitter was passed through a hole made on the lid. Plate 3 shows the picture of the transmitter node package. Plate 4 represents the alert information reaching the designated fire station, calling their attention to the actual node needing rescue or with suspected fire outbreak.

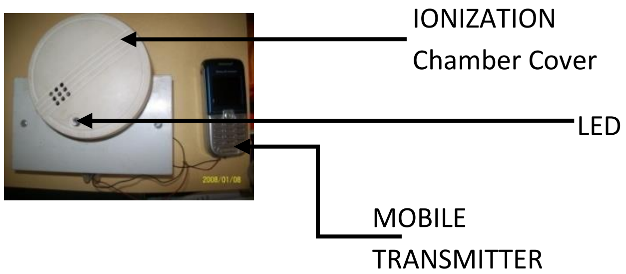

Plate 3: Transmitter Node Package.

Plate 4: Mobile Receiver with Message

D. Testing

After the assemblage, casing, and fixing the peripherals on the system, the testing was carried out to ascertain if proper and expected working condition was achieved. For the testing, A mobile phone, improvised fire scene with matches, paper, 9V Hi-watt battery were the materials used.

The node was taken in tandem and tested, the matches were lighted and applied to the paper, after some time, the light was blown and the smoke was allowed to pass to the sensor. On sensing the smoke by the sensor, the sensor enabled the transmitter and the unit code was sent to the server node. The server node received the signal and sent an intelligent signal to the user phone. The node was powered on battery. The major challenge of this project was that the transmitting range is not too wide in closed enclosed space, necessitating the need for the hardware to be kept as close as possible.

VI. CONCLUSION

The design and construction of a GSM – based Fire Detector System was successfully carried out and tested effectively. The system did not pose extra-ordinary constraint and the components and materials used conform to engineering standard. A close look at the circuit diagram of the smoke detector reveals that all the components used were all locally sourced and available. Also, consideration has been made in the area of cost and size (packaging) compared to other similar designs. In situations where components could not be obtained exactly, standard values closest to be calculated should be chosen so as to obtain optimum degree of accuracy and resolution in the design of the units of this device.

Finally, project design was challenging because it gave an exposure into the practical application of theoretical knowledge in solving problems associated with design and construction most especially in developing countries. Likewise it gave more exposure to fire issues with threatening hazards which has to be urgently attended to in the domestic and commercial environments.

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