

Development of a GSM-Based Smoke Detector and Temperature Monitoring System for Preventing Fire Outbreak

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Abstract:- Fire outbreak is one of the most deadly disasters affecting lives and properties all over the world. It has rendered many people homeless with others completely deformed. Therefore efforts must be geared towards curtailing the disaster. This research depicts the design of a smoke detector and temperature monitoring with microcontroller-based system by utilizing the GSM Module. The utmost aim of this research is for safety where its major importance lies in avoiding the fire accidents or explosion occurrence in households and its environment. It operates using Arduino Uno Microcontroller board in conjunction with ATmega328 chip. The core controller chip utilized is the ATmega328 which controls the household temperature notification subjected to the temperature sensor. A thermistor-based temperature sensor is used in sensing the heat from the fire. A notification message will be delivered to the specified personnel using short message service (SMS) via GSM module. When the system senses the pre-set temperature value or more, it instantly displayed a warning notification on LCD display and simultaneously sends an SMS alert to the users. This research will help users to expand their safety standards by having speedy response so as to prevent fire accidents. This will eventually allow the users to protect their lives as well as properties from the disaster.

Keywords:- Internet of Things, Electromagnetic Radiation, Smoke, Temperature Monitoring.

I. INTRODUCTION

Among the habitually happening disasters in structures, fire flare-up is known to be the most hazardous misfortune that could cause annihilation of lives and properties (Chun-yuan L., 2011 and Faris M., *et. al.*, 2014). Fire calamity is known to be intermittent, dangerous and most powerful misfortune contrasted with different risks. With the quick advancement of metropolitan development, the event likelihood of the incredible fire and other uncommon fiasco additionally expanded step by step. Flames in the early identification and early caution are two significant approaches to extinguish the fire quickly and stay away from extraordinary setbacks and property misfortune. Subsequently, the condition of setting clever alarm framework is significant inside structures particularly in the structures where numerous individuals live or important

assets are kept (Elbehairy H., 2012; Sen K., *et. al.*, 2015 and Mori H., 2016).

With the progression of human development, fire-wellbeing has been a superb concern. Fire dangers can be lethal and criticizing for industrial and household security, also forbidden for human existence. The most ideal approach to decrease these misfortunes is to react to the crisis circumstance as fast as could really be expected. Due to these stated reasoning, there comes the need of standalone autonomous fire detection systems. In a deadly circumstance, early recognition and quicker alarm will yield lesser misfortunes of property and life (Li *et. al.*, 2012). A fire or smoke alert system can be observed locally in the premises, or distantly at an inaccessible spot according to necessity.

The Internet of Things (IoT) is a new correspondence perspective that imagines a near future, where the objects of regular daily existence will be equipped with microcontrollers, transceivers for digital communication, and reasonable convention stacks that will make them ready to speak with each other and with the clients, turning into an indispensable piece of the Internet. The IoT idea subsequently, targets making the Internet much more vivid and unavoidable. Moreover, by empowering simple access and connection with a wide assortment of gadgets, for instance, home appliances, cameras, monitoring sensors, displays, vehicles, etc, the IoT will develop the headway of different applications that use the conceivably tremendous amount and grouping of data made by such gadgets to offer new sorts of help to occupants, associations, and public associations. This perspective for sure discovers application in a wide range of areas, like home mechanization, modern robotization, clinical guides, versatile medical care, car, traffic managee, and numerous others (Valan M., *et. al.*, 2013; and Valan M., *et. al.*, 2014).

II. METHODOLOGY

A. Basic Block Diagram of a GSM-Based Smoke Detector and Temperature Monitoring System

The development of GSM based smoke detector and temperature monitoring system mainly consists of Flame sensor, Thermistor based temperature sensor, GSM Module, buzzer, DC power supply and components such as transistors, capacitors and switch as shown in Figure 1.

When the operation of the system begins, the temperature sensor and the flame sensor will keep sensing the surrounding temperature and the presence of smoke. Whenever there is rise in room temperature i.e. the temperature values goes beyond the threshold value of the specified temperature programmed in the code, the pin to which the buzzer is connected becomes high and produces sound. The microcontroller on the Arduino UNO board will command the GSM module to transmit alert message according to the software code uploaded into the microcontroller to the user, a SMS will be delivered right away to the specified personnel to inform the personnel about the existence in the increase in the temperature of the household and to the authorized personnel. The proportional output signals from either the smoke detector or the temperature sensor transmits a proportional analogue signal to the microcontroller which will transform the proportional output signals into processed data. The processed data will be displayed on the Liquid Crystal Display (LCD) and it displays the temperature. When the temperature reduces below the threshold value or when the smoke detector is not sensing any smoke, the signals become low and the normal condition is displayed on the LCD.

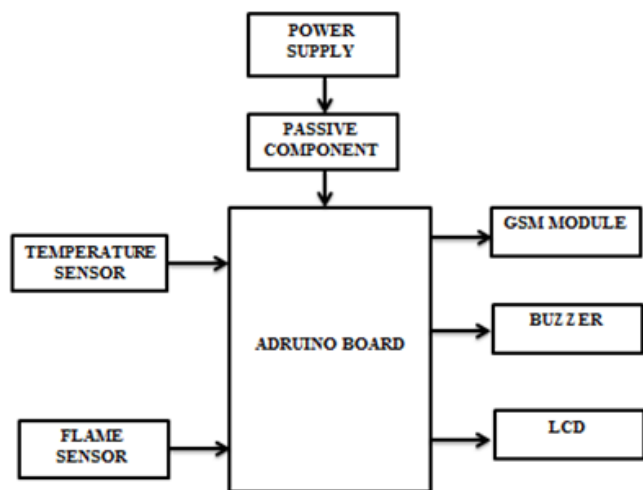


Figure 1: Basic Block Diagram of Instrument

B. Sensing unit: Temperature, flame sensor and the software development

i. Temperature

The thermistor based temperature sensor is categorized under the Thermo-resistive temperature sensors which utilizes an NTC thermistor for measuring temperature. They are resistors whose resistance value changes with change in temperature. The sensor is capable of reading temperature in the range of -55 to $+125^{\circ}\text{C}$ with an accuracy of $\pm 0.5^{\circ}\text{C}$ with an operation voltage of 3.3 V and 5 V operation. To get the temperature value, Steinhart-Hart equation could be utilized.

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{B} * \ln\left(\frac{R}{R_0}\right) \quad (1)$$

If the voltage from source voltage divider and the V_{ref} are the same, you don't need to calculate R_0 or find R to estimate the temperature. Writing the equation for the thermistor resistor in terms of ratio of ADC values;

$$R = R_0 \left(\left(\frac{adc\ Max}{adc\ Val} \right) - 1 \right) \quad (2)$$

Then,

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{B} * \ln\left(\frac{R_0 \left(\left(\frac{adc\ Max}{adc\ Val} \right) - 1 \right)}{R_0}\right) \quad (3)$$

R_0 cancelled out, which leaves;

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{B} * \ln\left(\left(\frac{adc\ Max}{adc\ Val}\right) - 1\right) \quad (4)$$

Taking the reciprocal of the result to get the temperature in kelvin;

$$T = T_0 + B * \ln\left(\left(\frac{adc\ Max}{adc\ Val}\right) - 1\right) \quad (5)$$

The value of T in equation 3.4 gives the temperature value of the environment in Kelvin (K)

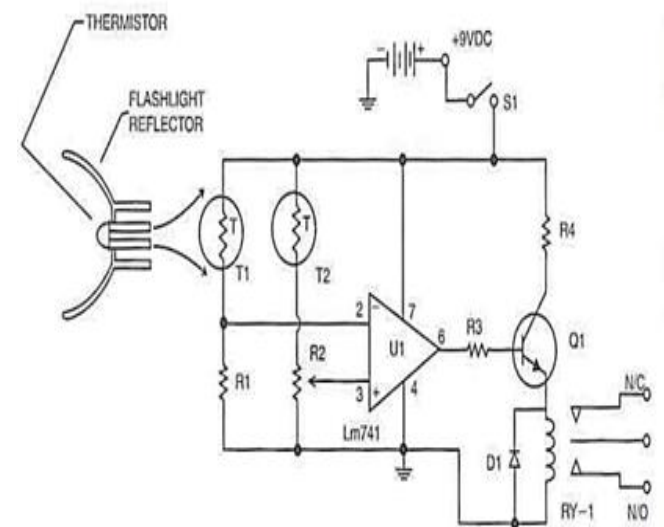


Figure 2: circuit diagram of the Temperature sensor

ii. Flame sensor

The flame sensor comprises of an electronic circuit with an electromagnetic radiation receiver. They use the IR flame flicker technique, which permits the sensor to operate through a layer of oil, water, vapor, dust or ice. They are activated when they receive electromagnetic radiation from one or more define wavelength according to their design in the UV or infrared spectrum.

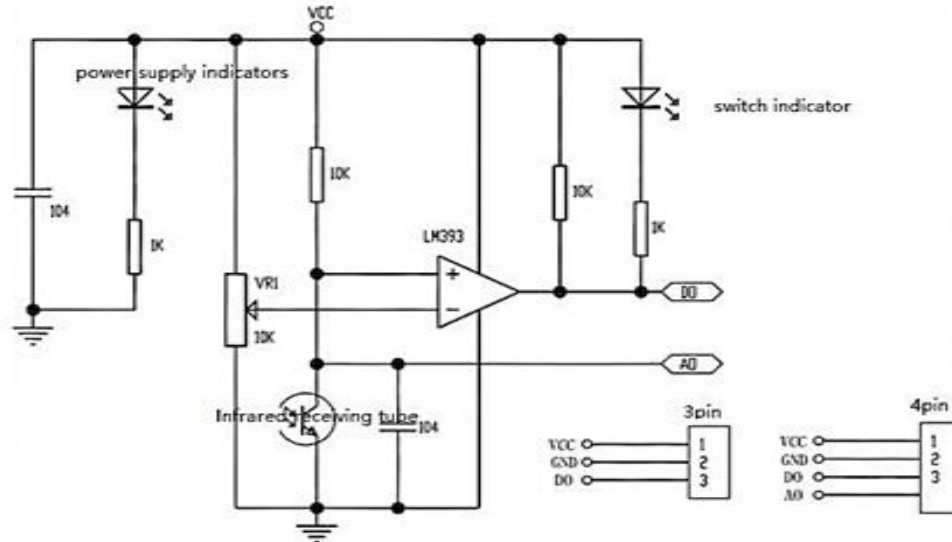


Figure 3: circuit diagram of the Flame Sensor

iii. Software development

The software utilized in this research is based on the flow chart in figure 4. When the system begins, the thermistor based temperature sensor will consistently detect the encompassing temperature. Whenever there is rise in temperature, thermistor based temperature sensor can detect the temperature value instantly. At the time when the temperature reaches 40°C or above, microcontroller on the Arduino UNO board will command the GSM module to send a notification SMS to the specified personnel. Value of temperature limit that can trigger the thermistor based temperature sensor can be altered in the programming code upon request by the specified personnel. The limit is not constrained to any value since the thermistor based temperature sensor sensitively detect the encompassing temperature with regards to the temperature range it can count (- 55°C to +150°C). During blistering climate in Nigeria, the temperature can reach up to practically 38°C. Consequently, the limit temperature to be distinguished; 40°C is definitely agreeable in accordance to the Nigeria’s weather. Figure 4 and 5 illustrates the flow chart of the GSM based smoke detector and temperature monitoring system and the pseudo codes it represents for the project respectively. By referring to both figures, the complete program can be executed in Arduino IDE software.

START

```

IF TEMPERATURE >= 40 DEG
  GSM ACTIVATED
  SEND SMS TO USER
  DISPLAY "FIRE ALERT!" ON LCD
  DISPLAY
ELSE
  CHECK TEMPERATURE AGAIN
    
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Figure 5: Pseudo code for the GSM based smoke detector and temperature monitoring system established from the flow chart

III. TESTING AND EXAMINATION

Performance of the Developed Instrument

The developed GSM-based smoke detector and temperature monitoring system performance evaluation was also carried out. The soldering iron was plug to a socket with 220 V and the temperature of the soldering iron was monitored. The hot soldering iron was brought close to the sensor. As the temperature rises beyond the threshold value, the thermistor based temperature sensor was set triggered which activates its analog pin on the microcontroller. As the microcontroller receives a proportional signal from the thermistor-based temperature sensor, then in turn activates the GSM module to be online. The GSM module sent message to the phone number(s) inputted in the programing code. Likewise for the flame sensor, pieces of paper were set on fire. The flame from the pieces of paper was brought closer to the flame sensor and the result carried out was the same. The developed instrument was programmed to detect “IF” the temperature of the environment goes beyond the threshold value “OR” the presence of flicking flame, at least one condition among the two conditions should be met before it should trigger the GSM module to send SMS to the appropriate personnel. Limited examination was established to observe the system’s response. The examination established was applying heat near to the thermistor based temperature sensor. Figure 6 shows the condition which the

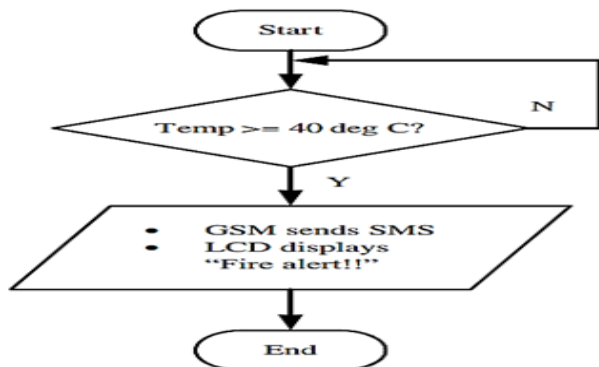


Figure 4: Flowchart of the GSM based smoke detector and temperature monitoring system

thermistor based temperature sensor is in ready mode to detect fire. Figure 7 reveals the SMS received by the specified personnel when there is increase in the encompassing temperature as notified by the system. Figure 8 shows when the thermistor based temperature sensor detects fire and a notification message appeared on the LCD display. While figure 9 displays the situation after the fire expunged



Figure 6: When the thermistor based temperature sensor is in ready mode to detect fire.

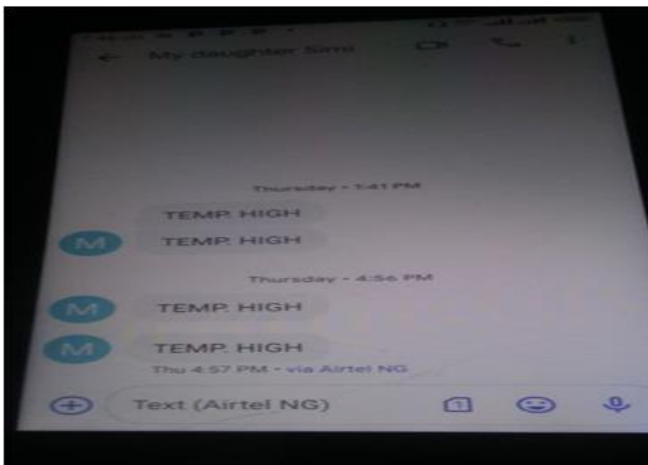


Figure 7: SMS received by the specified personnel when there is increase in the encompassing temperature as notified by the system



Figure 8: When the thermistor based temperature sensor detects fire and a notification message appeared on the LCD display



Figure 9: Displays the situation after the fire expunged.

IV. CONCLUSION AND RECOMMENDATION

i. Conclusion

In conclusion, the GSM-based Smoke detector and Temperature monitoring system developed shows good response and the performance excellent. It is a low-cost and medium coverage method of identifying, alarming and controlling fire and fire related incidents in the household. The unpredictable situation or critical situation could occurs in the household without the personnel’s’ notice. It utilizes a natural innovation and exploits SMS abilities to accomplish its proposed objective viably. This system would save cost, provide reliable services and instantly alert to the personnel in charge, thereby reducing (or even eradicating) loss of lives and property. Its applications range from the normal family setting even to huge modern conditions, presenting enormous adaptability. The capacity to distinguish warmth or high temperature is verifiable on account of the utilization of thermistor based temperature sensor in this research. This gadget can be applied in changed zones because of its adaptability and straightforwardness in dealing with houses, offices, schools, dormitories, lodging ventures, plants, vehicle businesses and a lot more territories which are identified with the group, individuals or valuable things. Users can simply apply the device in their interested area to protect the area from the existence of fire. At whatever point the temperature arrives at the cutoff (40°C), the gadget will quickly caution the specified personnel by sending a notification message via GSM. This will cause the clients to get mindful of the hazardous circumstance and can without much of a stretch keeps it from occurring by fast anticipation (use fire douser, call fire fighters and so on)

ii. Recommendation

After carrying out this research work, the following recommendations were made based on the limitations encountered during the implementation face of the study.

- Multiple sensors could be incorporated purposely to cover more extensive region, or sensor with higher reach inclusion could be created with the end goal of the research work.
- Fire sealing the framework would be prescribed to forestall harms to equipment parts.

- A better and less harming strategy could be executed towards quenching fire and controlling fire occurrences

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