

RF Based Advance Smart Fire Safety System for Industries and Shopping Malls

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Abstract: *The objective of the paper is to design a model system to detect the fire hazard and performing the respective action to ensure the safety of industrial people and extinguish the fire. The environmental condition of the industry was continuously monitored with help of flame sensor then it will be transmitted by using encoder and RF transmitter. Transmitted signal will be received by RF receiver then processed with help of a decoder and arduino controller. When the fire is sensed by the system such time following emergency actions take placed by the system such as kindle the fire alarm, opening the emergency exit doors in an automatic manner, send the fire hazard alert to near fire station by using GSM technology and actuate the water pump to extinguish a fire from the ceiling nozzles by precipitating the water after the defined time delay. Where LCD display also implemented with the proposed system to show the current situation of the industry. The most advantage of RF communication is effective, noise-free and which reduce the number of cables and filters. So, this project is prepared for the protection against a fire hazard in industries and shopping malls. Which is one of the methodology to achieve smart industrial safety system from the conventional safety system.*

Keywords: RF transmitter and receiver, Flame sensor, Controller (ARDUINO UNO R3), Liquid crystal Display (LCD), Global System for Mobile communication (GSM/GPRS), Door actuator and Water pump

1. Introduction

Nowadays, industries meet severe problems due to fire because of less awareness about the flammable elements. Industrial fire occurs due to short circuits in power lines, dynamic part of the machinery and temperature condition of the environment. A small spark is enough to produce a severe loss in thread industries, cotton mills and silk shops. Identifying the fire is the most important action in industries and also performing the essential actions like actuating the alarm, clear the workers from the fire zone and extinguish the fire is much time taking process in industries. In common approach many industrial emergency doors are in closed condition and which all are actuated manually. It is the most drawback in a conventional industry safety system to clear the workers from the firing place and making the way to enter the firefighters into the respective area (fire block). Conventional fire safety system has a limited facility such as actuating the alarm only. Which don't have the ability to perform the respective actions to ensure the safety of the workers and extinguish a fire in the respective zone. So, the objective of this smart fire safety system ensures the safety of works from fire hazard, provide the way to exit the workers from the firing zone and extinguish the fire in the respective zone with help of firefighters. If the fire is severe such time water pump was actuated to precipitate the water from the ceiling of the zone after disconnect the power supply from the zone with help of a relay or contactors.

2. Related work

A fire is a chemical reaction of carbon-based material that mixes with oxygen and is heated to a point where flammable vapors are produced. These vapors then come in contact with something that is hot enough to cause vapor ignition and results in a fire and its occurrence is random. Industry, home offices, hospitals etc. are very much vulnerable to fire that has the potential to cause harm to its occupants and severe

damage to property [1]. K. Suryadevara discussed the WSN based smart sensors and actuator for power management in intelligent buildings [2]. The other solution using wireless sensor network for fire hazard detection and monitoring was proposed by Elias et al. [3]. In this system, a wireless sensor was embedded in a micro-controller board and controlled the fire monitoring system. Furthermore, few solutions were proposed utilizing the high-end computing systems to monitor fire hazard. The detection of fire hazards, on the other hand, can lead to unnecessary false alarms that can be very expensive if the occurrence happens in a commercial building. As well, false fire alarms have been a nuisance to the fire department and cause tie-ups in resources and needless commotion that leads to panic [4]. The major characteristics of fire are it extends exponentially with time. Hence, timely detection of fire is critical for avoiding a major accident. Hence, the essence of having a sophisticated fire alarm and monitoring system is quite obvious [5]. Wire Less Sensors (WLS) have gained popularity because they have a variety of uses in different applications, such as target tracking [6]. WLS is also used in collecting data and monitoring both autonomously or with the help of users [7].

3. Block diagram and Description

Here each unit of the system will be classified according to the performance of the parts of a system such as a sensor unit, control unit, operational unit. The overall block diagram of the system shown in Figure (1).

3.1 Sensor Unit

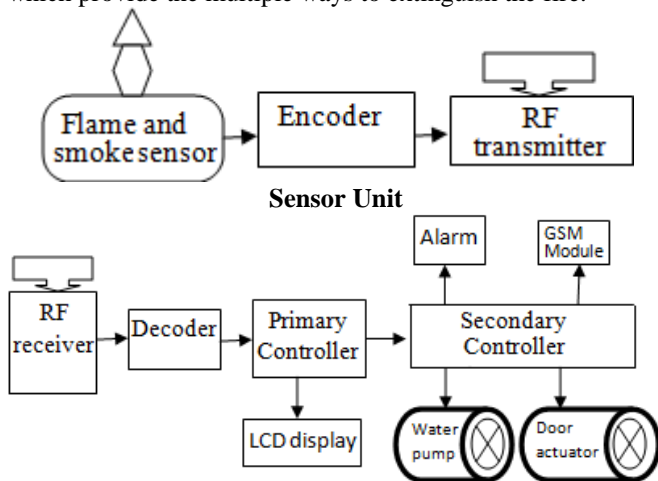
The flame sensor is used to detect the fire. It is very sensitive to the flame and radiations. Sometimes the smoke sensor is coupled with a sensor unit. The measured value of the environment is transmitter around the area by using RF transmitter (433MHz).

3.2 Control Unit

Control unit has an RF receiver (433MHz), decoder and two controllers (ARDUINO UNO R3). Which are named as ‘Primary controller’ and ‘Secondary controller’ depend upon their functions. Primary controller is capable of processing received signal, fire detection, LCD display control and fed the current information to Secondary controller. Secondary controller is used to driving the operational unit which has a fire alarm, GSM module, water pump and emergency door control. The RF communication has reduced the risk of noise and harmonics. So the computation process is easy and more accuracy.

3.3 Operational Unit

The operational unit is used to execute the required actions against the fire hazard. It has following components such as fire alarm, GSM module, door actuator and water pump. When the fire is identified by the system such time following actions take place kindle the fire alarm, opening the emergency exit doors in an automatic manner, send the fire hazard alert to the near fire station by using GSM technology and actuate the water pump to extinguish a fire from the ceiling nozzles by precipitating the water. The proposed automatic door actuating mechanism used to clear the workers from the fireplace without clash between them and which provide the multiple ways to extinguish the fire.



Control and Operational Unit
Figure 1: Block diagram of the system

4. Existing Methodology

Fire hazard is the most important problem in industries. So each industry has fire and safety department to ensure the safety of the overall industry. And also some automated system also implemented in the industries for continuous monitoring purpose. Here, the proposed system has a flame sensor/smoke sensor to detect the fire and RF transmitter for transmitting measured value around the area. The RF receiver and decoder are coupled with a control unit to know the information about the industry to control unit. If no fire symptom is detected by the sensor unit such as time fire alarm, GSM module, door actuator and water pump isn't activated by the control unit. In this condition, the system shows ‘NO FIRE’ in the LCD display by the action of

Primary controller. If the fire symptom is detected by the sensor unit, at the time control unit compares the measured value with the predetermined value. When the measured value is greater than the predetermined value such time primary controller shows ‘FIRE HAZARD’ in LCD display and kindles the secondary controller. So, the secondary controller activates the follows components such as fire alarm, GSM module and a door actuating system. Where alarm is used to make awareness about the fire, door actuator is used to open the emergency exit doors of the respective zone which is a useful one to clear the workers from the fireplace without clash between them and GSM module is used to send a fire hazard message to a near fire station. Which message contains the following information such as Name, Register number and location of the company.

After executing the above mentioned technological actions the system waits for some minutes. Then again checks the flame sensor output (Measured value) with a predetermined value. If there are no changes in measured value such time electrical power supply to the respective area will be interrupted by the action of relay and contactors. After the interruption of power supply, the water pump is activated by the system to precipitate the water from the ceilings for extinguishing the fire. This water precipitating methodology not suitable for all industries because due to the constraints of this methodologies. Some time water act as the accelerator for fire when it reacts with some chemicals. For example when water reacts with liquid a hydrocarbon such time water accelerates the fire. If no problem about water precipitating methodology in the industry, it is one of the most useful methodologies to extinguish the fire. We need an auxiliary power supply to drive the overall system. The overall function of the proposed system shown in figure 2.

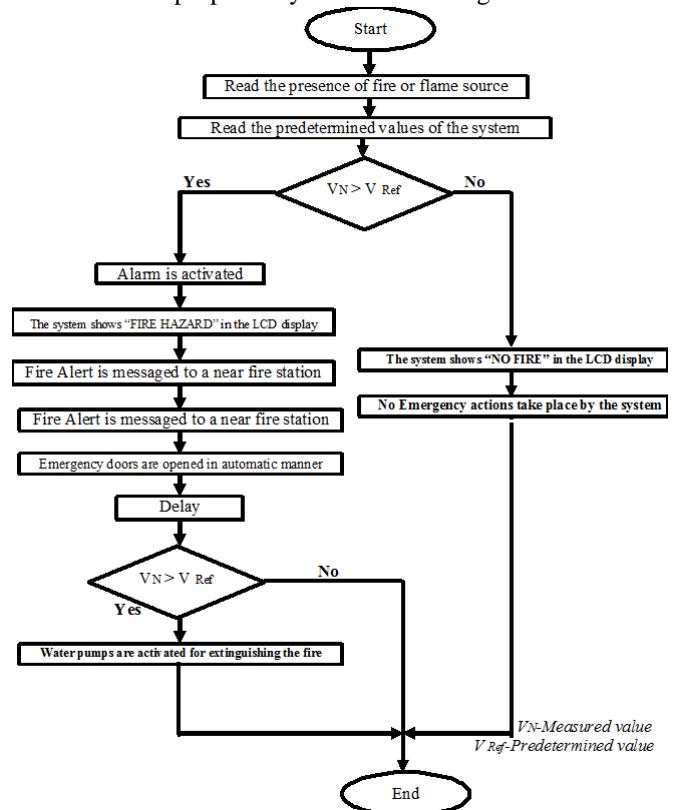


Figure 2: Flow chart representation of the system

5. Proposed Automation System

The Proteus 8 software is used to simulate the proposed idea of the system. Here the performance of the system classified according to the output of the flame sensor as follows

- No fire issue condition
- Fire issue condition

5.1 No fire issue condition

If no fire issue in industry such time flame sensor output is in negative logic. So measured value of the system is less than a predetermined value. Measured output of a flame sensor shown in figure 3.



Figure 3: No fire issue condition flame sensor output

In this condition, the measured value is in negative logic. So, the transmitted all the binary bits are equal to zero. Which is clearly shown in the following RF transmitter and receiver module simulation diagram 4. Here led D1 is the reference to ensure the performance of the RF communication.

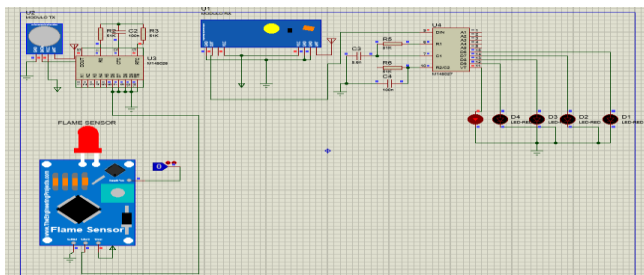


Figure 4: No fire issue condition RF transmitter and receiver communication diagram

We know that measured value is less than a predetermined value. So the primary controller shows “NO FIRE” in LCD display and transmits negative logic to the secondary controller. At this condition, the secondary controller isn’t activate the following parts of the system such as fire alarm, GSM module, door driving system and water pump. So the system does not send fire detection message to the near fire station and emergency doors are in closed condition (Refer a position of the rotor in the following diagram). The overall performance of the system is clearly shown in the following figure 4.

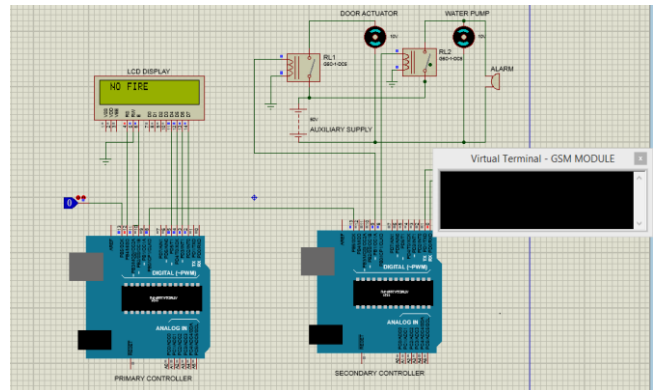


Figure 5: Simulation diagram for no fire issue condition of the proposed control and operational unit.

5.2 Fire issue condition

If the fire issue takes place in the industry such time flame sensor output is a positive logic. So measured value of the system is more than a predetermined value. The measured value of the flame sensor output shown in figure 6.

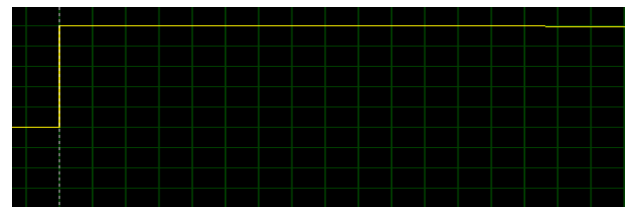


Figure 6: Fire issue condition flame sensor output

In this condition, the measured value is in positive logic. So, the transmitted all the binary bits are equal to one. Which is clearly shown in the following RF transmitter and receiver module simulation diagram 7. Here led D1 is the reference to ensure the performance of the RF communication.

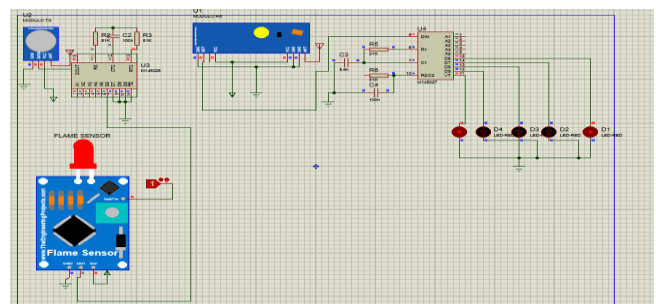


Figure 7: Fire issue condition RF transmitter and receiver communication diagram

In this event, we know that measured value is greater than a predetermined value. So the primary controller shows “FIRE HAZARD” in LCD display and transmits positive logic to the secondary controller. At this situation, the secondary controller activates the following parts of the system such as fire alarm, GSM module, door driving system and water pump. Simultaneously fire detection message is sent to the near fire station. Which message contains industry name and location detail. Here emergency exit doors are in open position (refer the rotor position of the door actuator). Performance of the system for this situation is clearly shown in figure 8.

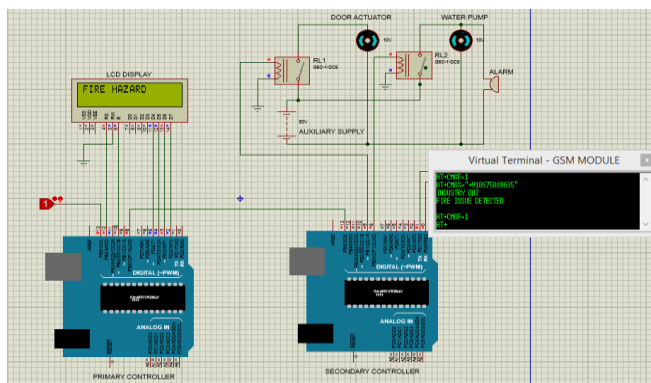


Figure 8: Simulation diagram for fire issue condition of the proposed control and operational unit

Due to this automated door actuation system risk in clearing workers from the fire area will reduce and which provide the multiple ways to firefighters to enter the respective zone. When the fire maintains more than the predefined time delay such time water pump become to action to extinguish the fire. Before implementing this water pump technology we ensure that which suitable or not.

Which system has the following constraints:

- We need an auxiliary power supply to drive the overall proposed system.
- We need to protect the overall proposed system from the fire. So we need inflammable and high fire-resistive materials to ensure the safety of the system.

6. Advantage of this Approach

- Cost is less for both implementation and maintenance.
- This technology ensures the safety of the worker in industries.
- The fire alarm is used to make awareness about the fire to workers.
- RF communication is effective and noise-less. Which reduce the number of filters in the data communication.
- This automated door actuating technology prevents the clash between the workers at emergency situations.
- Water precipitating a methodology is a suitable idea in many industries.
- GSM technology is the time-saving thing to contact a near fire station.
- It is more compact, simple and user-friendly.
- We can achieve a strong signal by adding additional antenna with the GSM module.
- Better performance and accuracy of the system can be achieved by adding more sensors to the proposed system.
- The LCD display was used to shows the current situation of the industry.
- Arduino controller is the most popular, effective and cheapest one.
- Arduino IDE language is used to program the controller. Which are an open source and most advanced one.

7. Conclusion

This paper is prepared to achieve an advanced smart fire safety system from the conventional fire safety system. Here proposed a methodology of fire safety system ensures the industry and workers safety. This smart fire safety system is economical, simple, efficient, compact, fast and user-friendly. Automatic door actuating system and water pump methodology is the most useful thing for industries. Using GSM to send the alert message to a near fire station is most suitable, wide availability, good coverage, and being cost effective. Automated water pump methodology is a new thing for industries to extinguish the fire at the sever fire situation. I hope proposed all the methods are effective and more suitable to achieve the smart fire safety system.

References

- [1] Schmidt-Rohr, K. "Why Combustions Are Always Exothermic," Yielding About 418 kJ per Mole of O₂. *Journal of Chem. Educ.*, vol. 92, no. 12, 2094–2099, 2015.
- [2] N. K. Suryadevara, S. C. Mukhopadhyay, S. D. T. Kelly, and S. P. S. Gill, "WSN-Based Smart Sensors and Actuator for Power Management in Intelligent Buildings," *IEEE/ASME Transactions on Mechatronics*, vol. 20, no. 2, pp. 564–571, 2015.
- [3] Manolakos, E. Logaras, E. Paschos, F. "Wireless Sensor Network Application or Fire Hazard Detection and Monitoring," *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, 29:1-15, 2012.
- [4] M. Ahrens, "False Alarms and Unwanted Activations from U.S. Experience with Smoke Alarms and other Fire Detection/Alarm Equipment," *National Fire Protection Association*, Quincy, MA, November 2004.
- [5] Morris, S. E., Moses, T.A. "Forest Fire and the Natural Soil Erosion Regime in the Colorado Front Range," *Annals of the Association of American Geographers*. vol 77 (2), 245–254, 1987.
- [6] [Li, W.; Zhang, W. "Sensor selection for improving accuracy of target localisation in wireless visual sensor networks", *IET Wirel. Sens. Syst.* 2012, 2, 293–301.
- [7] Morris, S. E., Moses, T.A. "Forest Fire and the Natural Soil Erosion Regime in the Colorado Front Range," *Annals of the Association of American Geographers*. vol 77 (2), 245–254, 1987.
- [8] Li, W.; Zhang, W. "Sensor selection for improving accuracy of target localisation in wireless visual sensor networks", *IET Wirel. Sens. Syst.* 2012, 2, 293–301.

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