

Fire Detection and Alerting System for Train Using Zigbee Communication

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Abstract – One of the most dangerous accidents in the world is a train accident. It is difficult to eliminate this accident. But it is possible to prevent those accidents using new innovative technologies. This paper, combines operation of an extinguishing system and a communication system using wireless communication. Several units are installed in each railway compartment. Each unit consists of a Humidity sensor, Temperature sensor, Smoke sensor, Flame sensor and GSM module along with an ATMEGA328 microcontroller. The possible ways to extinguish the fire is using a fire extinguisher and switching ON the water sprinkler system. When fire is detected it will give an alert to the nearby compartment and loco pilot Using ZIGBEE communication. Units in other compartments receive notification alerts so that the people may escape from the fire accident. Additionally, the detachment of the train compartment is carried out using ZIGBEE wireless communication.

Key Words: Train Accident, Zigbee Communication, Arduino, Alerting System, Fire Accident, Accident Prevention

1. INTRODUCTION

One of the most serious types of accidents is a train accident. It gives a risky life for both passengers and loco pilots. Hence, it is necessary to take safety precautions in the railway's department. One of the recent popular accidents in train is fire accidents in compartments. Recently, it has been very common news heard in the newspaper. If one compartment in the train gets fired, then the fire will travel to all compartments very faster. So it is necessary to take quick action to extinguish the fire before it completely spread. This may cause huge disasters and financial risks. After the huge fire accident, many technologies have been under research to extinguish the fire. In this paper, a system is proposed with eliminating fire using Arduino and ZIGBEE communication technologies. Using several sensors like humidity sensors, temperature sensors, smoke sensors, and flame sensors, It is easy to detect the fire in compartment. The reason for the fire accident may be a man-made activity or due to electrical short-circuit. There will be fire-detecting units in each compartment. That unit consists of Arduino UNO, GSM Module, and four sensors and ZIGBEE module.

Humidity sensors detects the moisture level changes in the particular compartment. The flame sensor detects the heat and any extreme flame that occurs due to fire. A smoke sensor detects the smoke coming from the fire. The temperature sensor updates the changes in the temperature. Whenever these sensors detects abnormal conditions, it automatically turns ON the fire extinguisher ball and then it will send the SMS to a nearby compartment as well as to the loco pilot. This system also has a detaching mechanism. This will prevent the fire caught into the other compartments. When sensors give high output, extinguishing will happen. If the fire is not quenched it will activate the sprinkler system in the train. At the same time, the DC motor will activate to separate the train compartment to avoid fire accidents. Once the fire is detected, microcontroller also sends a message to the loco-pilot of the train and nearby fire station using the microcontroller.

2. PROPOSED SYSTEMS

In this system, the microcontroller Arduino UNO controls the overall operation. The microcontroller gets all the input signals from the input components like the smoke sensor, Flame sensor and Temperature and Humidity sensor. It checks for the appropriate conditions to be met if it is a fire accident. The Output components comprise GSM (Global System for Mobile Communication), and LCD is used to warn the loco pilots with details of the compartment. The idea of a fire extinguishing system is to install 'units' in the compartments of the train. Each unit contains sensors like a Flame sensor, smoke sensor, temperature and humidity sensor. The sensitivity of the sensor is adjusted accordingly. When there is a fire accident, initially either the temperature, humidity, flame sensor or the smoke sensor goes high i.e. it gives 5V as output. So, when there is detection in any of the sensors, the microcontroller receives 5V from the sensors. Using the sprinkler placed on the top of the train it will extinguish the fire and the safety box consists of AFO (Auto Fire Off) extinguisher ball, 5V relay will open the closed box, and it will be easy for the passenger. The fireball should be thrown onto the fire correctly so that it will extinguish the fire.

3. METHODOLOGY

This paper is completely based on GSM communication, Zigbee communications and Arduino microcontroller. All the sensors have some pre-fixed value which is the threshold value. If it exceeds the value, the sensor will automatically send the signal to the microcontroller to do some specific tasks, here it will turn the fire extinguisher ball first and the water sprinkler system. The GSM communication is the interface between the user and alerting system. Whenever it detects any abnormal activity it will send an SMS to the user. ZIGBEE communication is a transmitter and receiver model which is used to communicate with the loco pilot and the other compartment. There will be an Arduino microcontroller which is already programmed with software called Arduino IDE. Using the Embedded C language, the whole program was written. Using the AT commands the user can receive the SMS from the GSM module. The detached mechanism will activate if there is a serious fire that spread to the nearer compartments. Four sensors like flame, humidity, Temperature, and gas sensors were used.

4. BLOCK DIAGRAM

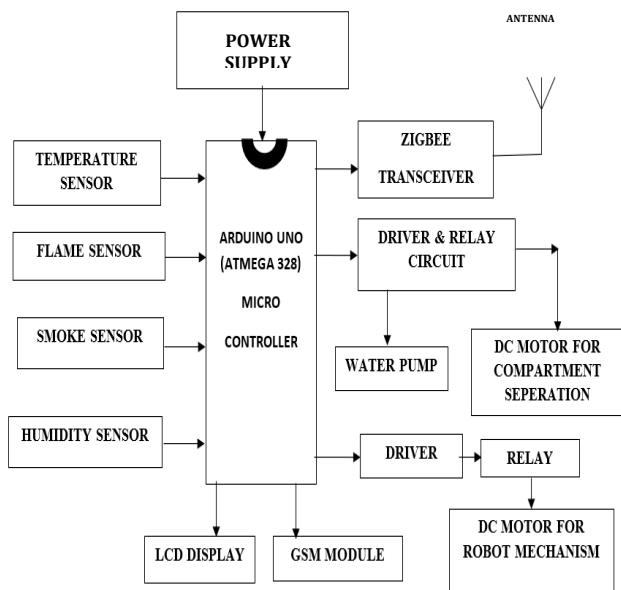


FIG-1: Transmitter Node

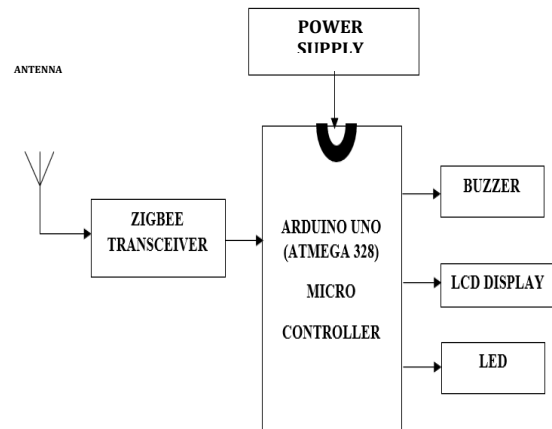


FIG-2: Receiver Node

Figure 1 and 2 represents the block diagram of the transmitter node and receiver node respectively. Here ATMEGA Arduino UNO is used as a microcontroller. Four sensors namely temperature, flame, smoke, and humidity sensor used. It will detect the conditions and update them to the microcontroller. There will be some mechanisms like water compartment separation. Using a 12 V DC motor the other compartment will be separated. The sprinkler system will be turned ON using the 12v DC water pump. These two mechanisms were controlled by using the relay driver circuits. The LCD will be interfaced with the microcontroller. It is used to display the values received by the sensors. There will be a separate DC motor for controlling the forward-moving mechanisms. The Zig bee module has both the transmitter and receiver in it. Every compartment has this module to transfer the message and build communication.

In the receiver node, The ZigBee transceiver receives any abnormal messages and sends it to the microcontroller to turn ON the alert using a buzzer and LED. Here, separate power supply is used for all the units in this system. This alert is also sent to the loco pilot of the train.

5. HARDWARE IMPLEMENTATION

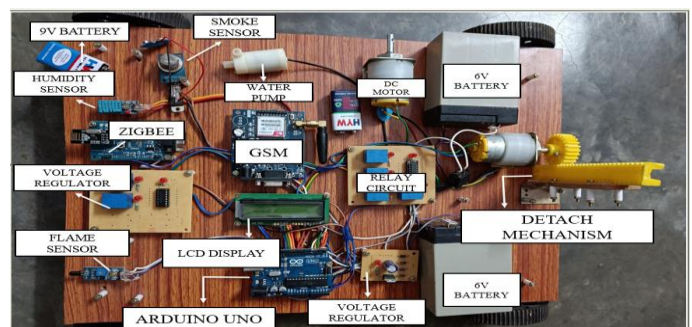


FIG-3: Transmitter Unit

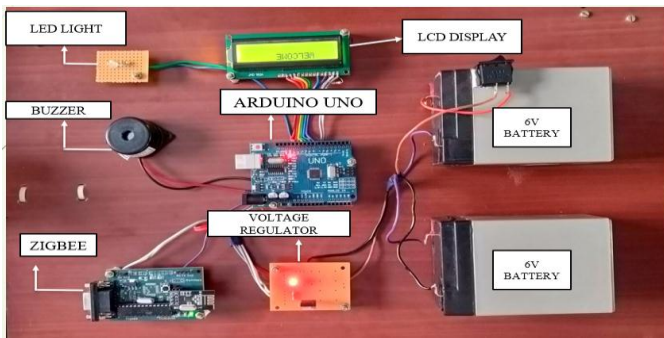


FIG-4: Receiver Unit



FIG-6: DC Motor (Fire Extinguisher Ball)

The proposed approach is based on GSM communications. The hardware setup has shown in Fig. 3 and 4. The kit is given a power supply by two separate 6-volt batteries. A voltage regulator IC is used to regulate the 12V to 5V supply to the Arduino microcontroller. When unit is powered ON, the DC motor keeps the Train unit moving forward. Two DC motor is used for the forward mechanism. Three channel relay is used for the forward mechanism, water pump and fire extinguisher ball. When the sensor detects the flame, smoke, temperature and humidity abnormally, it will send SMS automatically to Loco Pilot by GSM communication. It makes the fire extinguisher ball open from the box and it extinguishes the fire. The water pump is also used for extinguishing the fire.

A Fire extinguisher ball is a sphere-shaped product made of a waterproof plastic shell filled up with harmless environmentally friendly nontoxic chemical powder. The ball self-activates within least 3 seconds of contact with the fire. Fire extinguishers use a chemical substance that can easily cool the flame area. A portable fire extinguisher removes the fire that has taken place inside the train compartment.

The detaching mechanism is used to separate the train compartments.



FIG-7: Forward Mechanism

They are two DC motors for moving the unit in forward direction The mechanism is working by 12V DC motor it is 30 RPM motor is used to control that mechanism. ONE channel relay is used to control the move forward by operating the 12V DC motor.

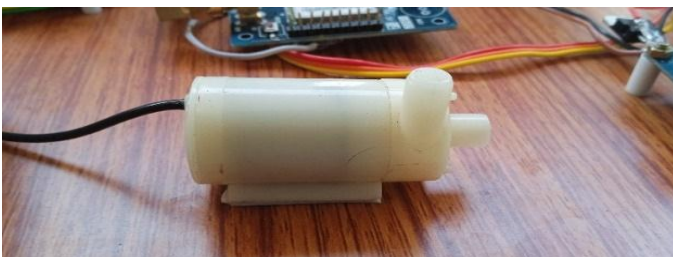


FIG-5: 12 V DC Water Pump

The 12V DC water pump is controlled from ARDUNIO. The sprinkler system will detect the fire to initiate within a few minutes. One channel relay is used to control the Dc water pump. When it gets a signal from the microcontroller, automatically the sprinkler systems opens the water by the DC water pump.

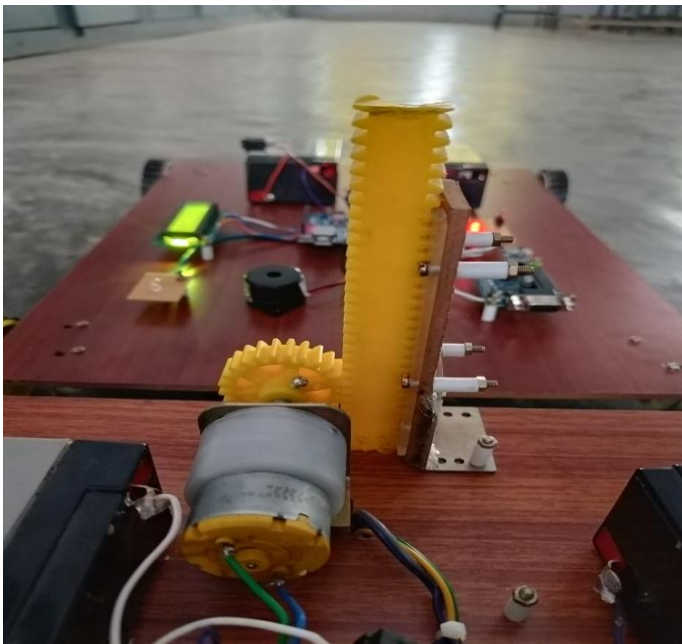


FIG-8: Compartment Separation Mechanism

In Figure 8, the compartment separation mechanism is shown. A 12V DC motor is used to separate one compartment from another. A gear wheel is coupled with the DC motor which is used to separate the other unit.

6. RESULTS

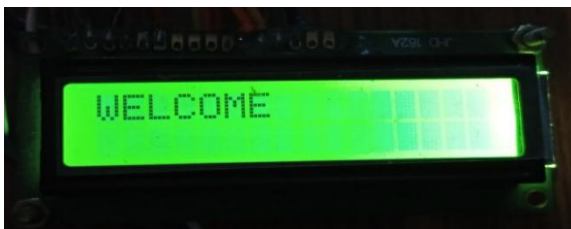


FIG-9 Welcome Message

When the unit is powered ON, the LCD shows the message "WELCOME" shown in Fig. 9. After that, sensor automatically starts to sense the flame, humidity, fire and temperature.



FIG-10: Value of Sensors

In Figure 10 LCD displays the values of sensors. "T" represents the current Temperature. "F" represents the

reading of the Flame sensor. "H" represents the reading of the Humidity sensor. "G" represents the Gas.

By utilising particular physical and chemical processes, the gas sensor transforms the constituents and quantities of various gases into conventional electrical signals. It is frequently employed in the detection of toxic and dangerous gases as well as natural gas leaks. When the GAS sensor shows the value '0' it is normal and when it is '1' it shows it is abnormal. Figure 11 shows gas abnormal.

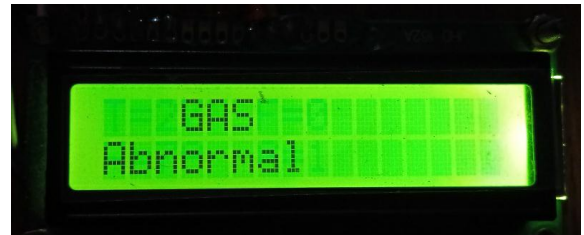


FIG-11: Gas Abnormal Message

The flame sensor is a short, thin metallic rod that creates a small current of electricity to confirm the presence of a flame burning within the furnace. Figure 11 shows the output of LCD displays 'FLAME ABNORMAL'. When the Flame sensor shows the value '0', it is normal and when it is '1', it shows it is abnormal. Figure 11 shows the flame abnormal.

Temperature and humidity sensors are also used here. When the temperature sensor shows the value '34', it is normal and when it is '35', it shows it is abnormal. When the humidity sensor shows the value '84', it is normal and when it is '85', it shows it is abnormal.

When the sensor detects the flame, smoke, temperature and humidity abnormally then it will send an SMS automatically to Loco Pilot by GSM communication. It makes the fire extinguisher ball open from the box and it extinguishes the fire. The water pump is also used for extinguishing the fire.



FIG-11: Flame Abnormal

This fig.12, shows the screenshot of the received SMS. When the gas sensor shows a value below '84' it is normal but here it is '98', So it is abnormal.

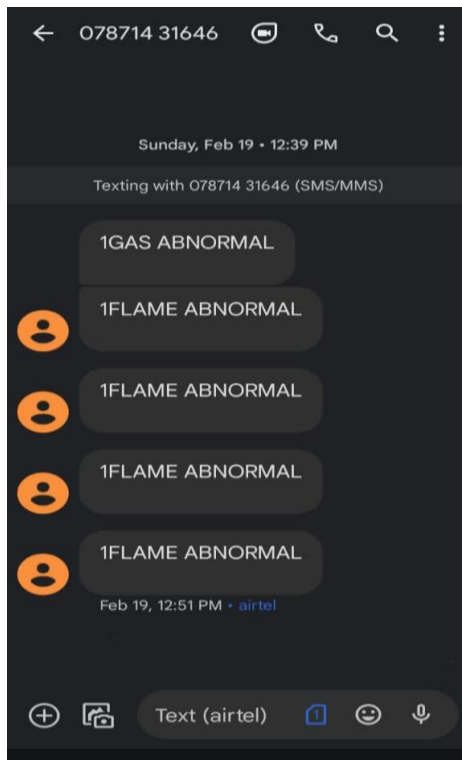


FIG-12 Screenshot of SMS

The Zig bee module has both the transmitter and receiver in it. Every compartment has this module to transfer the message and build communication.

In the receiver node, the ZigBee Transceiver receives any abnormal messages it turns ON the alert system using a buzzer and LED. Here separate power supply is used for all the units in this system. This alert is also sent to the loco pilot of the train.

7. Conclusions

The suggested approach provides early fire disaster extinguishment to reduce the damages. Using this system, safety and security systems are achieved and manage the information going to the surveillance centre and the safety system. Using the use of a flame sensor, humidity sensors, temperature and gas sensors, the primary goal of this system is to execute fire detection and rescue operations for rudimentary purposes. The GSM module notifies the loco pilot with a warning message. ZIGBEE communication, which sends and receives signals to every compartment to alert passengers and drivers as well as neighbouring train stations, and the compartment's separation in case of emergency using motor control and relays, improved this paper. In Future this paper can be improved with an automatic braking mechanism and IOT for real-time data monitoring.

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