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FSIT: Fire Safety in Trains

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Abstract

General incidents happening ongoing in trains nowadays happen due instant fire in railways because of multiple reasons resulting in health hazards and even deaths. This paper provides a remedy to reduce the losses of life occurring due to fire accidents in trains. In the past few years Indian railways has witnessed various forms of train accidents in which catching of fire is of serious concern. Fire on running bogie is severely dangerous than the stationary ones. The damage is severe because of lack of alertness and lack of communication which leads to the time delay in action. This project provides automation to the trains by applying automatic brakes and along with the ventilation in case of fire and smoke detection. The railway staff and passengers need to take all possible precautions in order to avoid any of the above mistakes so as to minimize the possibility of fire break out. The project consists of thermistor gas sensor, buzzer, fans, pneumatic actuators, solenoid pneumatic valve. Whenever the fire is detected with the help of fire sensors, thermistor and a safety circuit sends signal to solenoid valve and triggers the brakes and allows exhaust fans for proper air flow in and out of a chamber to avoid suffocation and it also starts the alarm to alert the authorities.

Introduction

Security is matter of concern for the travellers. Fire accidents in trains are life threatening. The major cause of train accidents are a variety of mechanical as well as human factors. Further "human error" is the result of many factors. When these accidents occur in moving train, then deaths increases by higher rates.
Factors can be

1. Lighting or use of fire near wood, paper, petrol or any such flammable material.
2. Carrying stoves, petrol, kerosene oil, fireworks *etc*. in passenger compartments.
3. Short circuit in the electrical wirings.
4. Use of naked light during delivery of authority token to the driver, inflammable loads shunting, sealing inflammable wagons , Lighted match sticks, cigarette ends carelessly thrown. Presence of pantry of Indian trains.
5. Lighted match sticks, cigarette ends carelessly thrown.
6. Presence of pantry in the coaches of Indian trains.

Several accidents due to fire occur in Indian railway but effective solution cannot be taken till today.as per reference it concentrates only on alertness of railway staff but not on stopping the rail which is the main cause of death, people have no chance to step down from fired bogie and ultimate lead to death.

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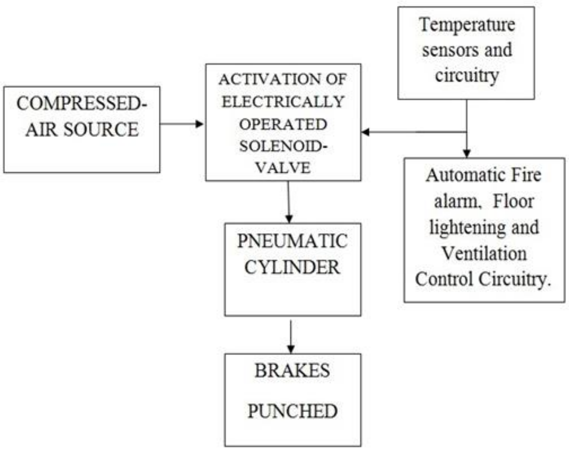
Latest fire accidents in train:

Train caught in fire	Date of accident	Cause	No. of people died
Delhi-Chennai Tamil Nadu Express	July 30, 2012	Short circuit	35 Killed, 25 injured
Gondia dongargarhmemu local	November 15, 2013	Unknown Reason	Injured people, no death
Nanded- Bangalore Express	December 28,2013	Short circuit & lack of alertness among people	26 Killed
H.nizamuddin-ernakulammangala exp.	December 28, 2013	Short circuit	5 Killed, 50 injured
Bandra-Dehradun Express fire accident	January 08, 2014	Unknown Reason	9 Killed, over 10 injured

Due to improper communication, delay in taking the action and improper service reach the damage is heavier. Whenever the fire is detected certain amount of time is taken by the information to reach to the railway staff available on the train and handsome time is taken away to react to the situation and applying brakes. Thus in order to shorten time interval for sending information and thereby for taking the action to take place the system has been designed such that as soon as the fire is detected by the sensitive thermistor sensor it sends the signal and apply the brakes.

Solution Proposed:



This paper implements the cost effective and non-complex pneumatic system to apply automatic brakes to the trains in case of fire detection. The system involves pneumatic cylinder to actuate the pneumatic brakes, thermistor sensor which senses the fire which in turns further sends signal to solenoid valve to send signal to pneumatic actuators and ringing the buzzer and turning the fans on to let the flow of smoke outside and letting the fresh air in. The system can be placed without replacing any system, as no necessary change is to be made to the existing system's infrastructure; hence the cost of implementation of this system is also less.

NTC (negative thermal coefficient) thermistors are installed in every bogie of train. In case of fire, temperature of bogie rises up which are sensed by NTC thermistor which decreases the resistance of thermistor and signals are sent to electronic circuit which starts exhaust fans to remove smoke, rings up the buzzer to alert railway staff, switch on the Led lights which shows the path to exit to the passengers in bogie and in the relay magnetic field is generated, as soon as the magnetic field is created key completes the circuit and DC voltage is transmitted to solenoid valve which flows compressed air through compressor to actuate the pneumatic cylinder and the brakes are applied.

The sensors used for detection of fire in the project are Thermistor, which are basically temperature sensors. Thermistor is an electrical resistor whose resistance varies with

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temperature and the name has been derived from thermal and resistor. It is widely used as inrush current limiters, for sensing temperature, as over current protectors that self-reset and also as self-regulating heating elements.

Thermistor can broadly be classified into two categories depending upon the classification of k. The resistance will increase with increasing temperature if k is positive and the device is called a positive temperature coefficient (**PTC**) thermistor, or **posistor**. The resistance will decrease with increasing temperature if k is positive and the device is called a negative temperature coefficient (**NTC**) thermistor. Resistors which are not thermistor are designed to have value of k as close to zero as possible so as to keep the value of resistance nearly constant over a very wide range of temperature. Sometimes the *temperature coefficient of resistance* α_T (alpha sub T) is used instead of the temperature coefficient *k*. It's defined as $\alpha_T = \frac{1}{R(T)}\frac{dR}{dT}$.

This sensor further drives an operation amplifier LM358 that is a dual op amp and it converts the analog signal coming from the sensor to digital output in the form of 1 and 0.

Assuming the relationship between resistance and temperature is linear, as first-order approximation, then:

$$\Delta R = k\Delta T$$

Where,

ΔT = change in temperature

ΔR = change in resistance

k = First-order temperature coefficient

- **Circuit Diagram:**

A) Schematic Diagram

The 532/358/LM2904 consists of two independent, internally frequency-compensated, high gain, operational amplifiers which have been specifically designed to operate from a single power supply over a wide range of voltages. Dual power supplies operation is alsopossible, and the low power supply current drain is independent of the magnitude of the power supply voltage. This operational amplifier drives the ULN2003 Darlington pair transistor IC that is used to drive high current output for switching on and off the relays. The output current of LM358 is low therefore, we use ULN2003 amplifier that has a capacity of 500mA current from single channel and has 7 such channels in it.

This IC further drives three relays that individually trigger on the solenoid valve running on 220V AC , dc fans for exhaust running on 12V DC and a buzzer as well as floor lights. So, whenever there is smoke or fire detected inside the train, Automatic brakes are applied with the help of 2 x 3 solenoid valve by triggering on the pneumatic actuator that is supplied constantly with compressed air. Also, other than this, some more features have been incorporated like switching on the floor lights indicated by LED's so that passengers could see the path, a warning buzzer is also triggered on and two exhaust fans on the rail coach are turned on simultaneously for the intake of fresh air inside the cabin.

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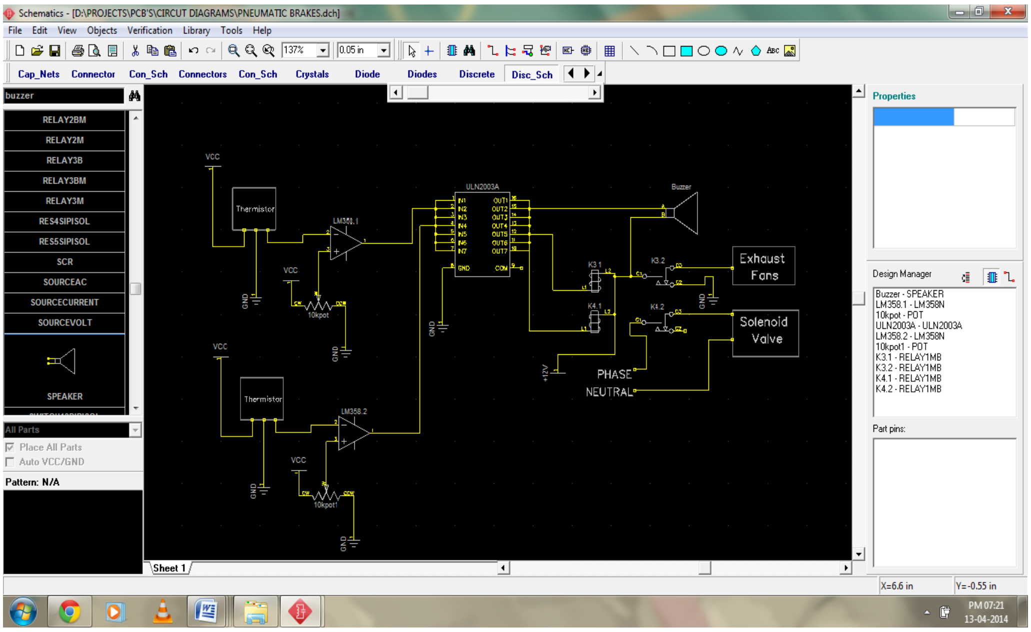

Figure 3. Circuit of Pneumatic Braking System

B) Complete Circuit Diagram

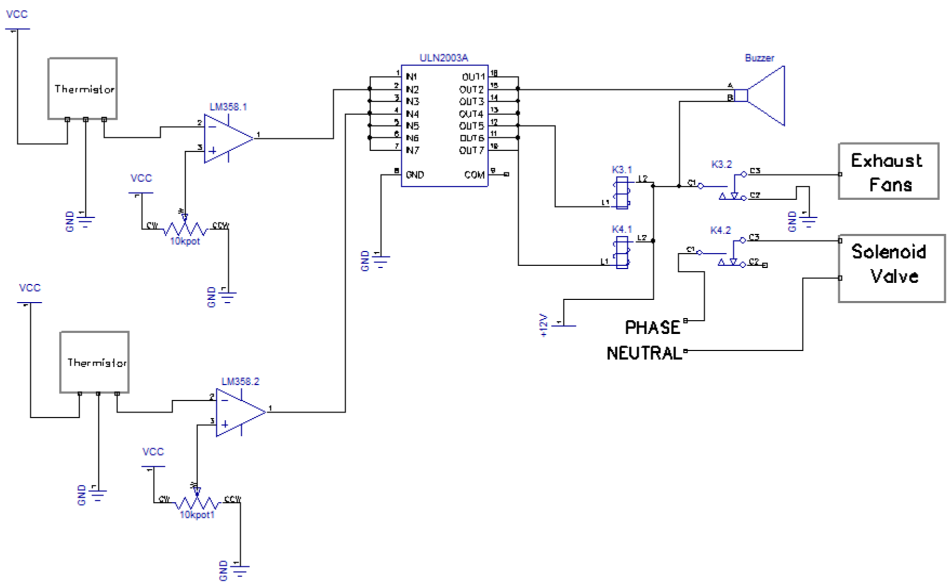

Figure 4. Complete Circuit Diagram

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- **Prototype Setup:**

1. Power Supply

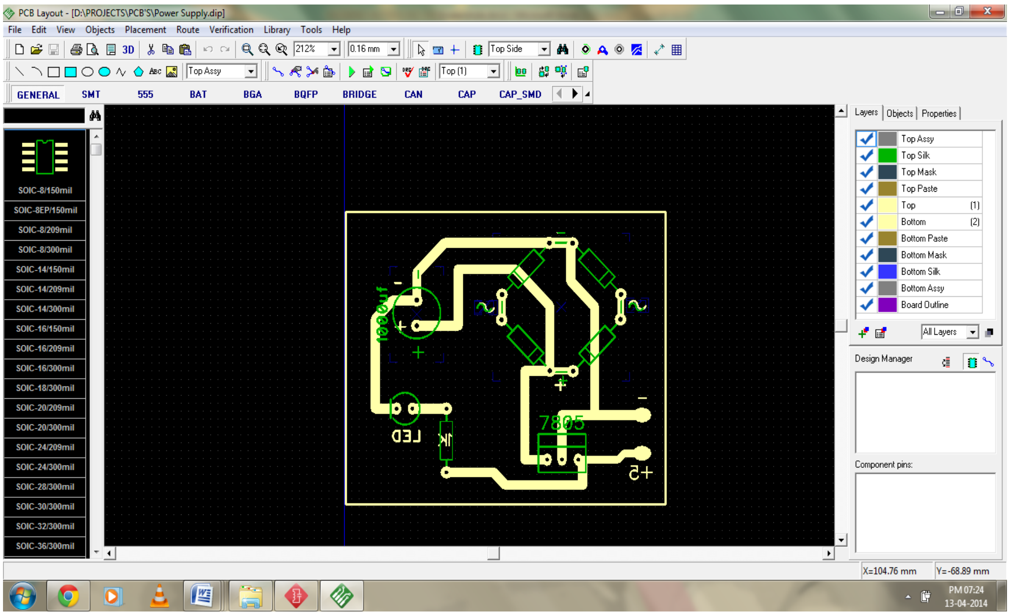

Figure 1. Power Supply Layout

AC current Power is supplied through the transformer. It divides the current to the two rectifiers. First rectifier is connected to NTC thermistor and to the potentiometer. A potentiometer measuring instrument is essentially a voltage divider used for measuring electric potential. A sensitivity of the Potentiometer is set at the particular value, when there is a normal condition potentiometer connected to the comparator sends output as off and no further current flows through OP AMP comparator. As soon as the temperature rises inside the bogie such that it crosses the set sensitivity of the potentiometer then NTC thermistor sends the ON signal to OP AMP comparator. Second rectifier is connected to the relay. One point of relay is connected to the first rectifier and another point to the second rectifier. When the Op Amp comparator sends the ON signal it generates the magnetic field, the circuit inside the relay completes and it activates the solenoid valve.

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2. Sensor Printed Circuit Board

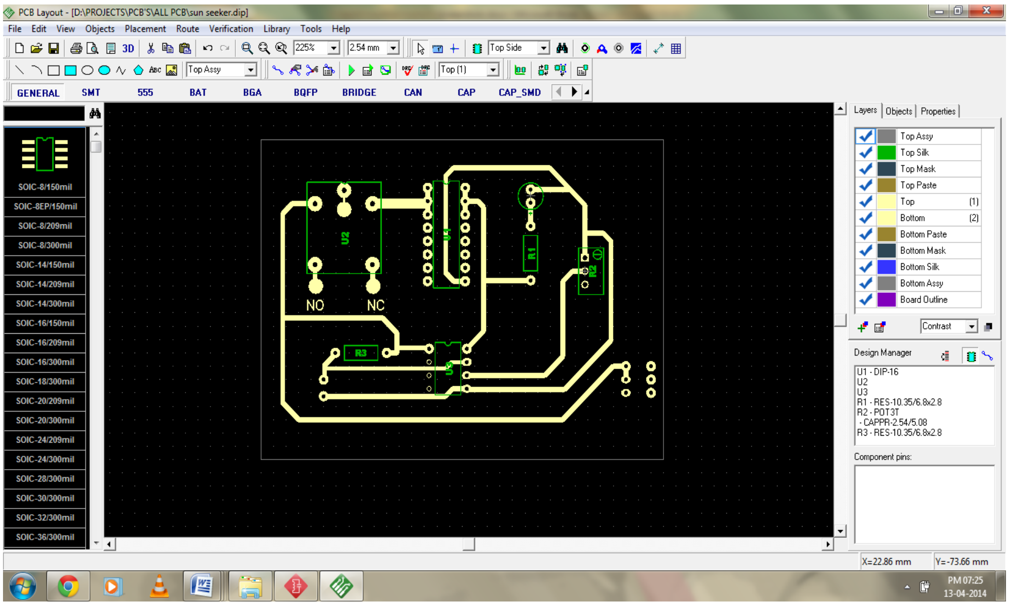

Figure 2. PCB Layout

- **Electrically Operated Solenoid Valve:**

An electrically operated solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid the flow is switched on or off in case of a two-port valve. Solenoids offer high reliability, fast and safe switching, long service life, low control power and compact design. The solenoid converts the electrical energy into another form that is mechanical energy which, in turn, closes or opens the valve mechanically. Solenoid valve used is working on 0.15- 0.8 Mpa (21.7- 116 psi), 24V DC, 4.8W.

- **Pneumatic Cylinder:**

Mechanical devices which use the power of compressed gas in order to produce force in linear reciprocating motion are known as Pneumatic cylinders. These are used to store fluid's potential energy; here compressed air is used and converted into kinetic energy as the air expands so as to reach atmospheric pressure. The piston then moves in the desired direction by the expanding air. The piston is shaped like a disc and force developed is transferred to the object to be moved by the piston rod. It is preferred to use pneumatics because storage. Single-acting cylinder has 40X50 maximum pressure 10 kgf/cm2 (145psi).

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Figure 5. Electrically Operated Solenoid Valve

Figure 6. Pneumatic Cylinder

- **NTC Thermistor:**

Thermistor is a temperature sensing element which is made up of sintered semiconductor material so as to display large resistance changes in ratio to small temperature changes. We can measure resistance by using small-measured DC (Direct current), passing through thermistor to measure the produced voltage drop.

Figure 7. NTC Thermistor

- **Air Compressor:**

Pneumatic systems are used extensively where equipment are plumbed commonly with compressed inert gas or compressed air. It is because an electrically powered compressor that is centrally located which powers the cylinders as well as the other pneumatic devices by solenoid valves often provides motive power in a safer, cheaper, flexible and more reliable way than a large number of electric motors. Maximum pressure is 175 psi.

MOTOR		NO. OF CYL.	RPM	RECEIVER		MAX. PRESSURE		PISTON DISPL		
HP	KW			CFT.	LTRS.	PSIG	KG/CM2	CFM	M3/M	LTR/MIN
2.0	1.50	2	675	5.30	150	175	12.30	7.60	0.210	210

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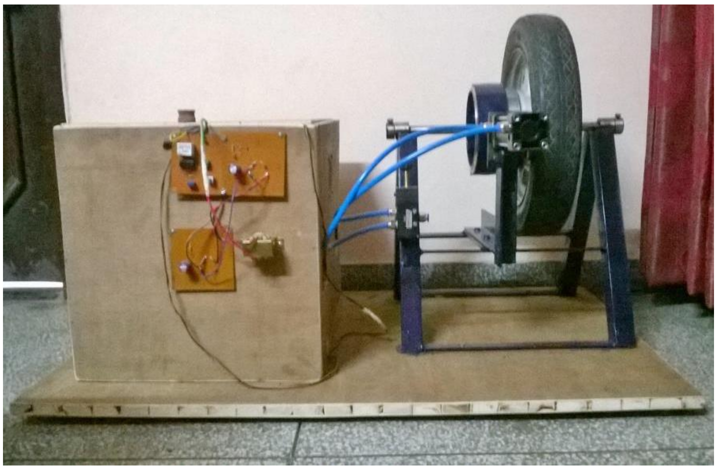

Figure 8. Prototype of Automatic Pneumatic Braking System

a) Released Brake b) Applied Brake

Experimentation:

The test was started firstly with lighting the fir inside the container having NTC thermistor. In first case the distance between the source of fire and the NTC thermistor was very minimal, as the temperature crossed to certain set value signal was sent and buzzer, exhaust fans, LED lights turns on and at the same instant pneumatic brakes applies.

In the second case fire was lit again inside a container but far away from the NTC thermistor, and again as the temperature raises buzzer, exhaust fans, LED lights turned on and pneumatic brakes were applied.

Result and Discussion:

a) Fire source close to NTC thermistor

Weight of Wheel	2kg
Speed of Wheel	45 rpm
Electrically Operated Solenoid Valve	40X50
Compressed air pressure	30 psi- 100 psi
Time Span in Applying of Brake	2 sec

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b) Fire source away from NTC thermistor

Weight of Wheel	2 kg
Speed of Wheel	45 rpm
Electrically Operated Solenoid Valve	40X50
Compressed air pressure	30 psi- 100 psi
Time Span in Applying of Brake	2 sec

In this study varying the distance of the fire source from NTC thermistor was experimented. The experiment shows that by varying the distance between the source of fire and the NTC thermistor had no effect on the sensors for sensing the temperature rise and time span for applying the pneumatic brakes was similar. Applying of brakes may vary according to speed, weight of wheels, size of electrically operated solenoid valve of wheels and the compressed air maintained in the train line running along the train length. We also found that when the temperature of NTC thermistor rises brakes are applied but as the temperature of the thermistor falls than the brakes that were applied, releases automatically and makes the train ready to go. Earlier when the emergency brakes were applied trains gets jammed and brakes are required to be released mechanically but this system has overcome this drawback of the emergency brake.

Future scope:

In the recent years, Indian railways have experienced number of fire accidents which has led to increase in number of deaths of the passengers. Implementation of this method will help achieve automation in the trains. Project has high sensitivity which in case of fire will automatically apply pneumatic brake along with the brakes it also help in rescuing the passengers by showing the path to the outlet and also notifying the staff about fire. It is one of the effective ways of achieving automation in less expensive manner and also without replacing the base structure of the Indian railways which somehow still lacks the automation.

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