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RF wireless sensor based system for avoidance of locomotive accidents due to track discontinuation

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Abstract
RF Wireless System for Railways is used to avoid train accidents due to track discontinuation. The system proposed in this paper involves the use of encrypted RF modules where RF receivers are placed over the train engine and RF transmitters are laid along with the track to avoid accidents due to derailment of trains. The advantage of the concept presented in this research paper is that whether any train is running over any one track or other different track, if discontinuity of the track takes place then the trains passing through that track will automatically get stopped and at the same time the warning will also be conveyed to the nearby station through buzzer. The Train module, RF Module, Control Module, Actuating Module and Braking Module are incorporated together to form system for accident avoidance due to derailment of trains due to discontinuities present in the tracks.

Keywords: derailment, locomotives, RF, microcontroller, track, buzzer

1. Introduction
Technological development are increasing continuously throughout the world. For making ease to human life technological advancements are accepted and implemented in all the possible fields and sectors. Research, Domestic, Commercial, Industrial, Agricultural, Transportation etc. are some of the major sectors involving best possible use of technology. Among the above mentioned sectors transportation sector is one which includes the involvement of each and every individual. The most common and affordable means of transportation is railways. Millions of passengers travel daily through it and even it is also used for goods transportation. But in spite of being a common means of transportation its safety consideration is questionable. Railway accidents are not hidden any more. Not only in India but throughout the world train accidents are taking place. Whenever the train accident takes place, it results in hundreds or thousands of casualties even in such an advanced technological era. Therefore, avoidance is incumbent. In the system proposed here RF wireless technology is used where RF Receivers are fitted over engine of the each and every train running over the tracks and RF transmitters are laid along track side. When there is discontinuity present in any track and if the train is coming over it, RF module receives the signal immediately from the track side RF transmitter within the range and it forwards the signal to control unit and actuating unit for activating the braking system. The proposed system utilizes RF transmitter and receiver, Arduino Software, Microcontroller, Relay Mechanism, buzzers, batteries etc.

2. Train Accidents and Derailment
Train accidents due to derailment and collisions are taking place almost after regular intervals and despite of technological advancements we are not able to stop it. Not only in INDIA but also throughout the world train accidents are taking place. Some of the possible derailment and other train accident situations are:

2.1 Derailment
In this situation the train gets derailed due to discontinuity of the track or if brakes are applied at an uncontrolled high speed.

2.2 Front to Front or Head-On Collision
In this case two locomotives are running towards each other due to less attention paid by drivers or wrong signaling by the operator at station. This causes front to front or head on collision.

2.3 Rear-End Collision or Front to Back Collision
In this situation two locomotives are running on the same track and in the same direction or one is stationary and another is moving towards it from back end, front to back or rear-end collision takes place.

3. Reasons
Discontinuity of track
Insincerity of work by staff
Low attention of driver
Improper communication within the network
Worst signaling
Worst weather condition
Uncontrolled speed

4. Existing Methods
There are so many methods which are existing or prevailing and also many methods have been proposed for Derailment situation but still accidents are quite common. Positive Train Control method initiated by National Transportation Safety

Board, USA. Anti-Collision Device is a train collision prevention system patented by Konkan Railway Corporation in India. Train Protection Warning System commissioned in southern railways, India. Train Collision Avoidance System commissioned in Mumbai, India. In most of the methods the attention is paid mainly on collision whether it is front to front or rear-end collision but not on derailment which is mainly due to discontinuation of tracks.

5. Proposed Method

In the proposed method Avoidance of Locomotive Accidents due to Track Discontinuation is divided into various modules i.e. Train module, RF Module, Arduino software, Controlling Module, Actuating Module and Braking Module.

5.1 Train Module

Train Module incorporates RF module receiver with Controlling and Actuating circuitry. RF transmitter and receiver is encrypted. RF encryption is related to an individual track. RF receiver in the train module is driven by an actuator corresponding to individual track. Irrespective of number of trains present over a particular track all the trains will have common encryption of RF receiver and transmitters and receivers are placed on their locomotives. Encryption for RF is to be provided with the help of data pin switches provided on the chipset. Based on the number of tracks running parallel, the equal number of RF receiver sets are to be kept over locomotives.

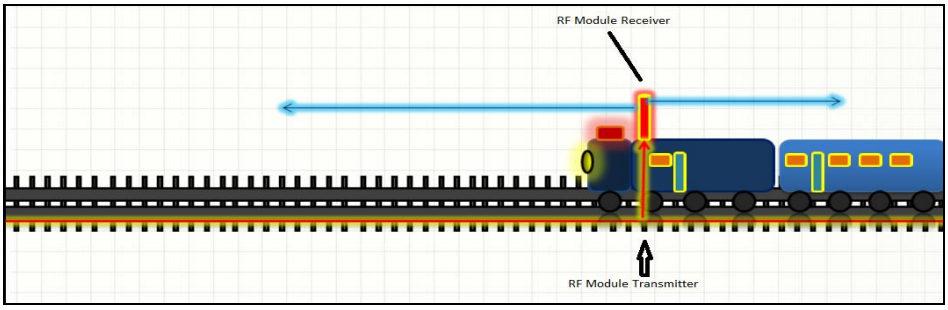

Fig 1: Train Module with RF Setup

5.2 RF Module

RF module i.e. Radio Frequency module is a small electronic device used to transmit and receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through the optical communication or through radio frequency (RF) communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and receiver.

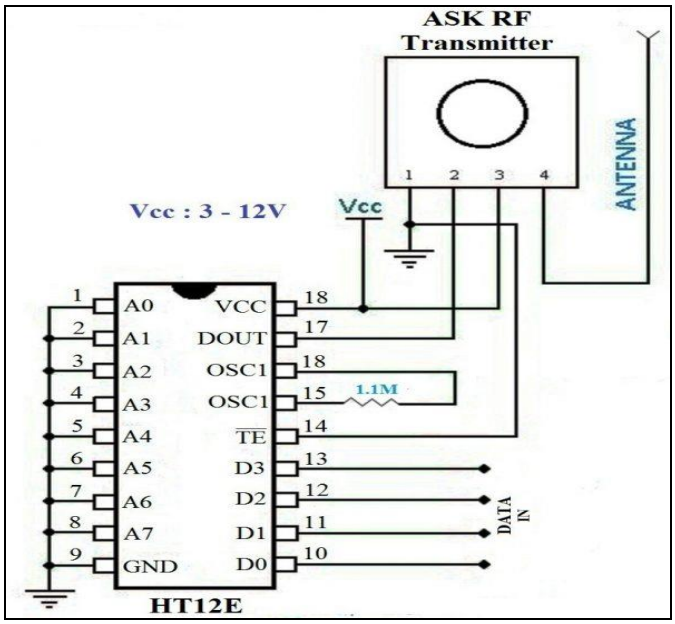

Fig 2: RF Module Transmitter

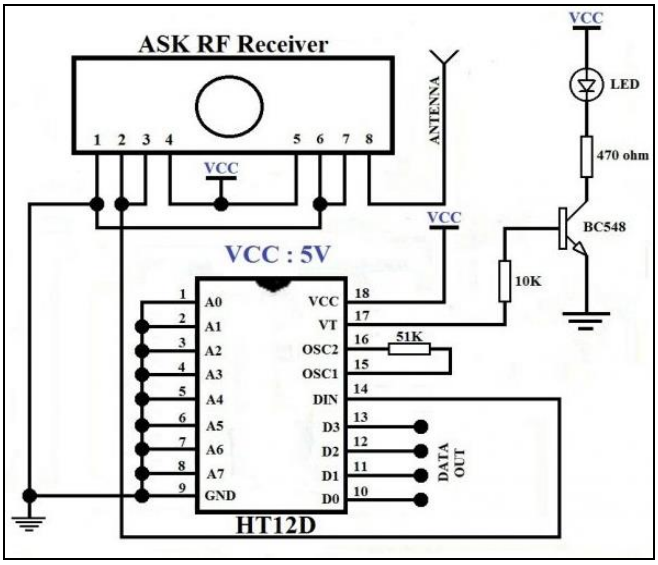

Fig 3: RF Module Receiver

RF transmitter module is a small PCB sub-assembly capable of transmitting a radio wave and modulating that wave to carry data. Transmitter modules are usually implemented alongside a micro controller which will provide data to the module that can be transmitted.

RF receiver is an electronic device that receives radio waves and converts the information carried by them to a usable form. It is used with an antenna. The antenna intercepts radio waves and converts them to tiny currents which are applied to the receiver, and the receiver extracts the desired information. The receiver uses electronic filters to separate the desired radio frequency signal from all the other signals

picked up by the antenna, an electronic amplifier to increase the power of the signal for further processing, and finally recovers the desired information through demodulation.
RF Transmitter module is connected with the communication channel laid alongside the track. The communication channel is so rigidly fitted with the track that if any discontinuity takes place in the track whether intentional or unintentional, immediately the communication channel will also brake. Due to brake in communication channel the RF transmitter gets activated and it transmit the signals which is received by receiver placed over the locomotives when it is within the range. RF receiver further sends the signal to controlling module, actuating module and finally train stops by operation of braking module. The communication channel is also connected with an alarming buzzer circuit. If communication channel brakes, it will activate an alarming circuit to alert the operators at control room of station.

Table 1: RF Module Specifications

Transmitter operating voltage	3-12V
Receiver operating voltage	5V
Signal Transmission Range	100 m
Transmitter Frequency	433.92 MHz
Receiver Frequency	433.92 MHz
Supply Current	3.5mA

5.3 Arduino Software

The open source Arduino Software makes it easy to write code and upload it to the board. In this software the programs are written in Java. The software is used with Arduino boards. The board that is used in this project is Arduino Uno with ATmega 328 microcontroller. Some basic steps of the program used in this project are:

```
const int ledPin1 = 10;
const int ledPin2 = 11;
const int ledPin3 = 12;
const int ledPin4 = 13;
const int sw1 = 2;
const int sw2 = 3;
int STATE1 = 0;
int STATE2 = 0;
```

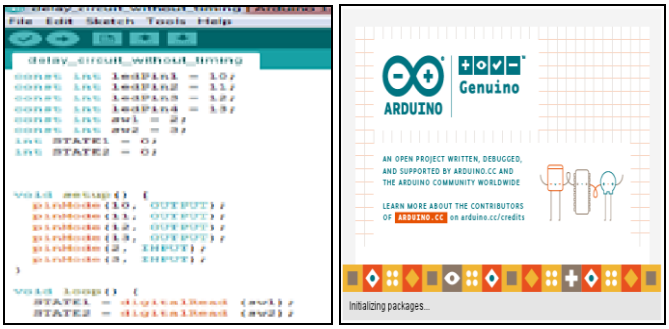

Fig 4: Arduino software setup

5.4 Controlling Module

High performance 8-bit AVR RISC based microcontroller ATmega328 is the main part of controlling module. It has following features:

Table 2: Controlling Module Specifications

Flash Memory	32KB
EPROM	1KB
SRAM	2KB
I/O Pins	23
Working Resistors	32
Timer/ Counters	3
Operating Voltage	1.8-5.5V

Three flexible timer/ counters are available with compare modes. Also the internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator are the features of ATmega328. In the present system AT mega 328 is implemented on Arduino Uno platform. RF module sends the track discontinuity information to train module which further forwards the same to control module and then to actuating module. Selection of input and output pins is based on track identity.

5.5 Actuating Module

The combination of transistors, relays and resistors form actuating module. It forwards the information received from track side RF module to braking module to finally stop the train. NPN Transistor BC548: $I_{c\ max}$ = 500mA, h_{fe} = 200
Relay: SPDT, 6-9V, r = 100ohm, I = 60mA

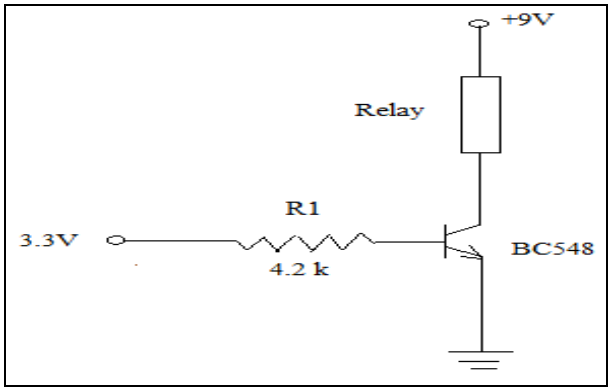

Fig 5: Actuating Module

Resistor value: 4.2K
Voltage from controlling module: 3.3V
Transistor BC548 is used as a switch along with SPDT 100ohm relay so that it can be operated at low voltage actuating signal received from controlling module.

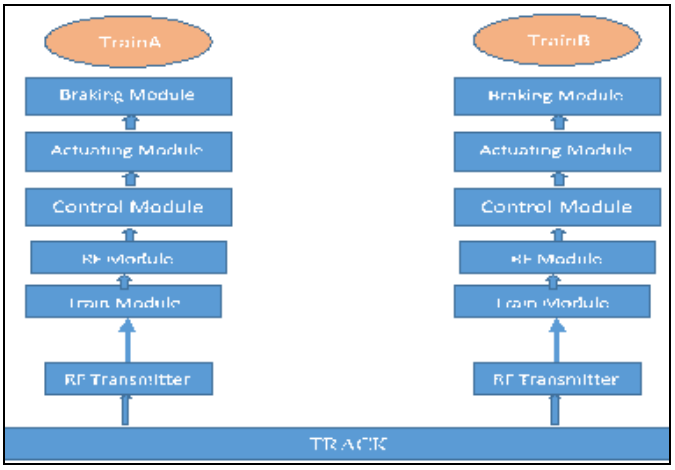

Fig 6: RF Module Setup for Individual Track

5.6 Braking Module

Braking Module is connected after Actuating module to stop the Locomotive. As soon as RF module gets activated after receiving the signal through train module from RF transmitter laid on the track side, it further sends the signal to braking module, through control and actuating module, which immediately apply the brakes to stop the train. In this project braking module disconnects the supply of model trains to stop them by the use of relay mechanism.

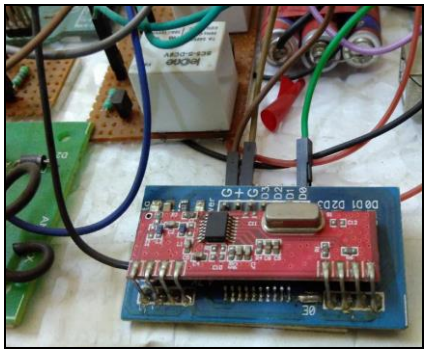

Fig.7: Fabricated Board

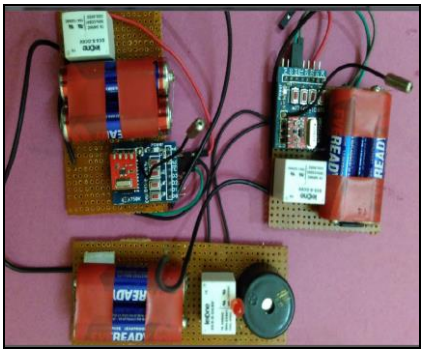

Fig 8: Testing Phase RF Module and Buzzer Circuit

6. Testing and Results

The project provides an effective system for Avoidance of Locomotives Derailment Accidents due to Track Discontinuity based on the emerging RF wireless communication technology. It has both hardware and software of Train Module, Controlling Module, Actuating Module and RF Module. Activation of RF is based on transmitter to receiver communication. In Indian Railways the average speed of train is around 100 km/hr. After braking train travels a distance of about 500 m due to inertia. Therefore train must be stopped at a safe distance before the discontinued section of track.
In this project the speed of model train is 1 km/hr.
Following observations were found during testing phase:

Table 3: Testing and Results

Testing Phase (On Track)	Distance Between Discontinued Track and Train After Stop
1	5 m
2	5.5 m
3	5.5 m

7. Conclusions and Recommendations

The concept utilized in this system is practically tested and verified at different sections of the track. After several testing phases it is found that this system can be implemented in Railways for avoidance of derailment accidents of trains due to discontinuity of tracks. This system is cost effective in comparison to other proposed or implemented systems. However use of RF module for such a system is a limiting factor due to range criteria.
The utility of this system can be highly increased if the concept of track discontinuity or derailment due to it is coordinated with ZigBee wireless technology. With the use of ZigBee module the distance at which locomotive is to be stopped before discontinuation of track can be set with more ease as the range of ZigBee modules if very high. Thus the avoidance of locomotive accidents due to track discontinuation can be completely stopped.

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