Design of novel track vigilance system in railway sheds

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Abstract. The work presented in this paper attempts to propose a vigilance system to alert the workers in the industrial areas especially in railway workshop shed and yards. Vigilance system in railway sheds offer an effective way to reduce the occurrence of railway accidents. Normally, staffs in railway sheds are working round the clock duties and placement of the rakes are also done round the clock. They follow a traditional system such as issuing of memos and announcements which are not sufficient to alert the workers about the arrival of rakes. This leads to the death of valuable lives. The proposed system incorporates relay module, limit switch and transceiver to detect the arrival of train and warn the workers with the help of hooter. The efficacy of the proposed system is checked and found indispensable to alert the employees in railway sheds.

Keywords — railway sheds, sick lines, vigilance system, relay module.

1. Introduction
In today’s world, Railroad transportation is widely used in all countries for transporting passengers and freights. Inspite of the economical aspect, the railroad accidents are equally dangerous and ends up with human loss. Hence, it is highly emphasized to concentrate more on the safety aspects[1]. The main purpose of this system is to detect the arrival of trains in railway workshop sheds. The previously related model [2] uses infra-red sensors to indicate the movement of the trains at the level crossing and the Arduino to control the opening/closing of gates [3]. The proposed system uses limit switch to detect the arrival of trains. The sick line shed activities of coaching depot at Chetpet, Chennai Egmore is considered for analysis in this model. There are pit lines, sickness and Intermediate Overhauling [IOH] sheds for maintenance of coaches. Sick line is the workshop for the major and repair maintenance of the coaches. It consists of modern facilities like pit for working under frame and lifting jacks and cranes for separation of coach & bogie for repair of all type of defects.

In general railway coaching yard layout consists of Carriage and wagon[C&W] OFFICE at one end and pit lines and sick lines adjacent to each other at the other end. All these pit lines and sick lines are laid and converging at Chief yard master [CYM] office so that shunting of different lines can be done from CYM office under close supervision of on duty yard master [YM]. C&W department which belongs to the mechanical department does the routine repair and overhauling practices. Whereas, CYM belongs to traffic department who is responsible for placement of coaches/ rakes in particular order as demanded by C & W department. Sick line shed consists of three lines for doing
repair and overhauling activities of both mechanical and electrical attention of main line coaches. In this small pit of 1 coach length is also provided in particular locations to do special activities. A placement memo in duplicate is served for following day by the C & W engineer to the on duty CYM. CYM receives the memo and acknowledges the same.

The CYM identifies the coaches inside yard and arranges for the placement inside the shed in requested order well in advance before commencement of day activities in the following day. Due to uncertainties, the placement takes place even after commencement of the day activity of sick line shed. Although memos are served by C&W department, the announcements are not conveyed to a large number of staffs report for duty around 08.00 hrs. Thus, staffs are unaware of the arrival of the rakes or coaches. Though, locos are provided with horn which is a powerful one that serves as an audible warning device in sickliness but during shunting of rakes/coaches which means a coach which is of 23.54m in length will enter the sick line shed with loco at the back end, the sound of the loco horn will not be audible enough to the workers working inside the shed.

Thus, lack of warning system causes many deaths and accidents. These kinds of accidents are more prevalent during night shifts. Instantaneous stop is not possible for any moving train, at the time of emergency situations. In case of any dangerous accidents, human losses as well as monetary losses are incurred. Thus, a vigilance system is emphasized and it is to be installed at suitable place to warn the workers well in advance about the arrival of the coaches to prevent the accidents. Firstly, the arrival of the train is detected by limit switch placed at 500m from the railway shed. When wheels of train come in contact with the limit switch, it triggers the alarm. Vigilance system in railway sheds is one of the useful aspect in controlling the frequent railroad accidents, leading to enhanced safety of the railway workers as well as reduce the damage loss to the railway management.

2. Proposed Methodology
The layout diagram of sick line shed is illustrated in figure 1. Sick line is the workshop for the major and repair maintenance of the coaches. It consists of modern facilities like pit lines for working under frame and lifting jacks and cranes for separation of coach & bogie for repair of all type of defects. As shown in the figure, 1, Sick line shed consists of three lines for doing repair and overhauling activities. As discussed previously, although memos are served by C&W department, the announcements are not conveyed to a large number of staffs report for duty around 08.00 hrs. Thus, staffs are unaware of the arrival of the rakes or coaches. Hence, accidents can occur and people may get injured due to the lack of warning system.

![Figure 1. Layout of sickline shed](image)

A warning system is emphasized and it is to be installed at suitable place to warn the workers well in advance about the arrival of the coaches. In order to achieve this, the limit switch is placed at 500m away from the sick line shed. It is placed on the inner side of the railway track. Though the Train wheels look circular, in reality they are not circular and are bevelled in order to obtain wider inside. Due to this structural design of this Train wheels , whenever the train takes a left or a right
turn, the Train wheels change in dimension due to the dynamic loads. So, the limit switch can easily contact the wheels of the train.

The limit switch detects the arrival of rakes or coaches. By incorporating XBEE transmitter and Arduino which is connected to the limit switch, the message about the arrival of train is transmitted to sick line shed. The message which is been transmitted is received by XBEE receiver [4]. The XBEE receiver is placed at the outer wall of the sick line shed. With the help of Arduino UNO and relay, the warning is given to employees at the sick line shed using hooter and flashlight. Thus, accidents can be prevented in a greater amount through this proposed system.

Block diagram of the proposed system is illustrated in figure 2. The block diagram consists of two blocks namely transmitter block and receiver block. The transmitter block utilises limit switch, Arduino UNO and XBEE transmitter. Arduino UNO is the main controller of the proposed system [5]. The receiver block uses XBEE receiver Arduino UNO, hooter and flashlight.

![Block diagram of proposed system](image)

**Figure 2.** Block diagram of proposed system

### 3. System Overview
The materials and components that are used in Warning system is discussed in the following section. As in normal control design, system can be roughly divided as input, output and processing sections. The main components of system are:

#### 3.1. Limit switch
The proposed system uses 3pin limit switch with AC voltage rating-125V, maximum DC voltage-14V, maximum current-5AMPS. A Limit switch is helpful in sending signals to the controller in case of any object comes in contact with it. Hence these limit switches can be used to stop or start any signal as per the requirements. They also come in contact and non contact options.

#### 3.2. XBEE Trans receiver
XBEE trans receiver used in this model is XBEE Pro 63mw Wire Antenna - Series 2B (ZigBee Mesh) with operating voltage of 3.3v@295mA and range of 500m. This trans receiver allows a very reliable and simple communication between microcontrollers, computers, systems, really anything with a serial port! Point to point and multi-point networks are supported.

#### 3.3. Controller
Arduino UNO is used as a main control unit to control the process of the whole system with Operating voltage of 5 to 9V, through USB-500ma, through external battery-1A.

#### 3.4. Other components
Hooters are used to warn the workers about the approach of train with operating voltage of 12V DC. Flashlight with operating voltage of 12V DC @0.67AMPS. With respect to power supply, a 9V battery is used in transmitter block and 18650 battery case with 3.7V,1000ma is used in receiver.
block. A single channel relay module is used in this proposed system with specification of Ac-250V, 5AMPS Dc-120V, 5AMPS. SG90 (micro servo) is used in this proposed system with operating voltage of 5V DC.

4. Circuit description

The wiring diagram of transmitter block is illustrated in figure 3. It consists of limit switch, XBEE transmitter, Arduino UNO, sliding switch, battery. As discussed earlier, limit switch is used to detect the arrival of the train. The sliding switch is used to turn on the transmitter block of the system. Once the limit switch comes in contact with the wheels of the train, it generates analog values. Arduino UNO is the main controller of the system. TX and RX of Arduino UNO is connected to TX and RX of XBEE transmitter. Thus, the controller at the transmitter unit system reads and process analog values of the limit switch and then sends this information to the XBEE module to be relayed wirelessly. figure 4. shows the wiring diagram of receiver block of proposed system. It consists of battery case, XBEE receiver, Arduino UNO, hooter, flashlight, relay module, servo motor and two switches.

The power on/off switch is used to turn on the receiver block of the system. The XBEE receiver is been interfaced with the controller. As soon the receiving the signals from the transmitter, the output of this receiver is given to a controller. The Arduino UNO processes the analog value that’s been transmitted. Thus, controller triggers the relay to activate the hooter along with flash light. The supply to the hooter and flashlight is provided by the battery through relay module. Thus, hooter with flashlight warns the workers about the arrival of the train.

Figure 3. Transmitter wiring diagram

Figure 4. Receiver wiring diagram
The analysis of the normal and abnormal operating conditions is addressed in this section. When a rake of 23.54m with an average speed of 20km per sec approaches the sick line shed, the wheels of rake comes in contact with the limit switch for 4.24 seconds. The special cases arise due to the differences in the speed of motion of rake.

4.1. Case 1: Normal Operation
When a rake is in motion with the average speed, the wheels of the rake come in contact with the limit switch for 4.24 seconds. The serial communication between the XBEEs will be established and the hooter warns the employees for 4.24 seconds. Since the hooter sound doesn’t long for much time, the usage of the second switch is not essential in the normal operation.

4.2. Case 2: Below average and standstill condition
When the rake doesn’t approach the sick line shed with average speed, the wheels of rake may come in contact with the limit switch for more time. In order to avoid the alarm sound for long time which might create an inconvenient environment at sick line shed another switch is provided to trip the hooter from the receiver block. Once the train get past the limit switch, the switch can be reset with the help of servo motor

5. Algorithm
The algorithm for the Warning system is given below.
STEP 1:  Start.
STEP 2:  Set the limit switch for arrival of train.
STEP 3:  Check for the arrival of the train. If the limit switch is triggered train go to step 4 otherwise loop to step 3.
STEP 4:  Read the analog values.
STEP 5:  Process the analog values and send them to XBEE module for transmission.
STEP 6:  After receiving, segregate the analog values.
STEP 7:  Process the analog values.
STEP 8:  Activate the relay module.
STEP 9:  Trigger the hooter with flashlight and warn the employees in the sick line shed.
STEP 10: Stop.

Figure 5a. Transmission flowchart  Figure 5b. Receiver flowchart
Flowcharts explain the sequence, looping and execution of the program of the vigilance system. The figure 5a, shows the program sequence that is executed in the transmitter unit. When the system senses any signal from the limit switch, the same is transmitted to the XBEE module which is wirelessly relayed. By following this process, the software is developed.

The figure 5b, shows the program sequence that is executed in the receiver unit. The transmitted signal explained in figure 5a, is received by XBEE present at the receiver unit, which in turn passes the signal to the microcontroller. The controller then segregates the analog values which is sent from the transmitter. The controller then processes the data and warns the employees with the help of hooter.

6. Proposed Model
This section illustrates in detail the connections between the different components used in transmitter and the receiver block of the vigilance system. The warning system worked successfully with the programmed logic to warn the workers at the sick line shed about the arrival of the train. Figure 6a, shows the assembled transmitter circuit. When arrival of train is detected by limit switch, it conducts the signal to the XBEE which is to be wirelessly relayed. Figure 6b, shows the assembled receiver circuit. When the limit switch is triggered, the serial communication is immediately established between two XBEEs. The Arduino process the data which helps to warn the employees with the help of hooter and flashlight.

7. Conclusion
The proposed system is indispensable in preventing accidents that are more prevalent during night shifts. It is understood that any human interference may lead to mistakes or hazardous damages. Hence, it is necessary to incorporate automation wherever possible to reduce the failure. With the help of limit switch which senses the arrival of train and hooter with flashlight, the accidents can be reduced to a greater extent by alerting the workers of railway sheds well in advance about the arrival of rakes or coaches. In the recent days, automation system has become part of occupational culture in any engineering sector due to its high reliability and accuracy. As a future scope of work, our system can be implemented in real time by fixing the current limitations using new technologies.

8. References
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