Automated Railway Signalling and Interlocking System Design Using PLC and SCADA

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Abstract - The paper is the design of Automated Railway signalling and interlocking system using PLC and SCADA. As there are few drawbacks in the Indian Railways can be rectified by using an automated railway signalling and interlocking system by using a PLC. The use of a PLC can be varied up to the requirements. The PLC is mainly used in industrial purpose, but nowadays it is being used for the accurate control of multiple operations. In the same manner the PLC can be used as a base system or a main controller for the successive operation of multiple trains as well. It is possible of controlling multiple trains at a time. In this project it’s not only just controlling the multiple operation of trains but also made the availability of crack detection and vehicle movement with automatic railway gates. The PLC would be good enough to control every operations which occurs during the process.

The entire process is designed in SCADA. Every trains will be having a wireless technology to communicate with each other and also these trains will send and receive signals from the base system which is installed in between them. So based on the priority the trains can proceed their way. Also the PLC will be having the connection with the traffic lights which indicates a train to move or stop. There are three conditions explained in the project. In these which two contains the crack detection and also the vehicle movement process. The first condition is just the passage of two trains with 4 platforms and also the base system is connected to the stepper motor to control the railway gates. By using the RFID sensors crack detection made easily possible in the second condition. III condition is having six trains with 6 platforms The Automatic movement of every train can be controlled by using two or more PLC. The design of the last condition is complex compared to the other two. The PLC used here is Schneider. And the PLC is equipped with the SCADA software for the design of entire process.

Keywords — Breakdown, Downtime, Availability, process capability, optimal inspection frequency, Critical Machine.

I. INTRODUCTION

Railway signalling has become more important over the years, with the increase in railway traffic and the use of high-speed trains. Railway signalling is a system used to direct railway traffic and keep trains clear of each other at all times. Trains move on fixed rails, making them uniquely susceptible to collision. Since the most important aspect of a railway signalling system is safety and the decision-making “interlocking system”. In railway signalling, an interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as junctions or crossings. The signalling appliances and tracks are sometimes collectively referred to as an interlocking plant. An interlocking is designed so that it is impossible to display a signal to proceed unless the route to be used is proven safe. To satisfy the safety standards set for railway- signalling systems, the interlocking software design must be taken into account, using formal methods. In this project, an automata-based railway signalling and interlocking system is introduced with a railway gate control and crack detection using a fail-safe programmable logic controller (PLC) on a scale railway model with simulated design in SCADA. Interlocking systems control all wayside elements in a railway yard. These systems are responsible for safe train operations and must prevent collisions and derailments from happening. It is absolutely essential that interlocking systems operate flawlessly, and as a result a lot of effort is put in their verification.
II. NEED FOR THIS SYSTEM

A. Safety

Even though the accidents are less in Indian Railways there should be a protection system needs to be installed to prevent by any chance of occurring. When there is a signal communication, the data sent and received will be accurate. So the priority based train can take the right actions according to the PLC instructions. At the same time the other trains which is being passed through the same track will wait for the first train to get moved. So there is no chance of getting collided each other.

B. Delaying of trains

Delaying of trains is a major issue currently we face. Presently it is rare to see that trains being reached at the right time. In order to eliminate this problem the signalling and interlocking design can be implemented. When there is an interlocking system the priority less trains can wait till the movement of other trains. Usually the fastest trains will have the high priority than the slowest. So the delaying issue can be solved by using an automated signalling and interlocking system.

C. Crack detection

Crack detection is one of the most important factor needs to be implemented in railways. There are many ways to detect the crack on the track. So the detection is only possible by using successive sensors. These sensors will be connected to the PLC for the exchange of information.

The RFID sensor is commonly used sensor now a days. 1 sensor indicates one receiver and also one sender. The sending and receiving antennas will communicate in every seconds so if they find out anything in the track it will be notified and the information will be sent to the plc. This is how the detection is possible.

D. Automatic railway gates

Automating railway gate would be an important aspect in Railway safety. Still in India almost in every areas the Gates are being opened and closed by humans. The process cannot be accurate when human operates it. It is better to use vibration sensors to detect if the train is coming or not. There will be a connection with the PLC so the data can be exchanged then the stepper motor on the Gates will get activated on time .So the process can eliminate a worker.

III. LITERATURE SURVEY

The track circuits can be controlled by a Programme Logic Controller (PLC) and the design with monitoring can be done in Supervisory control and data acquisition (SCADA) software[1].External devices such as switches or sensors can be given as the input of the PLC[1].The verification of signal exchange and interlocking method can be automated using a PLC[2].Usage of Ladder logic programming for the development of the system[2].Wireless communication system for the railway signal automation[3].The generation of safety conditions from signalling and interlocking principles using a SCADA model of a railway yard[3].The SCADA can be multi-tasking and are based upon a real-time database (RTDB)[4].

IV. BASIC PRINCIPLE

Figure 1: Basic principle

Track plans, such as presented in Fig. describe how these components are topologically configured. The operation of the various components in a railway yard is defined using control tables. These contain information about when a route can be set, positions of the points, and the aspect a signal should display. Control tables are responsible for enforcing the signalling principles. Route C from the control table is graphically depicted as a large arrow in Fig. Route C starts at signal s2 and ends at s4, and spans track segments ts4a, ts3a, ts2a, ts2b and ts1b. As a safety precaution, track segment ts0b is also required to be unoccupied before a train is allowed to enter the route. Track segments ts3a, ts2a and ts2b are also points; ts3a must be locked in the normal position and ts2a, ts2b must be locked in the reverse position. Points in this scenario are always moved together in pairs so that point ts3b must also be locked in the normal position before a train is allowed to enter the route.

V. EXISTING SYSTEM

Indian Railways is an Indian state-owned enterprise, owned and operated by the Government of India through the Ministry of Railways. It is the world's Fourth largest railway networks comprising 115,000 km of track over a route of 65,436 km and 7,172 stations.
A. **Train Traffic control**  
Railway control circuit are omnibus telephone circuits, which provides communication with each train working point. They should provide satisfactory and reliable communication between the controller and various way side station, important signal cabin, loco sheds, yard offices.

B. **Interlocking**  
An interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as junctions or crossings. Interlocking system used mechanical device both to operate the signalling device and ensure their safe operation. Electrical relay interlocking were used commonly.

C. **Communication System**  
The process of sending and receiving signal between two stations through different medium in known as communication system. In communication system there are three essential components that should be consider.

- Sending
- Receiving
- Medium

D. **Overhead Communication**  
Sending a payload of data (reliably) over a communications network requires sending more than just the desired payload data, itself. It also involves sending various control and signalling data (TCP) required to achieve the reliable transmission of the desired data in question. The control signalling is overhead.

E. **Underground communication**  
Communication is mainly comprised of transmission of data from the sender to receiver which may be in groups or from a train to another train, in which transmission deals with the amount and speed of the data through the transmitting medium.

VI. WORKING PRINCIPLE  
The working of the system is classified into three conditions. First let see the first condition.

A. 1st condition

The first condition indicates two trains and 4 platforms. Initially T1 train from the platform P1 will start, at that time the traffic lights turn green. When the T1 train is moving the T2 train will wait till T1 train clear the way. Also the traffic light turn red. Railway track is segmented for the easy analysing of trains. The trains will suddenly stop if it gets the red signal. Additionally after the passage of two trains the railway Gates can be opened and it allows the movement of vehicles. In this operation the T1 train will send a signal to the PLC which indicates that it is moving. Accordingly the PLC will send the information to the other trains. Also the traffic lights for moving train will be green, rest everything will be red for stopping of the other trains. Using this technology the easy movement of vehicles and trains is possible. The operations will become completely secured.
The block diagram indicates how does the PLC manages the complete operation. As we see in the figure the vibration sensors can measure up to 130 meters. So the movement of trains can be easily recognised. The PLC receives the signals from vibration sensors and Control the railway gates and the traffic light. The power supply is required for the working of PLC. The railway gate is being controlled by a stepper motor installed in it. These Motors will be programmed and controlled by the PLC. Opening and closing of railway gate is made possible by the controller.

B. 2nd condition

![Diagram](image1)

Figure 5: Three trains with six platforms

T1 starts moving according to traffic lights with the highlighted active route. T2 train will be stopped at segment ts6ab & T3 train will be stopped at segment ts4b with the red traffic lights. When T1 crosses ts6bc, T2 starts moving from ts6ab to P6 with traffic lights ON. T1 will be arrived at P3 with an announcement. When T2 crosses ts3bc, T3 starts moving from ts4b with traffic lights ON. RFID sensors detects the crack. Sensory details will be sent to PLC and the controller asks T3 to change the route. T3 changes the route as per the signals received from PLC.

C. 3rd condition

![Diagram](image2)

Figure 6: Crack detection

PLC sends route requests to T1,T2 & T3. Route request accepted by T1,T2 & T3. T1 starts moving according to traffic lights with the highlighted active route. T2 train will be stopped at segment ts6ab & T3 train will be stopped at segment ts4b with the red traffic lights. RFID sensors gets activated & checks for the errors. When T1 crosses ts6bc, T2 starts moving from ts6ab to P6 with traffic lights ON. T1 will be arrived at P3 with an announcement. RFID sensors gets activated & checks for the errors. T2 will be arrived at P6 with an announcement. When T2 crosses ts3bc, T3 starts moving from ts4b with traffic lights ON. RFID sensors detects the crack. Sensory details will be sent to PLC and the controller asks T3 to change the route. T3 changes the route and arrives at platform P4 with an Announcement.

When the switch clicks - Except T1, Every trains should stop at their red signals & T1 should reach at platform P3. With the movement of all other trains the T6 (Small) train will stop at segment ts4bc and make the way out for train T1. Accordingly the T3 train will stop at segment ts4ab and the T6 train will move from ts4bc to platform P4 and it stops. The T5 train will move from ts4b to platform P6. (When T5 is moving the T2 train will move from ts9b to ts6b). When T5 passes ts8c the T2 train will move from ts6b to platform P2. Finally the T4 train will move from ts6b to platform P5.
VII. PROPOSED WORK

The scope of this work is to develop the design of an automated railway signalling and interlocking system using Programic logic controller. The railway signalling system that makes use of the telecommunications between the train and the track equipment for the traffic management and infrastructure control. By means of the CBTC systems (Communications based train control), the exact position of a train is known more accurately then with the traditional signalling systems. This result in a more efficient and safe way to manage the railway traffic. It is capable of implementing automatic train protection functions as well as optional automatic train operation and automatic train supervision functions. By using the digital Radio Communication train made easy communication with each other. These types of digital radio waves carry the information regarding track details, train details, segments, destination etc. Radio communication systems sends signals by radio equipment involved in communication system includes a transmitter and receiver each having an antenna and appropriate terminal equipment such as a microphone at the transmitter and the loudspeaker at the receiver in case of a voice communication system.

The PLC will communicate with the trains by using digital radio waves. Also the Programmic logic controller can change the traffic lights Up to the requirements. The sensory signal will also be sending directly to the PLC to monitor the present condition. If the controller finds any errors or changes, suddenly it updates the information. So by using a controller train operators need not to communicate with other operator. The PLC will guide the train till its destination. The station master can update the PLC according to the requirement.

A. Components Required

1) Schneider PLC
2) Switch control
3) Power supply
4) CPU

B. Softwares Used

1) SCADA

C. Advantages of the Proposed Work

1) Make the passengers safe.
2) Reduce the human effort and accident occurrence probabilities.
3) Eliminate trains being delayed.
4) Avoid derailing.
5) Fast update of the relevant information.
6) Number of speed trains can be increased.
7) Easy traffic control.

VIII. RESULTS & DISCUSSIONS

The present existing system is manually and human controlled system. By employing the PLC for automatic control of railway trains would decrease the railway traffic. Also automating railway gate control at the level crossing, the time for which it is closed is less compared to the manually operated gates and also reduces the human labour. The accidents are avoided by using the stepper motor to open and close the gates automatically when it rotates clockwise or anticlockwise direction to operate the gate automatically by the PLC.

Apart from meeting the basic requirement of necessary safety in train operation, modern railway signalling plays an important role in determining the capacity of a section. The capacity decides the number of trains that can run on a single day. By proper signalling the capacity can be increased to a considerable extent without resorting to costlier alternatives.

The majority of the process allow actions to be automatically triggered by events. A scripting language provided by the SCADA products allows these actions to be defined.

IX. CONCLUSIONS

The automated railway signalling and interlocking system design will be a best Source of information in order to implement the hardware in railways. The aim of this project is mainly to eliminate major drawbacks currently facing. In the design the use of sensors and PLC makes the communication and also the detection easier than the traditional process.

REFERENCES

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