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Ensuring Fast and Safe Train Operation with Advancement Using PLC Interlocking

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ABSTRACT: With increase in demand for train transportation, train accident became a major problem. Secure train operation and monitoring can be established using interlocking. Presently, Indian railway has relay route interlocking which may fail due to human tampering or material failure. Replacing this with PLC based interlocking will avoid all this possible failure and even make this system more secure. This paper explains how PLC ladder programming is used to automatize and to improve track interlocking and signalization system in railways with extra security with help of working model made by our Team.

KEYWORDS: Rout Relay Interlocking (RRI), Programmable Logic Controller (PLC).

I .INTRODUCTION

The motive of Indian Railway is Zero accident, the lock and block system of train operation adopted by Indian Railways ensures the motto of Zero accident. The rules and conditions, framed for train operation are so rigid and safe proven that one cannot imagine the accident. But it doesn't come true on ground. Reasons are many, out of which important and unavoidable reason is Route Relay Interlocking adopted by Indian Railways to ensure conditions and logic of line clear. If this Route relay interlocking is replaced with PLC based system which is the subject of this paper, definitely accidents happened due to malfunctioning or tampering of relays will be brought down to zero. This sophisticated system based on PLC ladder logic detect the states of all input devices connected to PLC, execute the program logic and accordingly energize or de-energize all output devices connected to PLC[7]. In this system there is less number of relays and alterations/additions in the Rail yard is possible without much extra wiring. Further it will provide fast operation of points and signal which will ensure minimum loss of punctuality. It will also reduce man power, maintenance and costing of infrastructure etc.

II. NEED FOR THIS SYSTEM: EXISTING VS PROPOSED

A) Safety:

In the Railway Budget 2016-17, Mission Zero Accident was one of the Missions announced. Absolute safety in Railways is a topmost priority for the Government. Railway accidents not only lead to immense loss of lives and property, but also impact the psyche of general public for whom railways is a primary mode of transport.

Also In the Budget 2017-18, an exclusive fund called "Rashtriya Rail Sanraksha Kosh" (RRSK) has been made with a corpus of ₹1 lakh crore over a period of 5 years for giving a major boost to safety related works over Indian Railways[1]

In the PIB report published on 05.01.2018, IR has focused on two sub-missions:

1. Elimination of unmanned level crossings (UMLC) over broad gauge in the next 3-4 years.
2. Train Collision Avoidance System (TCAS) to prevent collisions and signal passing at danger by the Loco Pilot.

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In addition to Above 2 factors which are seen superficially important IR is having focus on improve signaling, electrical/electronic interlocking system with centralized operation of points and signals are being provided to eliminate human failure and to replace old mechanical systems.[2]

But one important aspect which is being ignored is "Failure and tampering of signal system "which is more important than Centralizing point operation.

From the statistical data of 80% accidents are happened due to human failure and 20 % due to tools / machine failure. If the root cause behind both the reasons is analyzed, it come out that , most of the accidents pertains to signaling system are due to tampering / failure of signaling system. [2]

Existing: The present system of signaling is not satisfying the requirement of safety, law breakers and mechanical failure still a major problem hence it is a need to find out the signaling system which doesn't allow tampering and which is fail safe.

Proposed : This project proposed the replacement of ancient Route Relay Interlocking with PLC ladder interlocking which is not only fail safe but can't be tampered in any way.

B) Cost Factor:

Existing: Present route Relay Interlocking is a combination of 1000s of relays with huge relays trays and air conditioned relays rooms which cost in Crores of Rupees for a single station interlocking..[4]

Proposed: As 1000s of relays and its complete infrastructure like huge room, ACs, Staff and Maintenance is being replaced by simple maintenance free PLC system, cost will tremendously reduced to an extent.

C) Man Power:

Existing: At Present system of Route relay interlocking needs huge maintenance schedule which need more and more skilled staff.

Proposed: In PLC based system, there is no maintenance and no man power needed as far as maintenance is concerned.

D) Delaying of trains:

Existing : 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 signaling and interlocking design can be implemented.

Proposed : as PLC switching action is fast and accurate, delay in operation can be eliminated and fast train movement is possible.

E) Detection of Rail Fracture:

Existing: In present system, tracks in yards are track circuited, so Whenever there is rail breakage in yards, path of signalling system got broken and system fails, in other words crack detected by the system But the same track circuiting is not available in block section and hence cracks in rails could not be detected automatically and one need to physically go and check the status which may introduce human error in the system

Proposed: The complete track can be track circuited and connected to PLC which will give alert whenever there is break in path i.e. crack in rail.

F) Gates:

Existing: There are 3 types of gate systems

A) Signal interlocked manned gates: Gate is provided with signal. When gate is opened, signal turns Red and when gate is closed signal turns Green. Operation of Gate is done by Gateman after taking order from Station Master through telephonic conversation and private number exchange.
Problem: Here if train dispatched in section but gateman did not close the gate, then signal will remain RED and train will stop in the section which causes delay.

B) Gate without signal interlocking but manned: In this case, station master inform the gateman to close the gate and gateman closes the gate but Loco Pilot don't know about the actual condition of gate as there is no signal prior to level crossing
Problem: If train dispatched in section but gateman did not close the gate, then there will be collision of train with road vehicles

C) Non interlock unmanned gates: In this case, there is as such no barrier, road users crosses the rail on their own. This is very dangerous condition and possibility of accident is very high.
In all above cases, there is only verbal telephonic assurance of closing of gate..Station Master passes the train on that assurance only. And this may lead to delayor accident.

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Proposed: The closing and opening of gate is interlocked by PLC based interlocking. So PLC will allow passing the train only after closing the gate. Even, if train is dispatched and later on due to miscreant activity if gate opens, then also, train can be stopped automatically by switching of power supply of OHE through PLC

III. EXISTING SYSTEM OF RRI

There are 5 different train operation system adopted by IR out of which mostly used system is Absolute Block System: Only one train can be send in the block section from station at a time. System is 100% secure to avoid entry of 2 trains on same line. Once the train departed from station in the section, the Lock and Block system get activated and put Starter Signal to RED which cannot be turned to Green unless, section ahead is clear of train.[5]

To ensure this, Route Relay Interlocking System is used in IR. Route Relay 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.

For dispatching train in section ahead, following conditions are required to be completed:

A) Points and crossings of Line on which train is passing are set and Lock to proper route.

B) Line ahead is clear of any obstruction. I.e. section is unoccupied.

To ensure these 2 conditions, huge network of points and crossings of different lines in the route, a long list of mechanical and electrical interlocks is involved. If we see the Relay Room of Station with 2 ML & 2 LL approximately 500 nos. Of relays are engaged to prove the system is set to move the train. More over Axle counter arrangement also needed to count the wheels entered in the section ahead and wheels exit from the section.

A) Operation of points:

To set the direction of traffic, points are need to be set to desired lines, these points are either set manually or by point machines. These point machines gets signal from cabin man / station master through RRI system.

B) Setting Routes:

To set the routes for particular train, a pre defined path is selected by station master or cabin man, required comment is given to RRI system , and RRI system set the points and crossing in that route as per need of train operation. This can be visualized in station masters panel.

C) Axle Counter:

Axle counters are used to count the wheels entered in section and exit from section. By this system can understand whether section is free of vehicles or occupied. Block section is the section between Last stop signals (Departure Signal) of one station to first stop signal (Reception signal) of another station. Axle counter is fitted just after LSS and FSS. These 2 axle counters are interconnected though cables and ensures occupancy of section.

D) Signalling:

As per predefined conditions of line clear signalling logic, sets the route and signals accordingly to guide the train. [4]

IV. WORKING PRINCIPAL OF PLC BASED SYSTEM

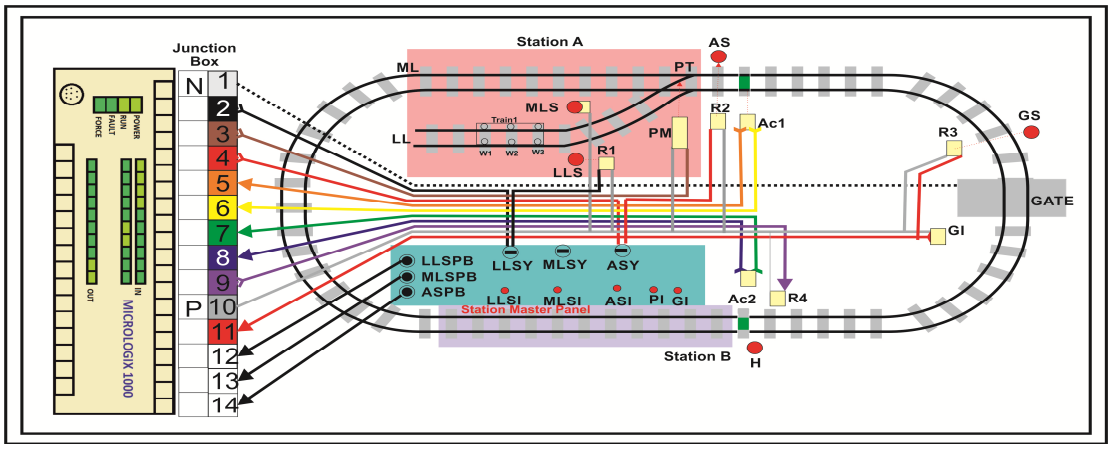

Figure1: Train movement

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Here there is an explanation of simple movement of train i.e. to dispatch train standing on LL to Main Line and then to block section ahead.

Conditions for Dispatching from LL to ML:

Whenever Station master wish to dispatch a train standing on LL to ML and Then to Section ahead :

A) SM will first give command to PLC system to set the route by pressing LLSPB & ASPB simultaneously.
B) In PLC, there is pre defined logic set for different operations and setting of routes accordingly.
C) PLC will ensure following as under :
   i. PLC will send supply to PM and will set PT
   ii. PLC will send supply to switch LLSY and LED LLSI - it indicates that LLS can be given
   iii. PLC will check AC1 , AC2 counters and Gate status GI – if counter proves that section is un-occupied and GI ensures that gate is closed then -
   iv. PLC will send supply to Gate signal and gate signal will Green
   v. PLC will send supply to switch ASY and LED ASI - it indicates that AS can be given
   vi. After satisfying that LLSI, ASI , PI and GI are glowing , then -
   vii. Station Master will press LLSY and ASY to give LLS (Yellow) and AS (Green) to Train standing on LL

Once the train passes the signal, signal LLS and AS will go automatically Red for following trains. And the system will set all signals to Red signal for next operation.

SM: station master, LL: loop line, ML:main line, LLSPB: loop line starter pushbutton ,ASPB: advance starter pushbutton, LLSI: loop line starter indication ,LLS:loopline signal, GI: gate indication, ASY: advance starter yes, AS: advance starter PM: point machine,

V. ADDITIONAL FEATURES WHICH ARE NOT AVAILABLE IN EXISTING SYSTEM

This is normal replacement of existing RRI by PLC, here following additional features can be added in the system to make it safer and accident free operation:

A) If Loco Pilot crosses the Red signal, PLC logic will identify the operation of axle counter even when train is not allowed to pass, It will immediately trigger the safety hazards with alert/warning and give command to Power system to switch off the OHE supply and in case of diesel train PLC logic will guide the train to empty line or sand hump.
B) If the complete track is track circuited or crack sensors are fitted , then in case of crack in track, PLC will not allow to move the train and will cut the OHE supply to stop the train already moved.
C) If gates are interlocked with PLC system, in case of boom damaged by vehicle or unauthorized opening of gates by gateman in face of coming train, the OHE supply will be cut off by PLC system to stop the train. [12]
D) In case of any failure either of signaling apparatus, point machine or point defects or itself PLC, the system will be automatically set to failsafe i.e. the signal will goes to Red to avoid any unsafe.
E)

Model Requirement:

- PLC Allen-Bradley's Micrologix 1000[11]
- Software: RSlogix micro starter lite[8]
- RS232 cable
- LED signals for indications
- Interfacing relays
- Power supply
- DC motors for track changing and level crossing
- IR sensor
- Hooters for alert/warnings

Figure2: Point crossing and track circuit.
Push pull actuator
input: 12v
lead length: 15cm
shift: 10mm

Figure3: Micrologix 1000
total input signals : 20
total output signals : 10
input voltage: 24v
output voltage: 24v
power supply :24v / AC 230

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Figure4: RRI Cabin of Nagpur, Central Railway[5]

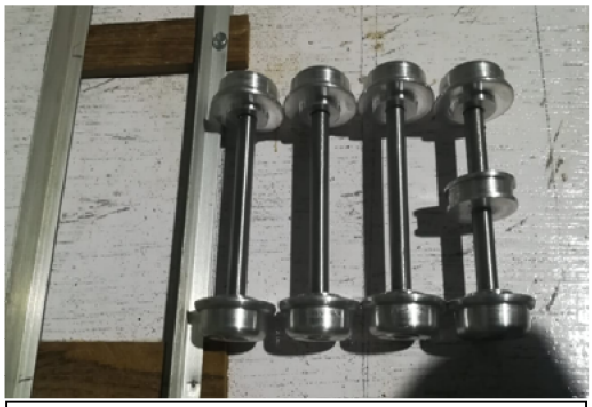
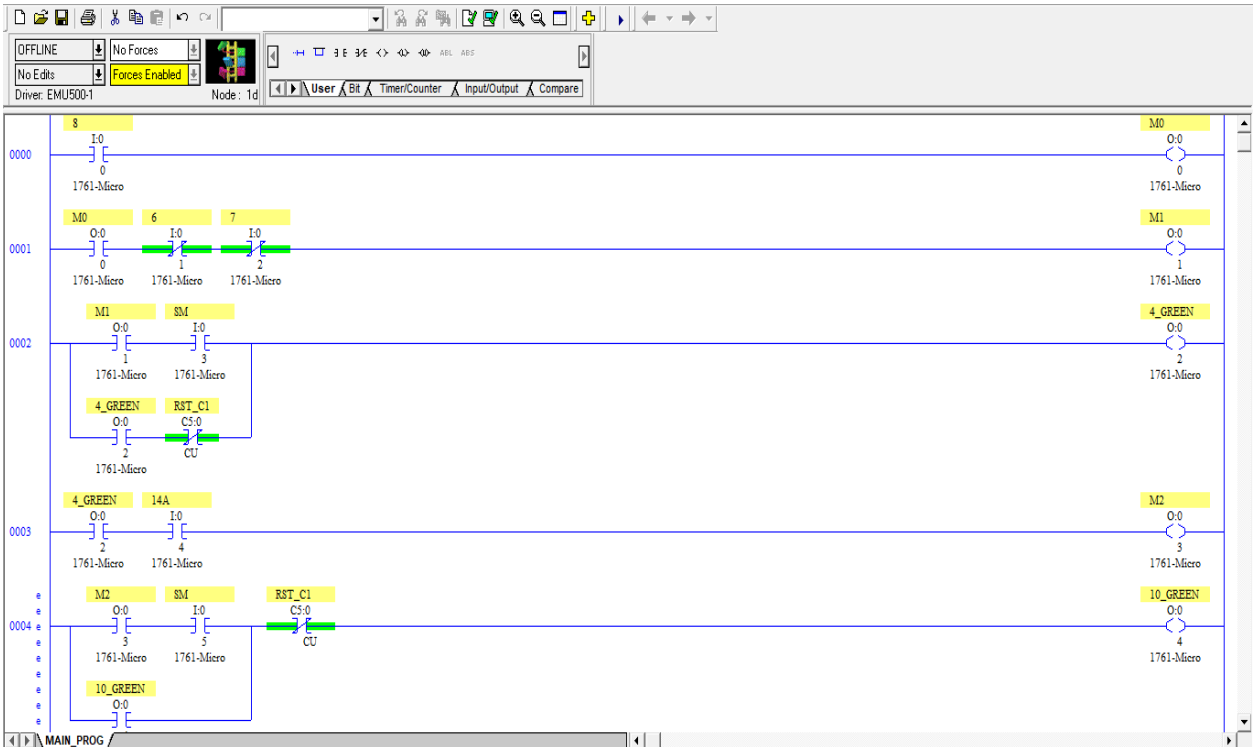


Figure5: mini wheels
Axle length: 5.5cm



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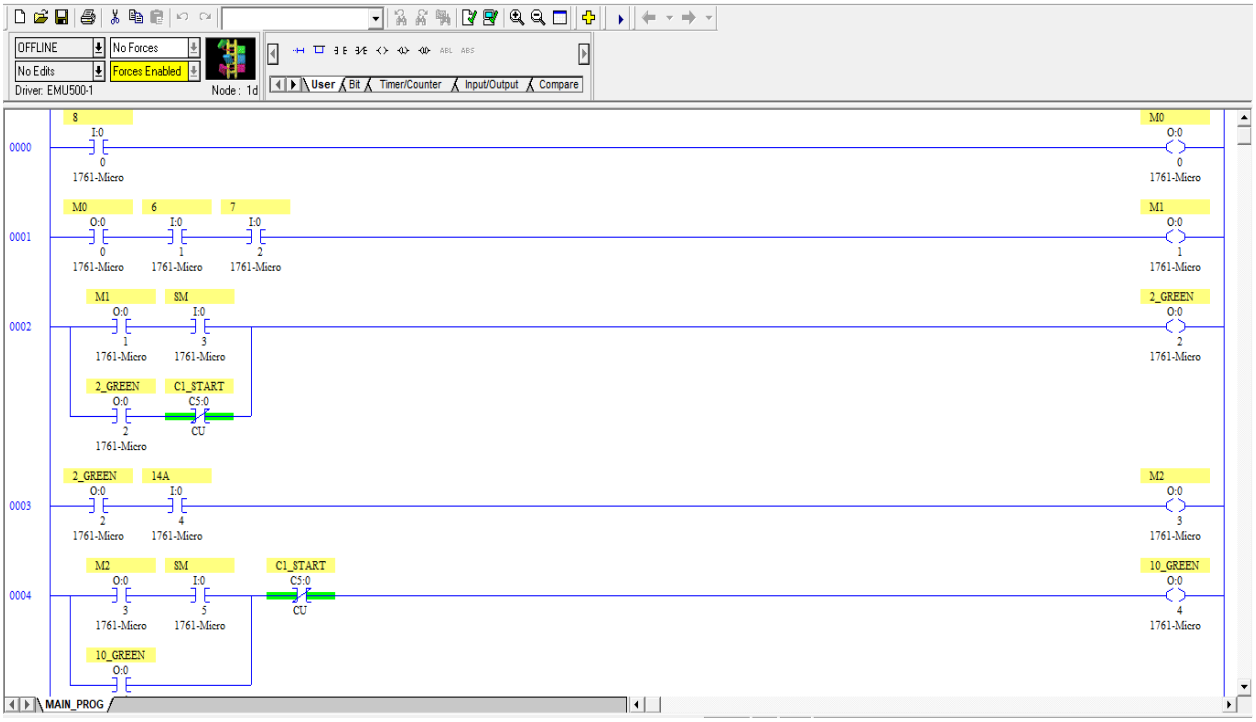

Figure6: ladder logic [10]

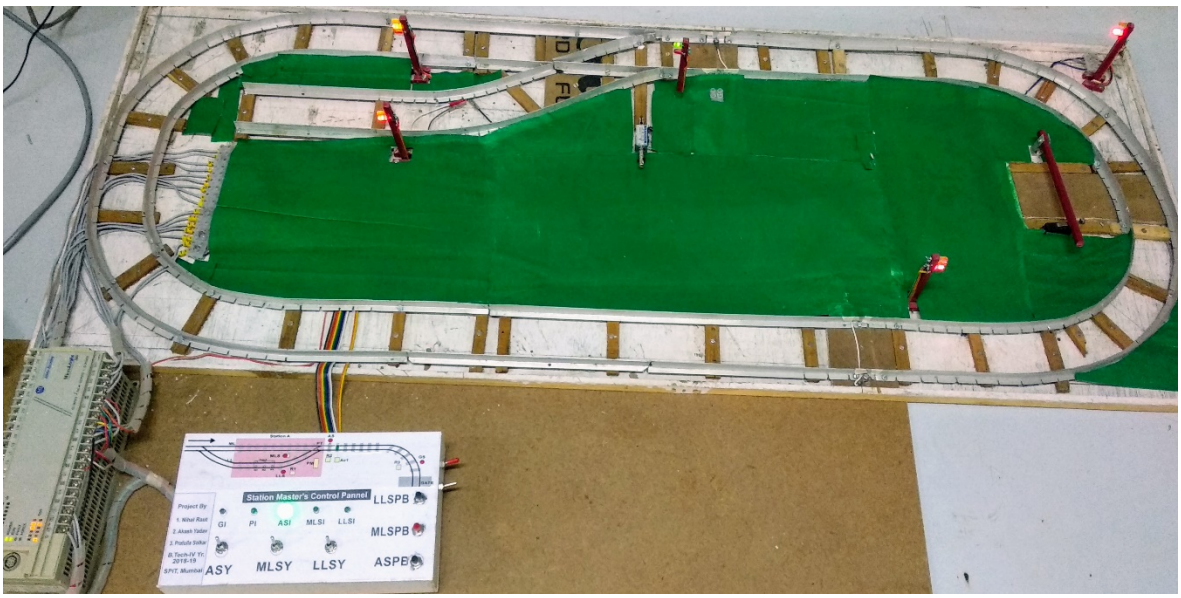

Figure7: Working Model made by our Team

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VI. CONCLUSION

By using PLC based signalling system for train operation, majority of drawback of RRI system is overcomed and enhancement of Safety in train operation with reduction of Man powers, cost and failures is achieved. By introducing role of station master will solve priority problem and delaying of train, additional features make the system advance and less prone to failure. Troubleshooting will no longer be an issue. Hence being one of the largest railway network and having lots of wayside equipment failure and accident can be brought down to great extent with PLC

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