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HEALTH MONITORING SYSTEM FOR RAILWAY TRACK AND POINT CIRCUITS

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Abstract-Track circuit ascertains the occupancy/clearance of a track section in Indian Railways. Point is required to divert train from one track to other. Track and Point Health Monitoring unit is a micro controller based wireless system which provides the information about point and track circuit. The system gives the currents and voltages taken by DC motor and the leakages between feed end and relay ends by measuring the voltages and currents across the ends. The record of Track parameters over a period of time can be useful for monitoring the deterioration of track behaviour like increased leakages over time line. The record of Point parameters over a period of time can be useful for monitoring the deterioration of various parts of the point machine and also dry slide chairs of the point over time line. This monitoring reduces the MTTR and increases the MTBF which is cost effective for the railways.

Keywords: Point, Track circuit, Mini Logger, Event Logger, Zig Bee, Sensor

Introduction

On 16th April, 1853, the first train service was started from Bombay to Thane. The Indian railway network is the world's 3rd longest railway network. Many accidents are taking place and some of them are due to the problem in control circuits. The proper maintenance/monitoring of the control circuits such as track circuit and point, the unsafe conditions can be reduced.

Point:

Point is required to divert train from one track to other. Point is operated by station master from his Room.

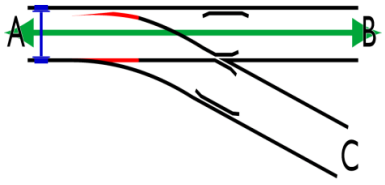

Figure 1. Point with switch rails showing movement of direction

In the above diagram red marked part is called switch or tongue rail. A point has a pair of switch rails – one open and the other closed. A closed switch diverts train from one line to other.

The above point is said to be set to normal – i.e. train can move between A and B. When point is set to reverse [left switch in the above diagram closes and right switch opens] train can move between A and C.

Figure 2. Point with DC motor

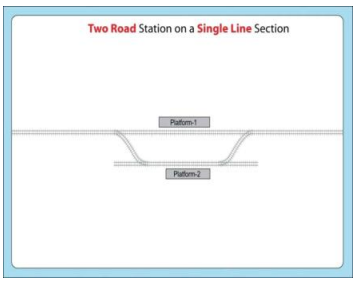

Figure 3. Road station on a single line section

In the above diagram Point normal means it is set to main line – reverse means set to loop line. [Platform 1 line is called main line and the second one loop line].

Point Operation:

Point is operated by electrically by DC motor or mechanically by steel rods connected to a lever. Point is operated by a two position switch or two buttons from panel or with a lever from cabin by station master (SM). The SM will operate the point according to the movement of train .Then the relays will operate according the knob operated. Since the relays are in interlocking state, they will be operated with the operation of single knob. Point normal and reverse indications are given to Station Master by LEDs.

DC Track Circuit:

DC Track circuit is extensively used in proving the occupancy/clearance of a track section on Indian Railways.

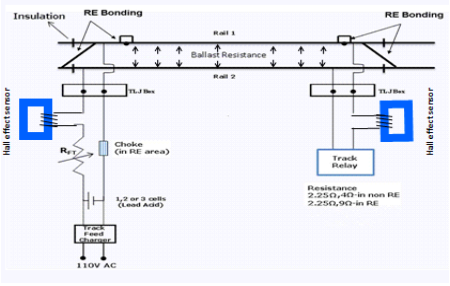

Figure 4. DC Track circuit

Track is divided into sections of maximum length of 450m. Each section is given a name– name comes from point, signal or road. Power is given at one end and collected at other end by a relay called track relay. Both rails are to be insulated from each other.

Track circuit operation:

When a train enters the section its axle shorts both the rails and prevents energy reaching the relay. When train vacates the section, energy is restored back to the relay. Insulation is provided at each end of track section to prevent power leaking from one track section to other. Power supply voltage is about 10V for track circuit and the Relay requires about 1.5V. Track circuit fails in case of rain as both rails are shorted by water. Even though the track is vacant it shows occupied. This monitoring process is simple, cheaper and easy to maintain .

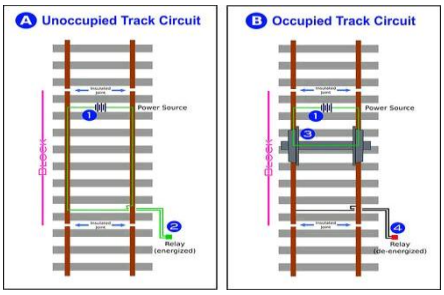

Figure 5. Track circuit Operation

In the above Figure A, the green line indicates the energy flowing from power source to the relay. When train shunts the track, shown in Figure B, the energy will be shunted by the wheels of the train .With this the railway staff can know the movement of the train in the station.

Problem Domain

In the previous section the operation of point and track circuit are explained. In this section we are going to explain the faults, associated with point and track circuit due to the improper maintenance.

Faults in point operation:

The point motor gets obstructed between the stock rail and tongue rails. If there is any obstruction between the tongue rail and stock rail the point will not set. So the train movement in that route will be cancelled. Due to the improper maintenance of the rails, sometimes the motor will take more time than normal operation to lock the point.

The friction clutch of the motor is generally used for overload protection of the point motor but when the friction clutch is worn out the point motor does not apply pressure on the switch rail. The point does not operated because of supply not extended to the locations.

Faults in track circuit operation:

Even when the track section is not occupied by a train, some electrical energy is lost in the rails because of the imperfect electrical insulation of rails with sleepers, ballast and earth and the resistance offered by rails. Unless such electrical leakage remains within "permissible limits" the track relay drops because of insufficient energy and causes "track circuit failure". There is also a limit for the maximum energy that can be received by the track relay. If that limit exceeds, the track relay may not drop even on the occupancy of the track section by a train. This leads to more serious "unsafe side failure".

Design Methodology

The main modules of this work are Mini Logger(ML), Event Logger(EL), Failure Analysis System(FAS) and Data Logger(DL).The Mini Logger logs the voltages, currents and digital inputs from the Point and Track circuit using Hall effect sensor and transfers data to the Event Logger for processing, through Zig Bee communication [1]. The EL send data to FAS for analyzing the failures and to the DL for recording.

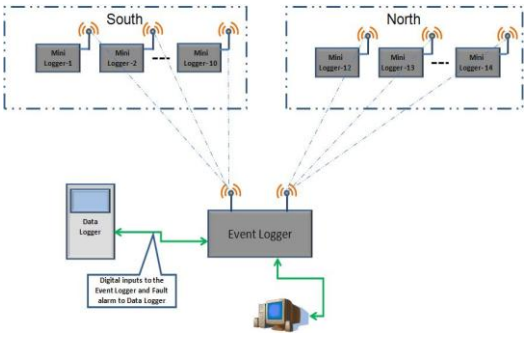

Figure 6. Architecture of the proposed work

Mini Logger:

This is capable of monitoring the Current and Voltage parameters of point machines and this acquired data will be sent to Event Logger through Wireless communication. Mini-logger is at the relay room to collect the data at the

site with respect to point and track circuit. Mini-logger sends the gathered data to the Event Logger with the help of Zig Bee. Mini-logger consists of 2 modules:

1) Processor module
2) Sensor module

Processor module:
This module process the input's coming from sensor module. The processor module requires 24V DC (18-32V Range) with 180mA Current for its operation.. To process the data the module uses 32 bit ARM controller [2].

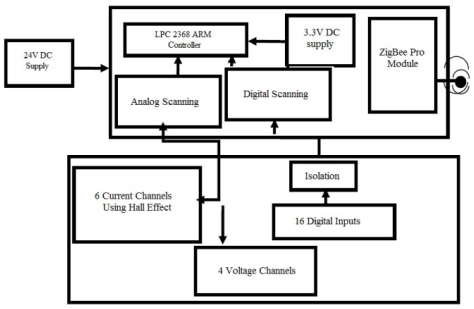

Figure 7. Architecture of Mini Logger

Mini Logger contains 4 voltage channels, 6 current channels and 16 digital inputs from the relays. Out of 4 voltage channels, two are 9v channels used for the track circuit operation, one 24v channel for giving the motor status to the station master(SM) when the SM operate the point from the panel room, one 110v channel for the point operation.

6 current channels can be used for both point and track circuit operation. The current readings are measured through the hall effect sensor LA 55P [3]. To know the status of the relays of both point and track circuit, 16 digital inputs are connected to the Mini Logger from the relays. The location box temperature is measured for every minute using DS1631 temperature sensor [4]. All this data is send to the Event Logger using wireless Zig Bee communication. The Zig Bee in the Mini Logger is configured as a router.

Sensor Module:
Sensor module plays key role to measure the currents, voltages and digital inputs. This module works with 24V DC. Sensor module is interfaced with processor module with the help of ribbon & FRC connector.

Event Logger:
The Mini Logger sends data to the Event Logger using wireless communication and this data is further validated, processed and stored in non volatile memory and same will be sent to failure analysis system and also to central place through data logger network. The controller used is 32 bit ARM based micro controller for receiving and transmitting the data. It works on 24V DC with 200mA.In this master unit the Zig Bee is configured as coordinator so the data coming from mini-logger is collected by the Zig Bee and sends to the LPC2468 controller [5]. The NAND Flash is used for the storing the data received from the Mini Logger, whereas SD RAM is used for data processing purpose.

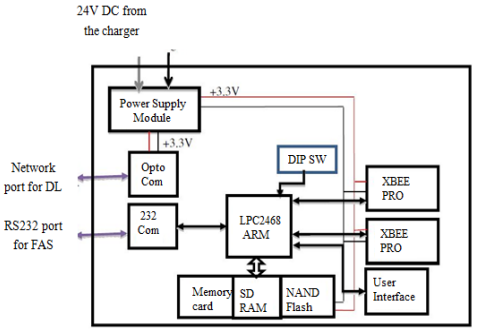

Figure 8. Block Diagram of Event Logger

Failure Analysis System:
The failure Analysis System is a specially designed for analyzing the Point and Track circuit operations .It retrieves the data from the Event Logger, process it and generate report and graphs which represents values which are logged by the Mini Logger. This System can generate the report in on-line and offline. Generally the faults will be taken by comparing with normal state graph Faults in point operation. When point is operated normally then the current signature of motor is as below. Normally the point operation will take 3sec to operate and draws current of 2A.

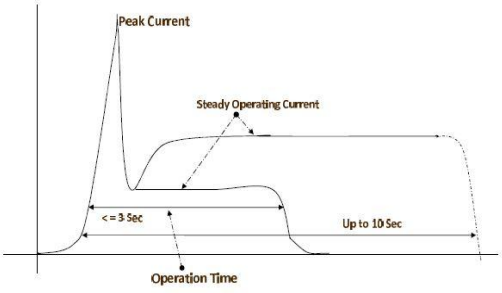

Figure 9. Current signature analysis of motor

Experimentation

Currents Measurement:
The objective of this work is to monitor the currents at point and track circuit. To do this we use Hall-effect sensors to measure the current. Based on analysis and requirements the measuring of currents at a location box is 6 types. so, we use 6 current sensors to monitor.

The sensors are wounded with 28 strands and 8 turns for track and 32 strands and 1 turn for point. The difference of turns between track and point is because the track circuit will operate the current of 250mA to 350mA range and the point operates at 3Amperes range, so to get the accuracy

the turns are rounded. The direction of winding should be according to the mark on sensor.

The sensor windings are tapped in series with the track circuit and the dc motor. The placing of sensors is different with different types of points.

Voltage Measurement:

In this work, we measure 4 DC voltage channels 2 for the track voltages,1 for point operation and the other for point detection. Two 9V DC channels are used for measuring the charger voltage or battery voltage. The voltage values can be measured using voltage to frequency converter AD7740 [6].

One channel is used for measuring the point operating voltage i.e,110V DC channel. The other is 24V DC channel which is used to measure the point detection voltage.

These 4 dc voltage channels are electrically isolated with one another. These channels are connected parallels to the systems at location box. The isolation between channels improve the Efficiency of the measuring system and avoids damage to the channels. The measured value is send to the processor module.

Digital Input Measurement:

Digital inputs measurement is the record of relays operated in the location box. With the help of these digital input we can identify the faults in operation of relays by comparing with relays operated in relay room and analog records created at location box. In our work there is provision for connecting 16 relays, these 16 digital inputs are potential free contacts. These 16 digital channels are electrically isolated using KP1010 isolator [7]. this connection is given to the wago connectors.

Results and Discussions

Online Results:

These are the results that could be observed at online in real time. Which gives the present status of point and track circuit to the station master in the panel room. Generally track circuit operates in the current range of 250mA to 350mA. Figure 10 shows the status of various track circuits in the station. The track circuit which has current range less than this specified range will be considered as low energization circuit this will causes wrong indication of presence of train. Low energization is caused due to the heavy leakage between the feed and relay end's. This gives wrong indication for station master as it is occupied by the train. This causes delay in the train movement. When the energy from the feed end is set to high value then the relay will be in pick-up state even when the track is in occupied state this is un safe fail condition which causes accident.

When the feed end current compared to previous adjusted value increases then the energization levels are between 100 – 150%. This is due to low ballast resistance. When the feed end current reduces compared to previous adjusted value then the energization levels are between 100 – 150%. This is due to high series resistance due to bonding or terminations energization level. when the Relay energization increases between 250% and 300% alarm is generated. A second alarm is generated when it goes beyond 300%.

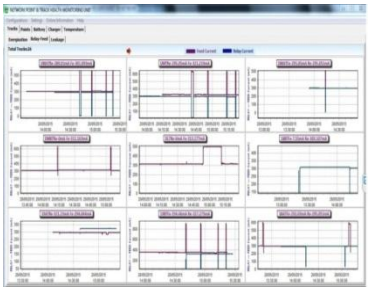

Figure 10. Track Circuits of Wangapally

Figure 11 shows the effect of rain on the track circuit behaviour. This indicates that the train is there on the track circuit but actually not. Due to this project this problem can be identified and solved in less time so that MTTR was decreased and MTBF was increased.

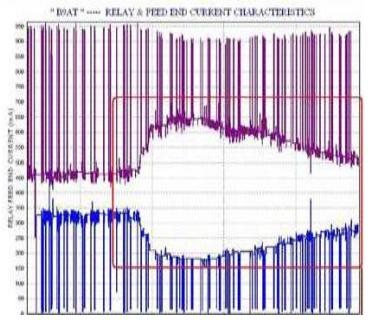

Figure 11. Track Circuit Current due to Rain

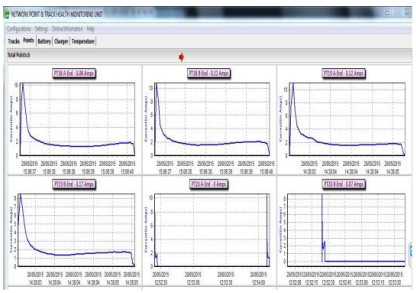

Figure 12. Status of various Points

Figure 13. More Initial Peak Current of Point

Initial peak Current is the characteristic of the motor. If this current persists for more time it may cause burning of the winding. This failure will cause damage to the motor and the motor should be changed frequently.

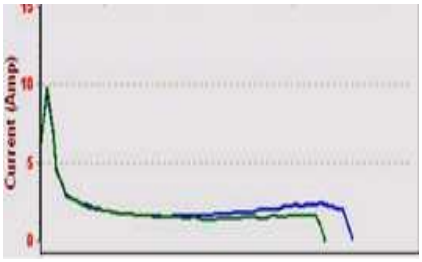

Figure 14. Point Machine Operated more Time

This problem occurs due to the improper maintenance of the rails. When the point is operated the motor will take more time than normal operation to lock the point.

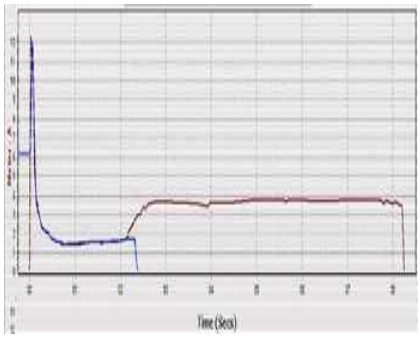

Figure 15. Point Machine Obstruction

If there is any obstruction between the tongue rail and stock rail the point will not set. So the train movement in that route will be canceled.

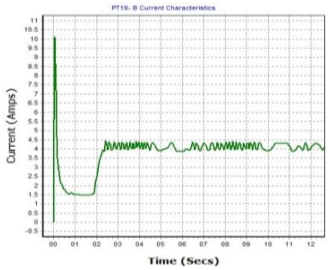

Figure 16. Point Machine Obstruction

Offline Results:

Offline results are used to analyze the behaviour of point and track circuit for continuously over a period of time to know their behaviour. The explanation is same as discussed in the online results

Figure 17. 11BT Track circuit Operation

The above graph shows the track occupancy by the train. The digital value is status of the TPR. When TPR is down the feed end current should be high and the relay end current Should be low. If the track is in unoccupied state TPR will be UP, feed and relay end currents maintain at same levels.

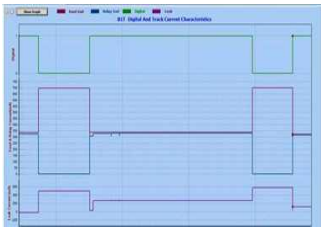

Figure 18. 11BT Track circuit Operation

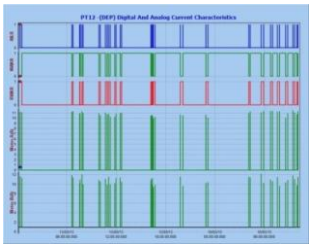

Figure 19. Point Operation

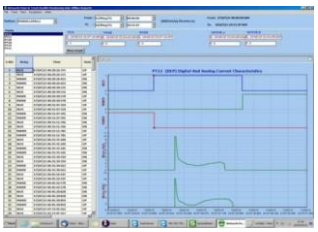

Figure 20. Ideal Point Operation

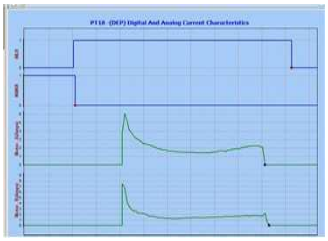

Figure 21. Ideal Point Operation

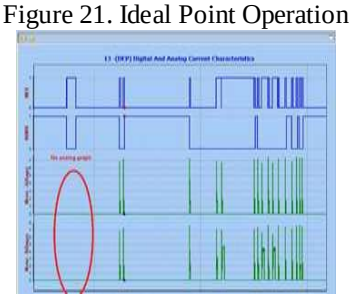

Figure 22. Point Not Operated

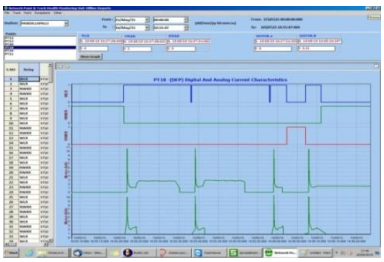

Figure 23. Point Obstruction

Conclusion

Health Monitoring System For Railway Track And Point Circuits plays vital role for monitoring the health of point and track and this is helpful in railways to reduce the MTTR and increase the MTBF. Record of track parameters over a period of time can be useful for monitoring the deterioration of track behaviour like increased leakages over time line. Record of Point parameters over a period of time can be useful for monitoring the deterioration of various parts of the point machine and also dry slide chairs of the point over time line.

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