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SMART RAILWAY NETWORK

MONIL SHAH, SANKET PADWAL, SOAMIL VORA & JIGAR KAPADIA

B.E., Department of Electronics and Telecommunication, Dwarkadas J. Sanghvi College of Engineering, Mumbai, Maharashtra, India

ABSTRACT

Smart Railway Network's (SRN) future is based on mobile communication and its ability to overcome fixed blocks so as to increase the utilization of tracks and interoperability throughout India. We have formalized various scenarios like the automatic announcement, expected minutes of arrival and centralized control of the system that would help provide a better understanding of the requirements. Data processing board on the train is a crucial factor for safe and efficient operation. We have structured the formal specifications of the behavior of each module hierarchically. An easily understandable documentation for the developers and customers; also, the simulation and automatic validation at every development stage is possible, hence increasing the safety and decreasing the financial requirements.

KEYWORDS: 89C2051, Infrared Sensor, VB 6.0

INTRODUCTION

Earlier system of manual exchange of train movement information from train to control office did not provide much assistance to the Controller to take timely and optimum decision for train controlling in case of any unusual event that puts operations out of gear. Similarly, timely information to the Assistant Station Master (ASM) was also not available for ensuring correct displays and announcements. To overcome this problem we come with the new technology of Smart Railway Network (SRN). Smart Railway Network project envisages "On Line" operation of the existing Train Indicators at various stations and also provision of Passenger Information System in the form of Video Display Units at the station entrances for indicating the train running information to the commuters. The SRN system primarily provides 'ONLINE' display of movements of all trains with Train Numbers/Rake numbers on video monitors as well as overview indication panel, located in control room. Interfacing with the train indicator boards at various stations for displaying expected time of train arrival information to commuters. SRN provides the video display units for current location of the train to commuters, with countdown in minutes. Interfacing with the announcement system for facilitating auto announcements, automatic recording and retrieval of train movements like Automatic time stamping of the train movements. It provides remote control operation of signaling interlocking system of two stations- Dadar & Goregaon.

It also generates management information system reports and statistical data, Offline planning tools like Time Table building and Simulation. SRN is compatible for future expansion, for provision of remote control operation of signaling interlocking system, providing additional workstations and public display system. As part of it, Radio Train Mobile Communication between Motormen/Guards of Suburban Trains and Controllers at Mumbai Central has also been catered for. SRN is a computer-based system located in the control office, which collects signaling status information (status of signals, points, track circuit etc.) from the various stations interlocking in real time basis. It also collects train identification information (train number, rake number, name of crew and platform number) from the train originating station, where it is manually fed. Display information is also available on a big rear view MIMIC indication display located in front of the controller, covering the entire section of Churchgate - Virar.

SRN ARCHITECTURE

The application servers and the associated unit, forming the master control equipment shall be located in the equipment room of the control centre. It is the main processor and heart of Smart Railway Network, controlling and supervising various activities of the entire system. The master controller is connected via optical fibre link with the entire station signal interlocking through REMOTE TELEMETERING UNIT called EBISAT. The information/status of track circuits, signals, points, route set etc. are transmitted from wayside stations to master controller. DEC's ALPHA 1000A Series Servers & Work stations constitute the heart of SRN. In all five servers are installed with Primary set comprising 2 servers in load sharing mode and other two in hot standby. The fifth one is Off Line server for Offline activities like time table building and simulation etc. To provide redundancy in data storage, RAID 1 configuration has been employed for organizing various hard disks on ALPHA Servers. These servers are connected in a dual FDDI ring (fig1) on Optical fiber on 100 MBps and various workstations are connected in star configuration on Optical fiber. The connections to Workstation from Fiber Hub (concentrator) to workstations are also dual to provide full redundancy. The workstations are connected in star configuration on fibre with dual FDDI connection so that in case of failure of one of the channel, workstation is still connected to the network.

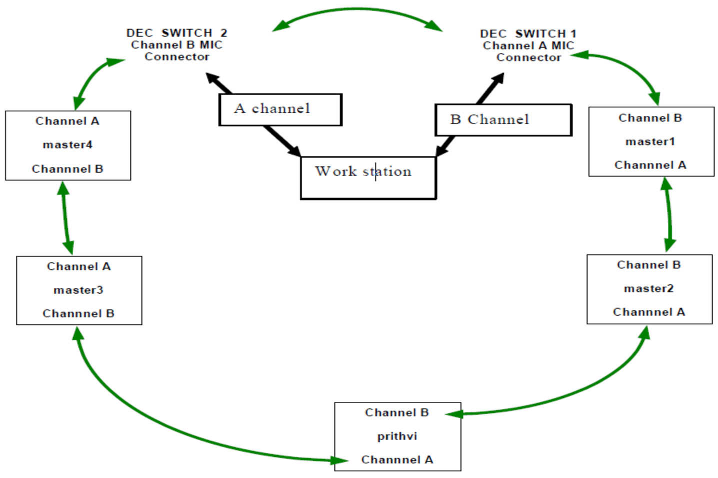

Figure 1: Dual FDDI Ring

As shown in figure 2 for overview of live train movements, track layout, status of points, aspect of signals, level crossing gates etc, Rear Video Projection Screens of M/s BARCO, Belgium have been installed in the SRN Control Room. The real time train movements on the 11 M Rear View Projection Panel are assisting our traffic controllers in efficient management of intense suburban rail operations. Any yard layout changes occurring can be carried out with ease through software requiring no expensive and time-consuming hardware modifications.

Figure 2: MIMIC Wall Display

TRACKING AND SIGNALING CIRCUIT

The signaling system governing normal operation of railways should constantly govern the train movement of the train, condition of the tracks, status of various signals on the tracks and the mechanism by which the train changes its track. The signaling system is based upon 'fail-safe' control. This includes interlocking which prevents the system allowing conflicting or dangerous moves to be made by trains. For example, a signal will not allow a train into a section if there is a train already occupying that section. One requirement of this interlocking is being able to determine where trains are on the track, and whether a particular part of the track is occupied by a train.

Track Section

Every length of track in a signaled area is split up into logical sections called 'track sections' or 'blocks'. For example, on the western line, each track section is about 150m long. 'Absolute block' refers to a system where the track is considered to consist of a series of sections, such that, when one train is occupying a section of track (the block section), no other train is allowed to enter that section. This is the most widely used system for ordinary train routes. In this case, a signal is placed at the start of each track section to indicate whether the section ahead is 'occupied' or 'clear'. The signal will not allow a train to enter the section unless it is 'clear'. Another example is track section containing a set of points. About 1 to 5m of track going in and out of a set of points might be one track section. This section would therefore need to be 'clear' for the points to be changed.

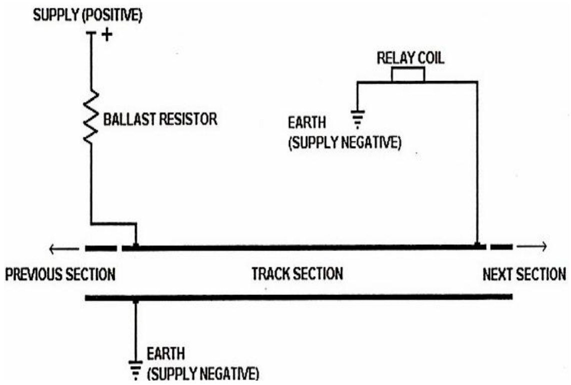

Figure 3: Track Circuit

For the state of the track sections (clear or occupied) to be used, to prevent or allow signals and points to operate, the state must be detected electrically. This is done using 'track circuits'. The requirement of the track circuit is that an electrical relay (electrically controlled switch) should be on if the track section is clear, or off if the section is occupied. This relay allows other electrical interlocking systems to 'know' whether that track section is occupied. To allow the relay to be turned on requires a power supply. Essentially, the circuit works by applying a voltage across the two rails in a track section. This voltage powers the relay. If a train enters the section, the wheels and axles make an electrical connection between the two rails and the voltage drops near to zero, turning off the relay. The relay will not turn on again until the last axle of the train has left the section regardless of the train length. Obviously, this system will only work when wooden sleepers are used, as metal sleepers would also make an electrical connection between the two rails, preventing the circuit from working.

Signal Control

The following is a circuit for an automatic signal (simplified). The main components of the circuit are:

The signal- It has one red light and one green. It is automatic, i.e. it is not controlled by a signal-box.

The track relay: As explained above, the relay turns on when the track is clear and off when the track is occupied. The relay contains a set of hang over contacts. (NO and NC).

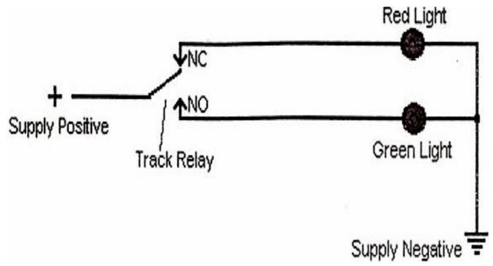

Figure 4: Simplified Automatic Signal Circuit

When the track is clear, the track relay is on and the NO contacts connect the power to the green light. If the track is occupied then the relay is off and the NC contacts turn on the red light. This signal works purely off the track relay and is not controlled by a signal person. The main components of the circuit in signaling system is given in the figure 5

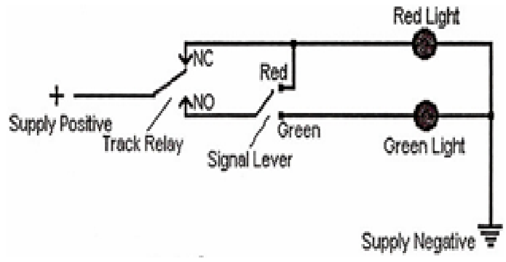

Figure 5: Signal Controlled Circuit

The idea of the circuit is that when the track is clear, and the signal lever is set to the green position, the signal goes green. If either the track is occupied or the signal lever is set to red, then the signal will be red. The signal person cannot set the signal to green if the track is occupied. The restriction on more than one train or rake occupying a block section is stringent and can be lifted only in very special circumstances, some shunting operations, for repair and maintenance work, or emergency operations. For instance, a material train may be sent into a block section that already has other departmental vehicles on it. A traffic train may be sent into a section that has an inspection trolley on the tracks. In all such cases, appropriate caution orders are issued to the drivers of the trains involved, and the driver of any vehicle that is proceeding into the block section in contravention of standard block working rules must carry the appropriate authority to proceed. Within station limits, however, trains may be moved around by the signalman or station master without reference to other stations or signal boxes, and in fact, depending on the rules for station working in effect for the station, shunting operations, calling-on signals, etc. may allow more than one train to occupy a section of track within station limits. There are many stations where two full trains are routinely moved to the same track, to use the same platform.

Fail-Safe

A 'fail-safe' system is one in which, by virtue of its design will fall into a 'safe' state if it fails. It does not mean the system will not fail or be faulty. Rather, it means that when the system does fail (it is always assumed to fail at some point in time), the failure will not cause an unsafe state to exist. An example is the simply controlled signal circuit. If the relay of track circuit fails, it will fail in its off state (this is an accepted fail state of a relay that is used within its allowed limits).

The relay being off will keep the signal red. If the control switch fails by not making a connection, either the red light will not work, or the green light will not work. A signal with no lights ON is regarded by our operating rules as being at 'stop'. If any of the wiring associated with the signal breaks, once again one of the lights will not work. A failure in the circuit will not cause the signal to go green. This would be called a 'wrong-side failure'. The only exception to this is failure of the earth rail in the track circuit, which, as explained above, is unlikely. All of the interlocking systems are designed to be failsafe. If something goes wrong, it will usually only result in a signal not clearing to 'proceed' or being unable to change points remotely. These are fail states that are preferable to signals being green with a train in front of them or points changing under trains.

DESIGN AND IMPLEMENTATION DETAILS

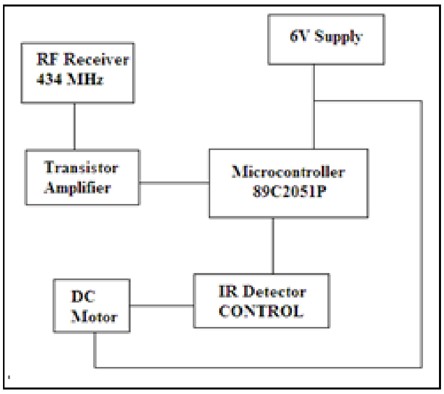

Figure 6: Functional Block Diagram of Train Controller

Microcontroller (89C2051P)

It is to count RF pulses that are being received. When more than 10 pulses are counted the microcontroller activates the motor driven by transistor. If the IR transmitter is on, it deactivates the motor causing the engine to stop. If the pulses counted are less than 10 within two seconds span, motor is deactivated.

RF Receiver

It uses 434 MHz ASK receiver to receive pulses. The engine is active only when it gets pulses from station controller.

IR Detector

The TSOP17 is a miniaturized receiver for infra red remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter. The demodulated output signal can directly be decoded by a microprocessor. 35 KHz pulses are given to enable the detector.

TRAIN CONTROLLER FLOWCHART

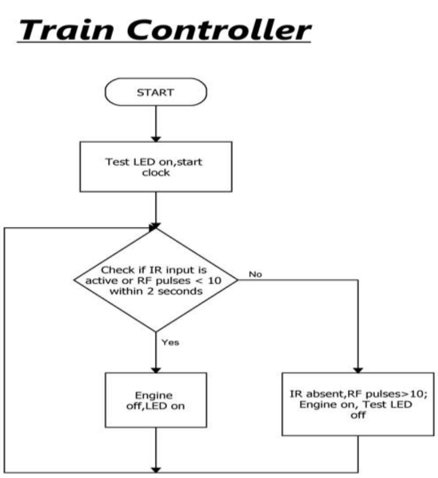

Figure 7: Flowchart of System

The train controller looks for the IR signal after every 2 seconds and also checks the position of train, if the track is empty or not for the train to be entered in the next section.

RESULTS

The VB6 based GUI provides on-screen real time monitoring of the trains relative to their position on the track. Visual Basic was selected as the primary programming language for developing the PC user interface because it enables the rapid application development of graphical user interface (GUI) applications, besides being easy to learn and use.

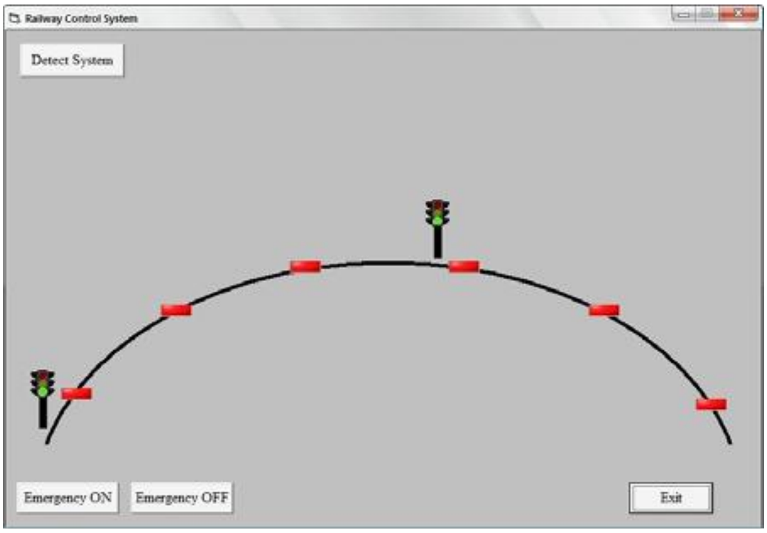

Figure 8: Track Position with Signal

The above figure shows the track layout with the location of train. If the train is there in particular section then that part will be represented by Green Color as shown in figure 9.

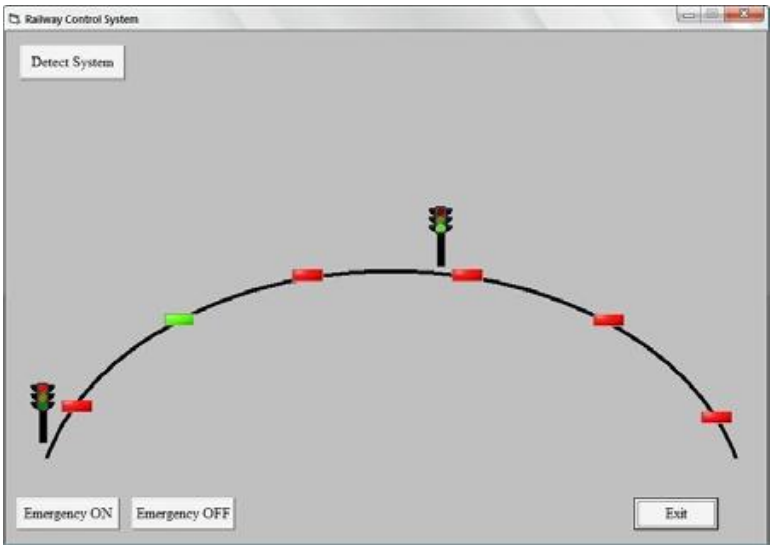

Figure 9: Showing Location of Train

The various states of the indicators in the GUI are as indicated above. An initialization run is carried out to ensure system synchronization. Once synchronized, the GUI indicates the location of the train in one of the six segments of the track. The corresponding indicator changes from red to green whenever the train passes over one of the six reed switches. Also the GUI signals are synchronized to switch simultaneously with the actual signals. Thus the GUI provides an overview of the entire train system. Moreover an emergency button is provided to switch off and restart the entire system in case of unexpected circumstances.

FUTURE WORK

The project uses wireless control for train movement. The current system uses wired medium to relay status of signals to monitoring unit. This can be made wireless by removing all the complexities of wiring as well as enabling the use of the wired medium for optimized communication purpose. The wireless system can also be efficiently used to control the speed of the trains. The flexibility of this project provides the scope to use the system in similar track-based systems like the metro. Also the entire system is automated requiring little or no human input. This would make it possible to implement a complete automated train system in the near future with the driver simply supervising the train's movements. This would greatly increase the efficiency of the entire train system. The implementation of wireless Smart Railway Network can one day revolutionize the Western Railways to Wireless Western Railways (WWR).

CONCLUSIONS

The project "SMART RAILWAY NETWORK" aims to automate operation of railway signaling and train monitoring. It shows two track sections of a line to demonstrate Automatic Signaling, Automatic Train Stopping System, Announcement, Expected in Minutes, and Train Monitoring on PC. The train movement control is achieved using wireless remote control. One more important feature is the 'fail safe' system and 'centralized power control' that enables emergency 'Shut Down' during danger or unavoidable circumstances. Thus the project "SMART RAILWAY NETWORK "acts as a BRIDGE between railway system and customers.

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