Simulation of Zigbee based Tacs for Collision Detection and Avoidance for Railway Traffic

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ABSTRACT
A ZigBee based collision avoidance system for railways has been proposed in this paper. The Train Anti-Collision System (TACS) has four sub centers namely, Train Subsystem, Station/Control Center Subsystem, Signalling Post Subsystem and Level Crossing Subsystem. A safe distance of 1 Km has been given for braking between the trains in case of collision distance. Based on the studies, it has been observed that even for two trains travelling at 120kmph, the safe distance after automatic braking under normal conditions has been estimated to be 920m. All subsystems have been designed and simulated using Proteus electronic simulation package and implemented. It is expected that if this system is implemented, train collisions can be avoided in the future.

Key Words
Train Collision Avoidance, Proteus, Electronic System Design, ZigBee.

1. INTRODUCTION
Train accidents occur normally due to safety violations resulting from 'human errors or limitations' and 'equipment failures' loosing precious lives. The Ministry of Railways (Railway Board), Govt. of India has referred Ten Train Collisions in the past for developing an efficient Train Anti-Collision system [1] and the need for research in this field. Konkan railways have proposed and implemented an Anti – Collision System [2]. However, a severe bug was detected on testing, in which the system causes running trains to abrupt halt for no apparent reason. The system did not take any active inputs from existing Railway signalling system, and also lacked two way communication capability between the trains and the control centers or stations, hence was later decommissioned [3].

The goal of this work is to design and implement a cost effective and intelligent full-fledged microcontroller and wireless based Train Anti Collision System to successfully prevent the train collisions. It aims to efficiently integrate into the existing signalling system [4] and avoid accidents in manned as well as unmanned level crosses, without changing any of the existing system implemented in Indian Railway. Presently, emergency may be passed through traditional tele-communication systems like Walkie-Talkies or other communication devices, Collision avoidance systems on same track using IR modules and ACD by Konkan Railway. But each of these systems has their own advantages and disadvantages. In the traditional communication method, human error or carelessness may lead to severe disasters as noticed in the past. IR sensors have limitations in due to the geographic nature of the tracks. The ACD system also is found to be ineffective as it is not considering any active inputs from existing Railway signalling system, and also lacks two ways communication capability between the trains and the control centers or stations, hence has been later decommissioned. Later geographical sensors have also been used which makes use of satellites for communication. But the system is costly and complicated to implement.

The proposed Train Anti Collision System consists of a 'self-acting' microcontroller and two way ZigBee [5] based data communication system which works 'round-the-clock' to avoid train collisions and accidents at the level crosses thus 'enhances safety' in train operations by providing a 'NON-SIGNAL' additional 'safety overlay' over the existing signalling system. The system operates without replacing any of the existing signalling and nowhere affects the vital functioning of the present safety systems deployed for train operations. The proposed system gets data from the moving trains, control-centers/stations, Signalling Posts and level crossings. The efficiency of the system is expected to be considerably increased as the proposed system takes inputs from the signal posts and also from the level crossing gates. As more relevant data are included, it is expected that the present system may assist loco drivers in averting accidents efficiently. As no change is necessary to be made to the infrastructure of the existing system, the cost of implementation of this system is also less.

The system has been designed and simulated using proteus. Models of the rail traffic systems has also been made and tested. The rest of the paper is organized as follows. Section 2 deals with the overview of the proposed system detailing the schematic diagram, block level representation and detailed explanations for various blocks with their process flow diagrams. Section 3 details the circuit diagram and proteus simulation details followed with the experimental setup of the Entire prototype, conclusion and references.

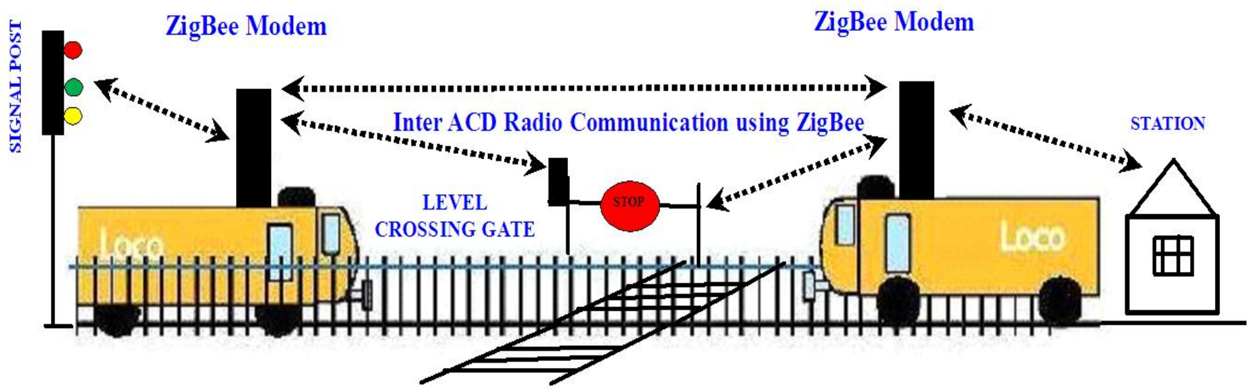

Fig 1: Schematic Representation of the proposed TACS (Train Anti-Collision System)

2. OVERVIEW OF THE PROPOSED SYSTEM

Figure 1 shows an overview of the proposed system. The proposed Train Anti Collision System consists of a 'self-acting' microcontroller and two way ZigBee-based data communication system. 'TACS Network' consists of mobile subsystems (on Locomotives and Guard's Brake Vans), track changing sections subsystem, subsystem in stations, subsystem in level crossing gates and the subsystem in railway signal posts. Loco subsystem communicates to other locos within a radius of 3000 meters [5] using radio frequency. The system communicates with the nearest signal posts, Level crossing gates and control stations to continuously monitor various signals arriving in the control center and taking decisions based on the received data. ZigBee modem communicates with other subsystems providing a mesh interconnection between all subsystems. The control station controls and monitors the entire system in the TACS network. Whenever a collision-like situation is 'perceived', 'TACS Network' is likely to prevent 'head-on' and 'rear-end' collisions in mid-sections, collisions at 'high speed' in 'station area', 'side collisions' with derailed vehicles obstructing adjacent line, collisions due to 'train parting or jumbling' and collisions with 'road vehicles' at level crossing through 'Train Approach' warning and detection of 'Gate Open'. Train subsystem also gives 'Station Approach' warning to drivers. Moreover, using manual switches on the train subsystem, Drivers, Guards and Station Masters can also 'stop' trains when any unusual is detected. Different subsystems of TACS when installed on Locomotives (along with their Auto-Braking Units), Guard Vans, Railway signal posts, Stations, Track changing sections and at Level Crossings (both manned as well as un-manned), form a 'TACS Network'. The proposed model makes use of ZigBee protocol as a medium of transferring information. The data reception and transmission between the different subsystems are performed using Wireless RF data communication system. The Wireless RF module sends capsules of data as an 8 bit format comprising of the signals obtained from various points described. Figure 2 shows the pictorial representation of the TACS control center. When all subsystems and control center works in conjuncture, an efficient TACS gets implemented.

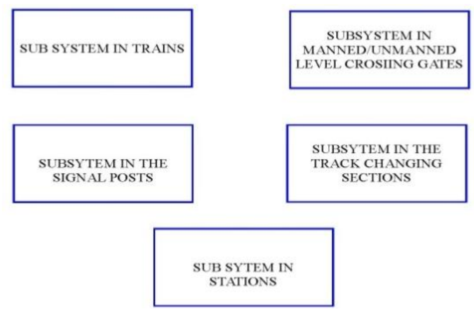

Fig 2: Block Representation of TACS

2.1 Subsystem in Train

The subsystem to be stationed in the train has a ZigBee module, a microcontroller unit, and an alarm with necessary driver and power supply units. The role of the subsystem in the train is to alert the Loco pilot in case of emergency. In case of threatened collision, automatic braking system takes control and the train will be stopped. The ZigBee modem sends and receives data at regular time intervals. The send packet contains information such as Track-ID, Direction of movement and train ID. The packets may be received from Control Stations, Level crossing, Stations, Signal Post and passing Trains. Each time, a packet is received, the Track ID and the direction of motion of the train is checked. If the Track ID and Direction of motion of the train are the same, then the Train is automatically stopped. The Block Diagram of the subsystem in the train and the flow chart for the data flow are shown in figures 3 and 4 respectively.

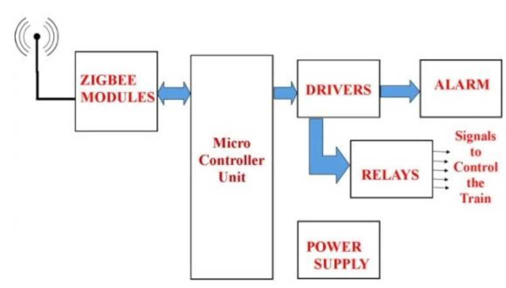

Fig 3: Schematic Representation of Subsystem in Train

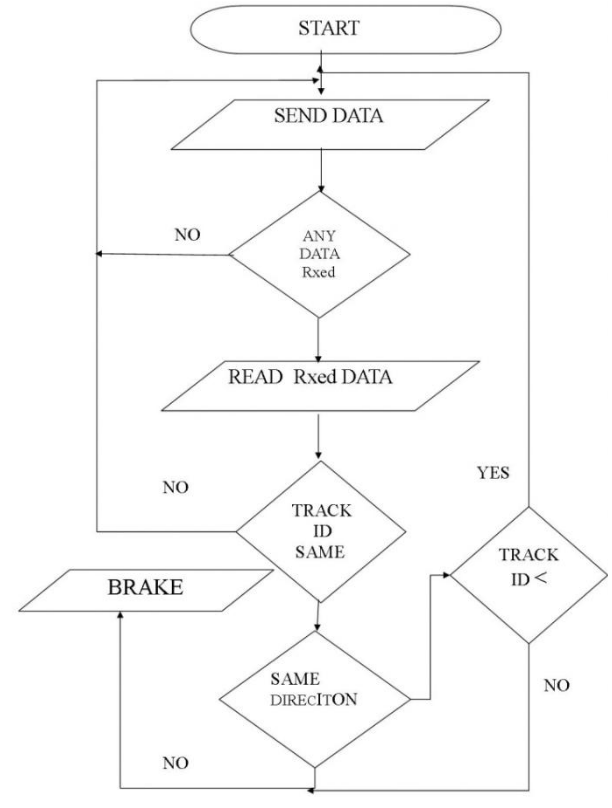

Fig 4: Flow Chart for data flow in TACS Subsystem - Train

2.2 Subsystem in Stations/Control Centre

The Stations/Control center subsystem has a ZigBee module, a microcontroller unit, a PC with software and database and an alarm with necessary driver and power supply units. The role of the subsystem in Station/control center is to process the data received from other subsystem in the coverage area and broadcast it to the other subsystems. The data updating has to be accomplished with the aid of the control center. The ZigBee modem sends the updated data and receives the data to update at regular time intervals. The 8-bit control sub center packet contains information such as Track-ID, Direction of movement, Train ID and Control Bit. The Block Diagram of the subsystem in the Stations/Control center and the flow chart for the data flow are shown in figures 5 and 6.

2.3 Subsystem in Level Crossing Gates

The Level Crossing Gates subsystem has a ZigBee module, microcontroller unit and an alarm with necessary driver and power supply units. This subsystem continuously checks for data received from passing trains subsystem. When the train approaches at 3 km distance from the level crossing, the alarm circuit and visual display alert circuit gets activated. This helps the pedestrians and vehicles to stay away from the railway track when the train passes. The Block Diagram of the subsystem in the level crossing gate and the flow chart for the data flow are shown in figures 7 and 8 respectively.

2.4 Subsystem in Level Signal Post

The fourth subsystem of the TACS, deployed in the Signal Post has a ZigBee module and a microcontroller with necessary driver and power supply units. The role of this subsystem in Signal Post is to send data based on the light in the signal post. If the light is red then the module will send the data to stop the train, if yellow, it sends the data to alert the loco pilot to reduce the speed. If the signal in the post is red, the data bit ‘D7’ is set to ‘1’ else it is set to ‘0’. The train in the vicinity of the signal post, if receives a packet with ‘D7’ ‘1’, it checks for the Track ID. Same condition is applicable for ‘green’ and ‘yellow’ signals also. If the track IDs are similar, then the train is stopped. The Block Diagram of the subsystem in the Rail Way Line Signal Post and the flow chart for the data flow are shown in figures 9 and 10 respectively.

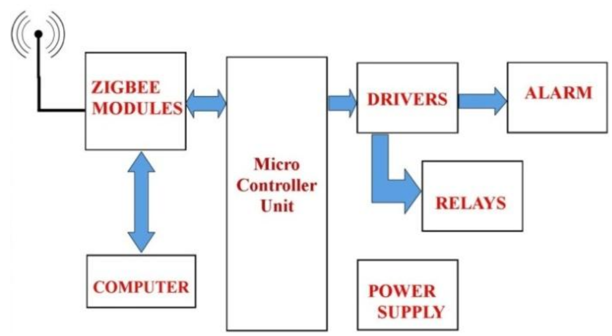

Fig 5: Schematic Representation of Subsystem in Stations

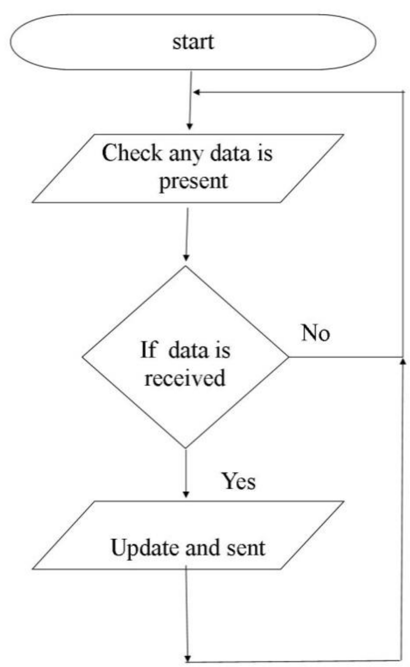

Fig 6: Flow Chart for data flow in TACS Subsystem – Stations/Control Centre

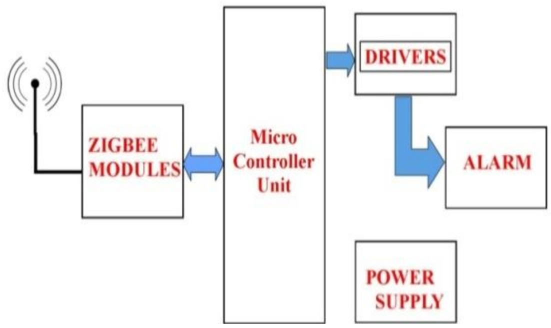

Fig 7: Schematic Representation of Subsystem in Level Crossing Gates

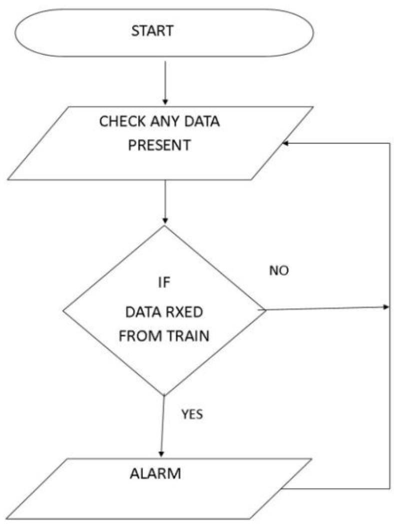

Fig 8: Flow Chart for data flow in TACS Subsystem – Level Crossing Gate

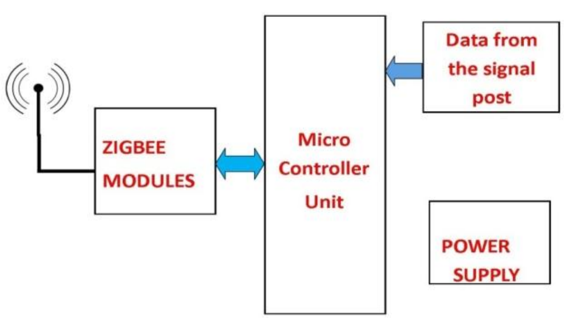

Fig 9: Schematic Representation of Subsystem in Signal Post

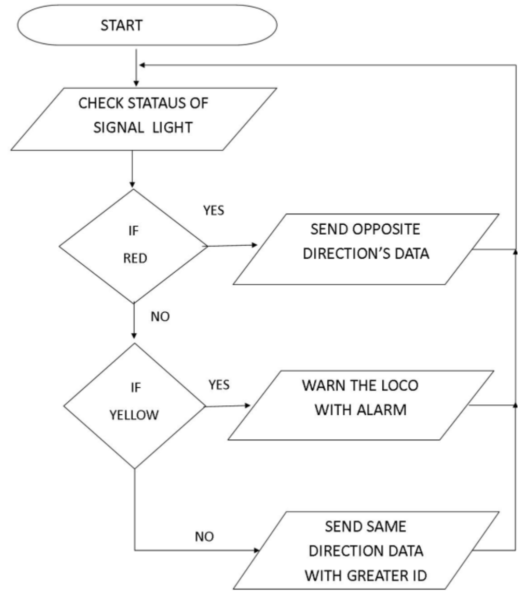

Fig 10: Flow Chart for data flow in TACS Subsystem – Signal Post

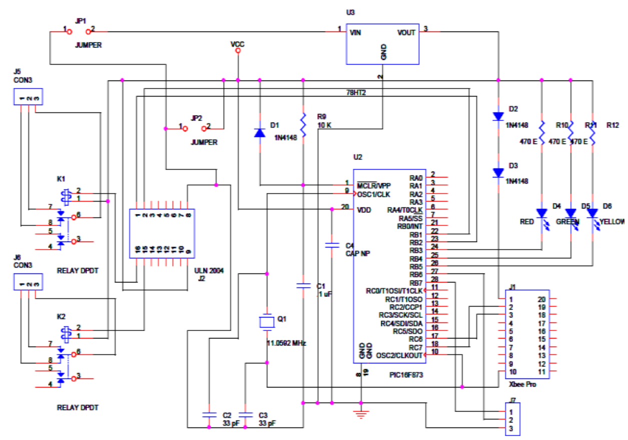

Fig 11: Circuit for Train / Level Crossing Subsystem

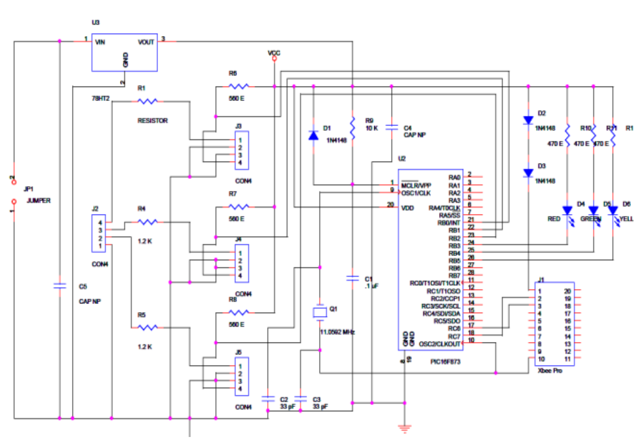

Fig 12: Circuit for Signal Post Subsystem

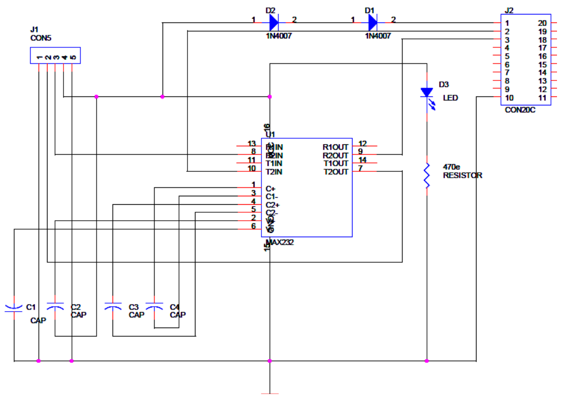

Fig 13: Circuit for Control Centre

Fig 14: Prototype of the Train Anti Collision System

3. SIMULATION RESULTS AND ANALYSIS

Simulation of the proposed scheme has been carried-out in Proteus. The circuits for the various subsystems have been simulated and all the necessary conditions verified. Circuits for various subsystems have been shown in figures 11 to 13. The designed Prototype of the proposed TACS is shown in Fig 14. and the snapshot of the proteus simulation result is shown in Fig 15.

4. CONCLUSION

In this project, an anti-collision system for trains have been designed, simulated and tested. The simulation has been done using proteus and testing has been carried out using the developed prototype. It has been estimated that if the system is implemented in railways, two trains accidently on the same track but in opposite direction at 120kmph [6] may stop automatically with a safe distance of 920m [8]. Hence it is expected that, major train mishaps can be prevented and human life saved if this system is implemented.

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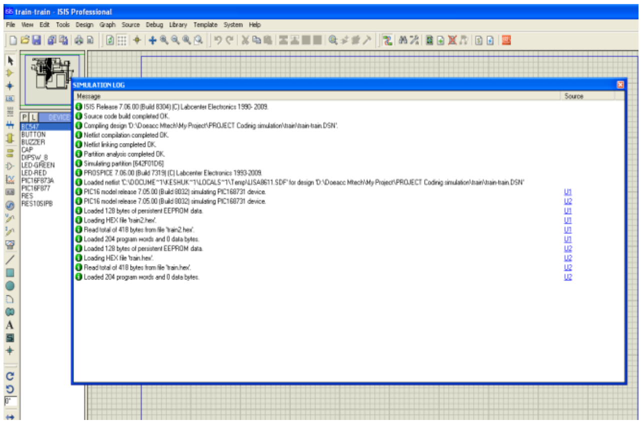

Fig 15: Snapshot of the proteus simulation

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