High Performance Radio Frequency Identification System for Unmanned Railway Level Crossing

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Abstract – Accidents at railway level crossing in India have claimed the lives of 1539 peoples over the past decade. Of those 1125 deaths have occurred in unmanned level crossing which goes to an average of 112 peoples per year. The main reason behind this is that the unmanned level crossing numbering 18,200 is a shocking 52% of the total number of level crossing. This positively puts road users in great peril. The government of India is hesitant to create these level crossing manned considering the huge capital it needs to invest i.e. approx. 2450 crores towards labour cost per annum and Rs.700 crores per annum towards maintenance and operational cost would be needed. Other options like constructing bridges or subways may amount to 400,000 crores. To avoid the above said tragedies, this system gives the intelligent remedy by automating the entire level crossing using 2.45GHZ RFID. The main motivation behind this idea is that this RFID implementation demands a surprisingly low cost of approximately 200 crores for the whole country. The basic plan is to place individual RFID tags with unique ID in each train .These tags will be read by readers placed adjacent to the tracks strategically positioned a definite distance away from the level crossing. The train is detected by the RFID reader and is sent to microcontroller for comparing with predefined data and open/close of gate using stepper motor/hydraulic system. This can be used in any rugged environment if train passes through.

Keywords: 2.45GHZ RFID, Unmanned Level Crossing, Obstacle Detection, EPC, ETC, Microcontroller AT89C52, LAN, IR LED, Stepper Motor.

I. INTRODUCTION

The objective of this system involves the developing of a fully controlled and automated railway level crossing (gate) using High Performance Radio Frequency Identification (HP- RFID) system. Whenever a train approaches a level crossing, the gate should close automatically and after the train passes, the gate opens automatically. This system specially makes use of RFID technology and specifically 2.45GHZ (Active RFID) microwave range which forms the heart of our system. It is capable of automatically detecting very high speed (up to 300kph) moving objects at long read range. It has read/write capability, no line of sight detection and less sensitive to electromagnetic interference. It is highly accurate (99%) and so it is reliable for real time processing

II. EXISTING SYSTEM

Presently no level crossing in India is automated. Those of that is manned needs a huge labor cost of approximately Rs.2450 crores once a year. There are quite a number of bridges and subways built across many level crossing But construction cost are also high approximately 400,000 crores. There are also unmanned level crossing where the road user is at his own risk leading to lots of accidents. So the golden solution to this problem seems to lie in the hands of the simple technology of HP-RFID. Other sensor except 2.45GHZ RFID cannot detect fast moving objects such as trains. For example IR technology cannot detect fast moving objects and also cannot be used in rugged environments.

2.1 *Disadvantages of Existing System*

- Manual control
- High risk for road users
- Very slow operating speed
- High maintenance cost
- High labour cost
- Can’t used in rugged environment

III. PROPOSED UNMANNED LEVEL CROSSING SYSTEM

Present day systems do not scope up with the raising demands. There is a great demand among public for an accident free railway crossing. Level crossing accidents are mainly due to negligent driving of the commuters crossing the tracks. Hence the best idea would be such that the level crossing detect the train automatically and either open or close.

So we propose a system of automation using 2.45GHZ active (RFID) radio frequency identification to detect the trains and hence operate the railway crossing. This technology which works in real time has features like frequency hopping, license free.

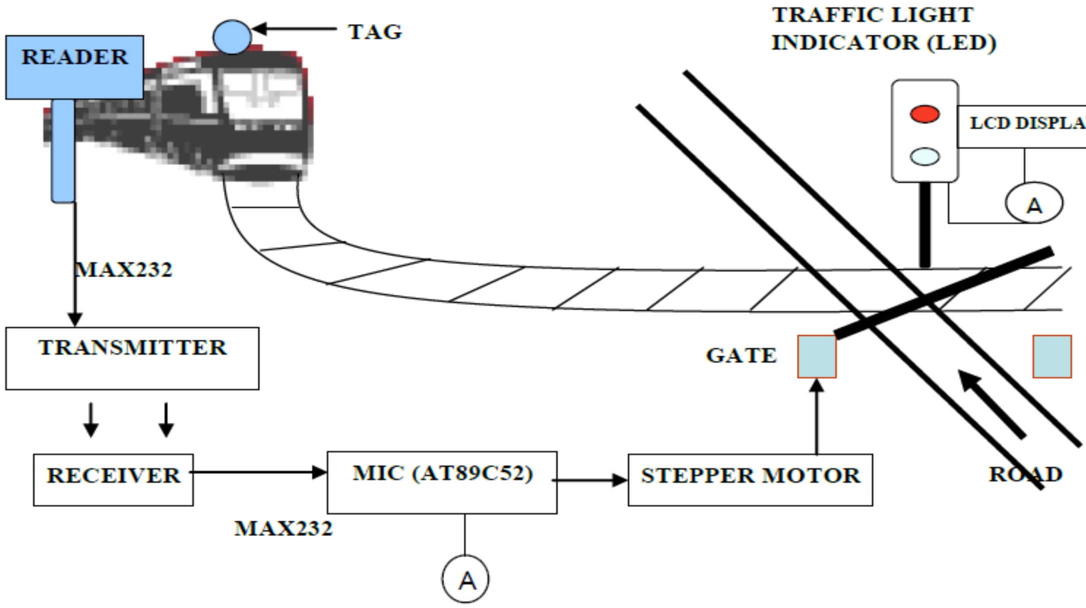

Fig.1. General Architecture of unmanned level crossing

The general architecture of unmanned level crossing is shown in figure-1. Now let us see each blocks of this system the way it works to produce efficient opening and closing of the gate using real time architecture. This system (HP RFID) divided into five parts that's given below,

1. Positioning of RFID tag
2. Positioning of reader
3. Identification of train
4. Data communication process
5. Embedded control

3.1. Positioning of RFID Tag

The tag should be mounted on the surface of train such that it is easily detected by the reader and it should be made sure that the reader on any account does not miss the tag. The ideal position would be on the top of the train in the front engine. But since 2.45GHZ can pass through many materials including metals and other opaque objects, it can also be placed inside the train. Another tag can also be placed on the other side of the train so that even if one tag fails (though the probability is very low), the reader can detect the other train.

3.2. Positioning of RFID Reader

The reader is placed adjacent to the track mounted on a pole some distance (approx.7km) away from the gate (Fig-2). There is also another reader fixed on the other side of the gate some distance away (approx. 7km). The reader should be placed well away from the gate. So we chose 7km considering the factors like closing the gate, alarm before closing and transmission delay. Even after this if a vehicle gets stuck, we use Obstacle Detection to warn the train driver.

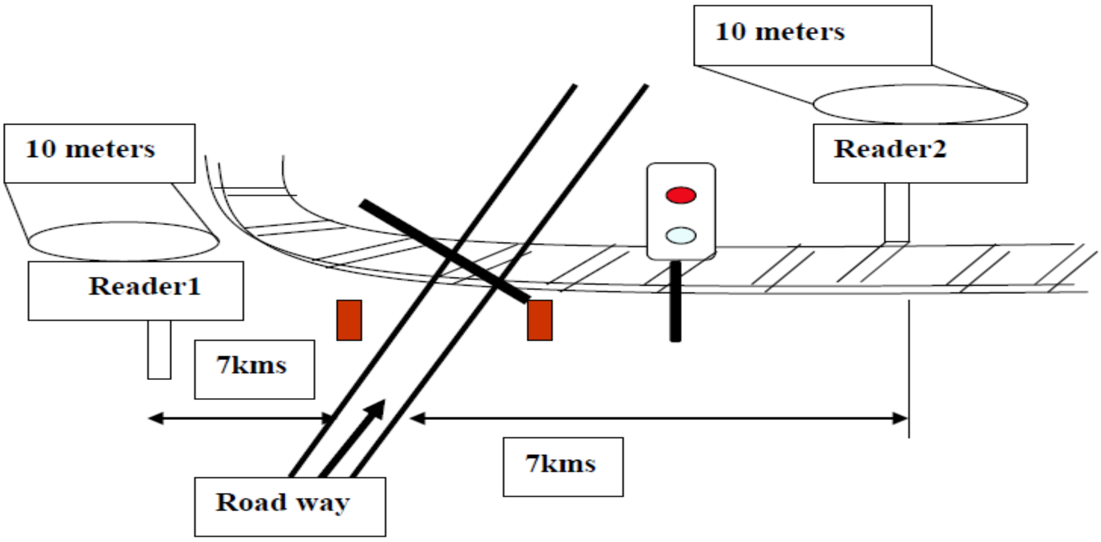

Fig.2. Positioning of RFID reader Architecture

Since the reader can detect a long distance we can safely place it away from the track on a tall pole such that it is away from reach of stray animals. There is a casing around the reader to protect it from harsh environments such as rain or heat. By proper orientation of the antenna the readers can detect a distance unto 500 meters. Reader used in this system detects unto 10 meters.

3.3. Identification of Train

The reader powers an antenna to generate an RF field. The reader emits clock pulses. When the tag passes through the field of the reader, the tag picks up these clock pulses. The tag then responds to the signal.

The tag contains a unique code called EPC (Electronic Product Code). EPC can also be coded as ETC code (Electronics Train Code) for convenience. Similar to EPC code; ETC code has four blocks which has two parts namely train identifier and position identifier. This identifier is used to find out the name of the train and the position identifier is used to identify the side and compartment in which the tag is present and also the direction in which the train is traveling. Example of ETC is

11	11101	00111	000001
Header	Train code	Compartment	Side

But advanced readers can detect the direction of movement of any tag even without this code (example: readers sold by tag master company). The tag sends this unique ID to the reader. This code can be sent to level crossing and nearby railway station to pin point the location of the particular train.

3.4. Data Process Flow Diagram

Figure-3 Shows how the data flow through various components in this system. At first when the tag approaches the station, the reader1 picks up the signal from the tag. i.e. the tag sends a unique ID to the reader. When the train passes away from the gate reader2 picks up the signal from the tag. When a reader detects a tag, this signal is passed to the microcontroller (AT89C52) placed near the gate through the communication interface. The data is compared with predefined data which says which train passes in which track and which direction. In this system the reader is directly interface to the microcontroller AT89C52 through MAX232.

But in real time since the signal has to be transmitted for long distance, reader is connected to a RF transmitter which sends the signal through wireless to the receiver. The receiver is connected to the microcontroller through RS232 interface. There can also be extra features such as connecting many readers across many gates across a local area network (LAN). We are dividing the RFID readers into pairs those on start point and those on the end point. Once the train has entered the first track we will be sending the details of the reader along with the information collected by it through the LAN network. Every reader has an Ethernet port or serial port which is used to form network with other readers or computers. As all are single way transactions we use star topology.

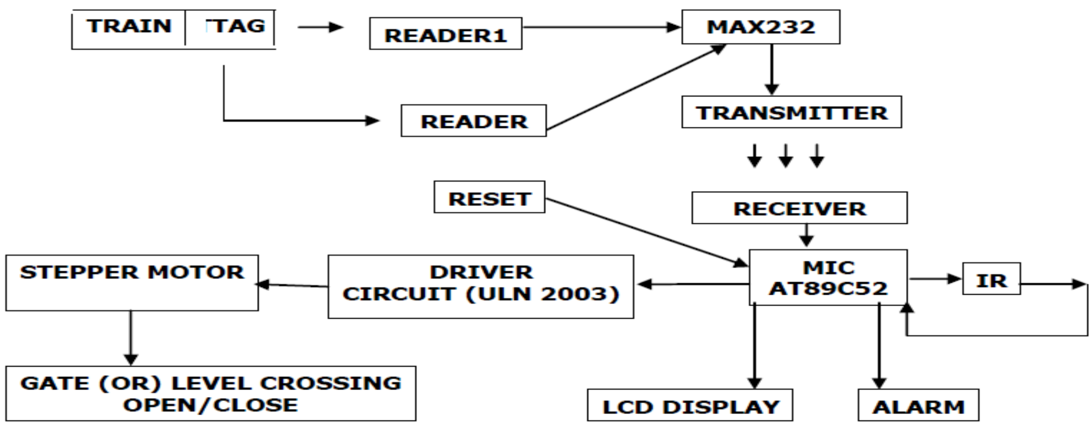

Fig.3.Data Process Flow diagram for Unmanned Level Crossing

This is very useful as the railway level crossing can be brought under a centralized control by controlling it with a single PC. Also by this feature the security is increased. For this many readers are connected to a single PC. Once the pc received the data the pc knows the gate which should be activated and now we use wireless communication to activate that particular receiver. Each receiver is tuned to a particular frequency. The pc is connected to the transmitter through MAX232 port. This transmitter sends signal to the particular receiver and this receiver is connected to the microcontroller through MAX232 port. If high energy transmitters are used, large distance up to 20 nautical miles can also be covered. Once the receiver receives the data the control passes over to embedded networks.

3.5. Embedded Control

Once the receiver receives the data with the help embedded system (hardware and software). The received data is checked and compared with the data that is given by user. Once this data is found to be correct, then the control is transferred to loud speaker (buzzer). Along with the siren there is also red light warning LED to alert the road users. The gate open/close is also indicated by a 16*2 LCD display.

After minimum of one minute, the gate will be automatically closed. Similarly the gate can also be opened. It is done using Stepper Motor. In real time Hydraulic System can be used. Thus we avoid unnecessary accidents happening in the level crossing. The main condition here is to analyse how to avoid accident if someone is stuck in middle. For this Obstacle Detection circuit diagram is shown in Figure-5.

3.6. Advantages of Proposed System

- High and long read range
- Accuracy (less than 0.001% missed or erroneous reads)
- Automatically detect the train
- Lower operating cost and No line of sight
- Less sensitive to electromagnetic interference , vibration , shock , temperature
- Real time information processing
- Prevents interference with other system frequencies
- Correct reading of ID tag safeguarded by 32 bit error correction code.

IV. HARDWARE MODULE CIRCUIT OF PROPOSED SYSTEM

The heart of the circuit is active 2.45GHZ RFID reader and tag. This system is especially suited for our application. It can detect fast moving objects and can detect long distances ranging from 10 meters to 500 meters the other components of the circuit (Shown in Fig-4) are Microcontroller AT89C52, MAX 232 interface, LCD display, Stepper motor, Buzzer and LED and Obstacle detection circuit.

The 230 volt AC supply is converted to 12V AC supply and converted to DC with ripples and then this ripple is removed and converted to 5V DC supply and given to respective ICs

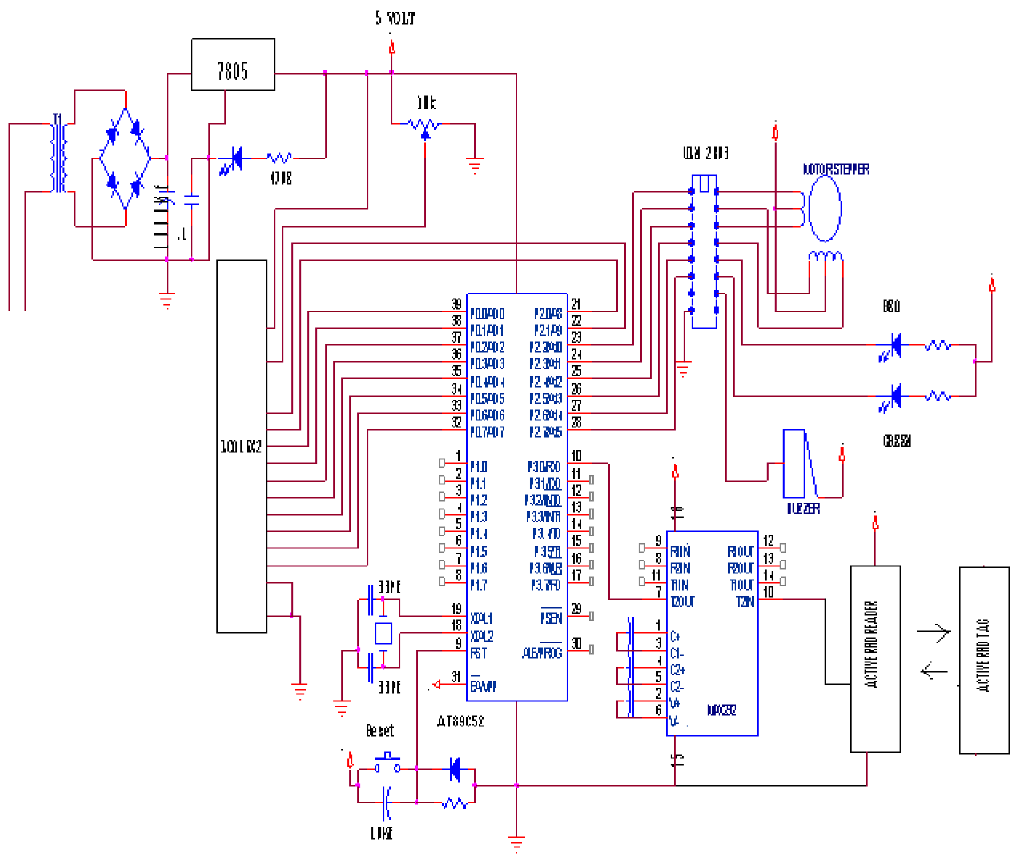

Fig.4. Hardware Module Circuit diagram of Proposed Unmanned Level Crossing system

The microcontroller is programmed to operate LCD display, stepper motor, traffic light indicator and buzzer. The microcontroller program also has the unique ID of the RFID tag. The RFID reader is interfaced to microcontroller using MAX 232 at pin number 10. The 16*2 is connected to port0 of microcontroller. The input of driver circuit IC ULN2003 is connected to pin2 of microcontroller and output is connected to stepper motor. The buzzer is connected to pin10 of IC ULN2003 and traffic light indicator LEDs are connected to pin11 and pin12 of ULN2003.

4.1. Gate Closing Operation

The DC supply is given to all circuit including RFID reader. The RFID tag has an inbuilt power supply from a battery. When the setup is switched on the LCD screen displays the data stored in it. The reader continuously transmits a high energy RF field described by the antenna position in all directions. When a tag comes in contact with the field of the reader, the tag get energized due to electromagnetic induction, and this energy transfer will activate the tag and activate the microprocessor inside the tag and transmit the unique ID stored in it to the reader. The reader’s antenna receives these unique ID and sends the data to the microcontroller using MAX232.

The microcontroller executes the program depending on the data received from the tag. Then the microcontroller sends corresponding output to display, buzzer, traffic light LED and finally stepper motor. Now the LCD screen displays the message “GATE CLOSE” Simultaneously the buzzer is activated and red LED is activated.

After this the stepper motor starts operating using ULN2003 driver circuit which also includes a delay time from the microcontroller. The gate arm which is connected to the shaft of the stepper motor closes very slowly step by step (step angle is 1.8°).

4.2. Gate Opening Operation

When the train passes the gate another reader detects the same tag and gate open operation take place. Now also the unique ID is transmitted to the microcontroller by similar process. Now LCD screen displays the message “GATE OPEN”. The buzzer is switched off and the green LED is activated and red LED is deactivated. The stepper motor is now used to open the gate. The stepper motor comes back to original position slowly step by step.

4.3. Obstacle Detection

When there is an obstacle gets stuck when the gate arm is closing, for detecting this obstacle we use IR technology. This obstacle detection (fig-5) setup is placed near the gate so that any obstacle can be detected immediately. The circuit consists of IR transmitter, IR receiver (TSOP), NE555 timer, buzzer, LED indication for train and supporting circuit.

A 9Volt DC supply is given to the input terminal of the circuit. The NE555 timer is used for both IR transmitter and receiver. It generates a clock pulse of frequency 38KHZ. This is used to operate the IR transmitter. The transmitter used to transmit IR signals of frequency 38KHZ continuously. The output stage is energized. This output is square wave.

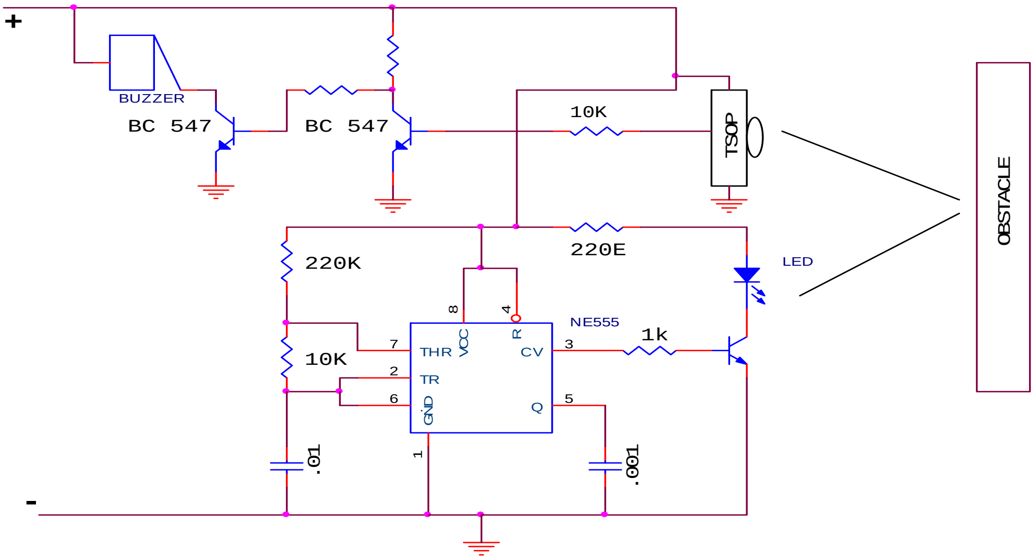

Fig.5. Circuit diagram for Obstacle Detection System

The IR LED emits infrared rays in the frequency range of 38KHZ. When there is a obstacle, the signals are reflected back to the receiver. IR receiver (TSOP) receives the signal frequency of 38KHZ transmitted by the IR LED. The pin no 3 of TSOP is the output pin. If the signal has been received, then pin3 goes low. Otherwise pin3 goes high. Now two transistors are used as NOT gate to invert the signal from pin3 of TSOP and send to buzzer and LED indicator. Immediately buzzer alarm is activated. Simultaneously a Warning Red Led Indicator for the train is also activated so that the train can be stopped immediately. This total circuit is called as Obstacle Detection System. This system will be activated only at the time of closing of gate.

V. PROBLEMS ANALYSIS ON AUTOMATED SYSTEM AND SOLUTIONS

The main four conditions (problems) here to analysis and provided the solutions for those conditions are given in Table I.

Table I. Performance (Problems) Analysis

S.No.	Problems (Conditions)	Solutions
1	The vehicle is struck in between the two closed gates	We just increase the spacing b/w the Railway line and gate
2	The vehicle is at the closing gates.	We uses IR technology here (Obstacle detection- fig: 5) this will be activate only at time of closing of the gates.
3	Tag is failure after gate is closed.	We can use more than one Tag and all readers should be in one network
4	We can't identify which direction the train will come	Tag master RFID tags are identify the direction of train automatically

VI. CONCLUSION

High performance Radio Frequency Identification (RFID) system was designed for automation of unmanned level crossings in Indian railways. By automating the level crossings the number of accidents in the level crossings can be brought almost near to Nil. For detecting the fast moving objects i.e. the train, 2.45GHZ RFID is the most efficient and comparatively cheaper option. Hence this system was choosing. When the train approaches near the railway level crossing the gate arm closes automatically and when the train passes, the gate closes automatically.

VII. FUTURE ENHANCEMENTS

This entire network can be made wireless in the near future. The range of wireless transmission can also be increased to a large extent. If this wireless technology is fully implemented then we will be able to monitor the train throughout automatically. The train name and number along with the exact time at which it has passed is displayed on the LCD screen and also recorded on a memory device for future reference. By using special tags, the direction in which the train is passing is also detected. Presently for finding the direction, the train ID compared with the predefined data and some other futures scopes are given below,

- Track changing mechanisms can be made automatic.
- Preventing collision of trains (Anti-collision device).
- The read range and speed of RFID can increase.
- In future will install warning system and automatic bomb detector.

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