Automated Railway Gate Control and Object Detection using Wireless Communication

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Abstract - **In this paper, our aim is to implement automatic railway gate control system at unmanned railway level crossings to prevent accidents that occur because of railroad intrusion and unawareness of the approaching train. The system also checks for any obstacle that gets stuck in the track and communicates with the railway signal to change it appropriately to alert and stop the train.**

Keywords - Automatic Railway gate, Obstacle detection, Railway signal, IR detector, XBee, RF module, 8051 microcontroller

I. INTRODUCTION

Railway is one of the oldest forms of transport across the world. It is widely used for passenger and goods transportation. Railway is a very large network that connects the remote locations. There are large number of people who depend on railways for their daily transport for longer distance at a cheaper tariff. While the railway is responsible for safety, they may not always live up what they are supposed to do. It is not always the fault of the railways. There can be many factors involved in personal injury cases arising from a serious or deadly train accidents due to derailments, unprotected railroad crossings, human distraction, mechanical failure, etc. Even though there are many modern techniques that prevent railroad accidents, still there is lagging in railway safety.

II. LITERATURE SURVEY

On account of preventing railroad accidents, more electronic systems are invented. The approaching train is detected using IR sensors [1][2][3][4] accordingly the gates are operated (open/close). Any obstacle on the track is identified using Ultrasonic sensor [1][3]. In this method, the IR sensors are placed at a distance from the gates and employs wired connections between the sensors and the railway gate. There are chances of disconnection of the system that causes system failure. The usage of ultrasonic sensor [1][3] is not an efficient way of detecting an obstacle on the track as it may detect for smaller objects that crosses the railway track at that time. This drawback has been overcome by using GSM technology for communicating with the gate [2]. The train is detected using IR sensors and the information about the train is intimated to the gate through GSM service [2]. There is another drawback of GSM that there may occur network problems that makes the system failing to communicate to communicate with the gates.

III. PROPOSED METHOD

In proposed method, the ultrasonic sensors and GSM technology are replaced with RF transmitter/receiver pair to identify the approaching train, IR sensors for obstacle detection and XBee transceivers are employed for communicating with the railway signal.

A.Microcontroller

A micro controller is an integrated circuit or a chip with a processor and other support devices like program memory, data memory, I/O ports, serial communication interface. A microcontroller does not require any external interfacing of support devices. Intel 8051 is the most popular microcontroller ever produced in the world market.

(i) 8051 Microcontroller Architecture

A microcontroller's internal architecture, data memory organization, program memory and pin configuration are different in their versions. The basic architecture remains same for the MCS-51 family. All microcontrollers in MCS- 51 family are represented by XX51, where XX can take values like 80, 89 etc.

(ii) Schematic and Features

The general schematic diagram of 8051 microcontroller is shown. There are 3 system inputs, 3 control signals and 4 ports (for external interfacing). A Vcc power supply and ground is also shown.System inputs are necessary to make the micro controller functional. The most important of this is power, marked as Vcc with a GND (ground potential). XTAL 1 and XTAL 2 are used for the system clock inputs from the crystal clock circuit. RESET input is required to initialize and start the microcontroller to default/desired values. There are 3 control signals known as External Access (EA), Program Store Enable (PSEN), and Address Latch Enable (ALE) are used for external memory interfacing.

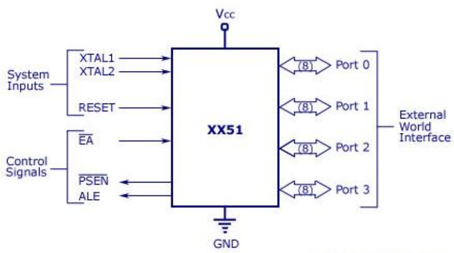


Fig-1. xx51 schematic Inputs and Outputs

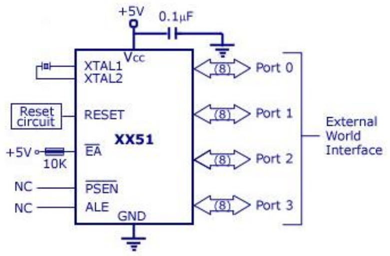


Fig-2. Schematic System Inputs for Stand Alone Operation

As mentioned above, control signals are used for external memory interfacing. If there is no requirement of external memory interfacing then, EA pin is connected to Vcc and the other two pins PSEN and ALE are left alone. A 0.1 micro farad decoupling capacitor connected to Vcc (to avoid HF oscillations at input). There are four ports: Port 0, Port 1, Port 2 and Port 3 which are used for external interfacing of devices like DAC, ADC, 7 segment display, LED etc. Each port has 8 I/O lines and they all are bit programmable.

(iii)8051 Internal Architecture

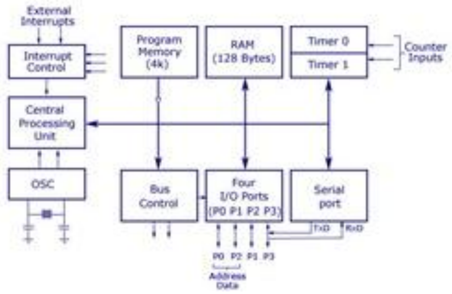


Fig-3. Simplified Internal Architecture of xx51

The internal architecture of 8051 micro controller is easy to understand. The system bus connects all the peripheral devices with the central processing unit. 8051 system bus is composed of an 8 bit data bus and a 16 bit address bus and bus control signals. Devices such as program and data memory, I/O ports, serial interface, interrupt control, timers, and the central processing unit are all interfaced together through the system bus. The RxD and TxD pins (serial port input and output) are interfaced with port 3.

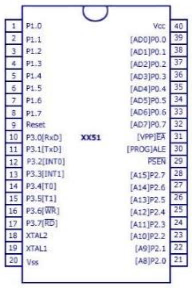


Fig-4. Pin-wise Signal Assignment of xx51

B. RF module

An RF Transmitter and Receiver pair is used for wireless communication. The wireless data transmission is done by using 433 MHz Radio Frequency signals that are modulated using Amplitude Shift Keying (ASK) Modulation technique.

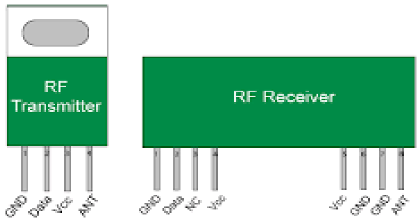


Fig-5. RF Transmitter/ Receiver Pin diagram

An encoder IC HT12E and a decoder IC HT12D are used to implement the wireless transmitter and receiver.

(i) HT12E Encoder

HT12E is an encoder IC that converts the 4-bit parallel data from the 4 data pins into serial data in order to transmit over RF link using transmitter.

(ii) HT12D Decoder

HT12D is a decoder IC that converts the serial data received by the RF Receiver into 4-bit parallel data and drives the LEDs accordingly. The HT12E encoder IC converts the 4-bit data from the 4 data pins that are connected to the buttons into serial data. The serial data is sent to RF transmitter. The RF transmitter transmits this serial data using radio signals. Then the RF receiver receives the serial data. This serial data is sent to HT12D decoder IC which converts it into 4 bit parallel data.

C. IR Transceiver

An infrared sensor emits and/or detects infrared radiation to sense its surroundings. The basic concept of an Infrared Sensor which is used as Obstacle detector is to transmit an infrared signal, this infrared signal recoils from the surface of an object and the signal is received at the infrared receiver.

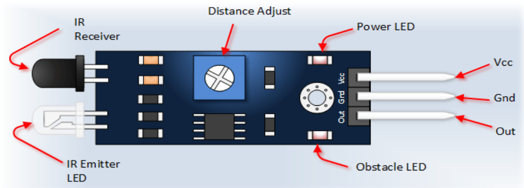
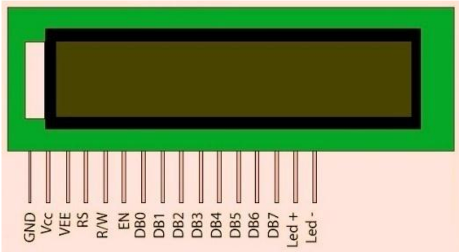


Fig-6. IR Transceiver pin diagram

There are five basic elements used in a typical infrared transceiver. An infrared source, a transmission medium, an optical component, infrared detectors or receivers and signal processing unit. Infrared lasers and Infrared LED's of specific wavelength can be used as infrared sources. The three-important media used for infrared transmission are vacuum, atmosphere and optical fibers. Optical components are used to focus the infrared radiation into th media or to limit the spectral response. Optical lenses made of Quartz, Germanium and Silicon are used to focus the infrared radiation. Infrared receivers can be photodiodes, phototransistors. The important specifications of infrared receivers are photosensitivity, detectivity and noise equivalent power. Signal processing is done by amplifiers as the output of infrared detector is very small.



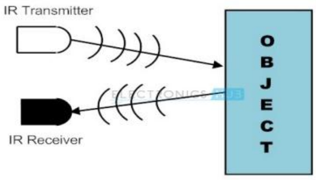


Fig-7. IR Transceiver working

D. XBee:

The XBee and XBee-PRO RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks.

Fig-8. XBee transceiver module

The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

(i) Features:

- Indoor/Urban: up to 100’ (30 m)
- Outdoor line-of-sight: up to 300’ (90 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm
- TX Peak Current: 45 mA (@3.3 V)
- RX Current: 50 mA (@3.3 V)
- Power-down Current: < 10 µA’

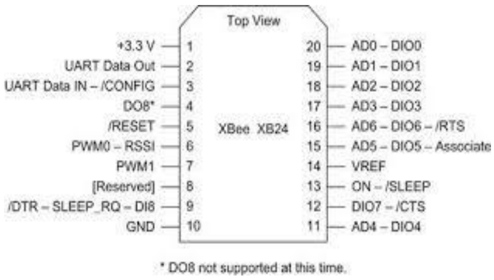


Fig-9. XBEE Pin Diagram

(ii) Description – Xbee

Baud Rate	: 9600 to 38400. Serial UART mode
Packet Length	: Variable or Fixed
Line of Sight	: 30+ meters range / 10 meters range indoors
Modes of operation	: Config mode and Run mode

1 Multiple channel selection enabling upto 255 different pairs to work in the same area

2 On board jumper Setting for Config/Run Mode and Packet/Byte Mode

3 Direct Replacement for wired Serial Cable and for serial communication

4 Works with CC2500 Wireless Transceiver module

E. Liquid Crystal Display

The LCD is a commonly used alphanumeric dot matrix liquid crystal display (LCD) controller developed. The control interface and protocol is a de-facto standard for this type of display. The character set of the controller includes ASCII characters and some symbols in two 28 character lines. Using an extension driver, the device can display up to 80 characters.

The LCD is limited to monochrome text displays and often used in fax machines, laser printers, copiers, industrial test equipment, networking equipment, such as routers and storage devices.

Common sizes are eight characters in a row (8x1), and 16×2, 20×2 and 20×4 formats. Larger custom sizes are made with 32, 40 and 80 characters and with 1, 2, 4 or 8 lines/rows. The most commonly manufactured larger LCD display configuration is 40x4.

Character LCDs use a 16-contact interface that commonly use pins or card edge connections on 0.1 inch (2.54 mm) centers. Those LCD displays without backlights may have only 14 pins except the two pins powering the light.

1. Ground
2. VCC (+3.3 to +5V)
3. Contrast adjustment (VO)

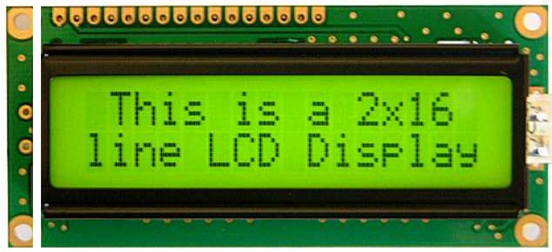


Fig-10. LCD Display Pin Connections

4. Register Select (RS) RS=0: Command, RS=1: Data
5. Read/Write (R/W). R/W=0: Write, R/W=1: Read (This pin is optional due to the fact that most of the time you will only want to write to it and not read. This pin will be permanently connected directly to ground.)
6. Clock (Enable). Falling edge triggered
7. Bit 0 (Not used in 4-bit operation)
8. Bit 1 (Not used in 4-bit operation)
9. Bit 2 (Not used in 4-bit operation)

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10. Bit 3 (Not used in 4-bit operation)
11. Bit 4
12. Bit 5
13. Bit 6
14. Bit 7
15. Backlight Anode (+) (If applicable)
16. Backlight Cathode (-) (If applicable)

The nominal operating voltage for LED backlights is 5V at full brightness, with dimming at lower voltages dependent on LED color. Non-LED backlights often require higher voltages.

F. DC Motor

An Electric DC motor is a machine which converts electric energy into mechanical energy. The working principle of DC motor is based on that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force.

Fig-11. DC Motor

The direction of mechanical force is given by Fleming's Left-hand Rule and its magnitude is given by F = BIl Newton.

(i) Working Principle :

A motor is an electrical machine which converts electrical energy into mechanical energy. The principle of working of a DC motor is that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force".

G. L293D Motor Driver

L293D is a Motor driver integrated circuit which is used to drive DC motors rotating in either direction. It is a 16-pin IC which can control a set of two DC motors simultaneously. The L293D uses 5V for its own power and external power source is needed to drive the motors, which can be up to 36V and draw up to 600mA.

The L293D works on the concept of typical H-bridge, a circuit which allows the high voltage to be flown in either direction. In a single L293D IC there two H-bridge circuits which can rotate two DC motors independently.

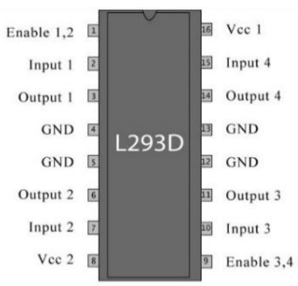

Fig-12. L293D pin diagram

Due to its size and voltage requirement, it is frequently used in robotics applications for controlling DC motors, including Arduino projects.

(i) Working Principle:

There are two Enable pins on L293D. Pin 1 (left H-bridge) and pin 9 (right H-bridge). To drive the corresponding motor, pin 1 or 9 need to be set to HIGH. If either pin 1 or pin 9 goes LOW, then the motor in the corresponding section will stops working.

The four Input pins for the L293D are pin 2 and 7 on the left and pin 15 and 10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of the motor connected on the left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided at the input pins as LOGIC 1 or LOGIC 0.

(ii) Logic Table of L293D

Assuming a motor connected on left side output pins (pin 3,6).

Table 1: Logic Table of L293D

Pin 2	Pin 7	Output
Logic 1	Logic 0	Clockwise direction
Logic 0	Logic 1	Anticlockwise Direction
Logic 0	Logic 0	Idle [No rotation] [Hi-Impedance state]
Logic 1	Logic 1	Idle [No rotation]

In a similar way, the motor can be operated across input pins 15 and 10 to control the motor attached to the H-bridge's right side.

(iii) Voltage Specification

The voltage (Vcc) needed to for its own working is 5V but L293D will not use that Voltage to drive DC Motors. The driver IC should be provided with that voltage (36V maximum) and a maximum current of 600mA to drive the motors (maximum resistance 60 ohms).

V. METHODOLOGY

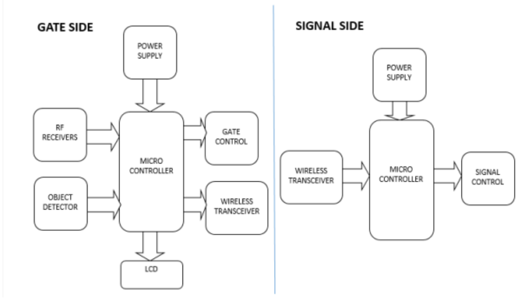

Fig-13. Block Diagram of the proposed method

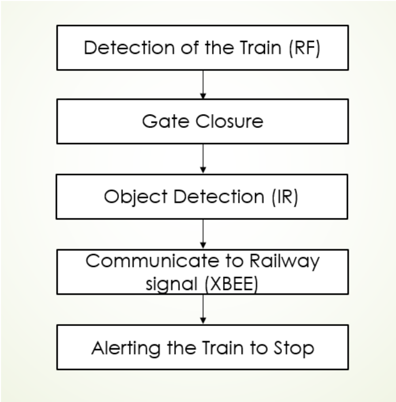

Fig-14. Working procedure of the proposed system

VI. RESULTS AND DISCUSSIONS

(i) Gate side

The RF receiver 1 fixed at the railway gate detects the RF transmitter signal code fixed in the train's front end, when it comes into the receiver's sensitive range. When the RF receiver gets the code, it sends a control signal to the DC motor driver through the microcontroller and closes the gate. After closing the gate, the Object detecting IR transceiver circuit is switched ON and starts checking for any obstacle (vehicle) on the track. The immovable obstacle is identified by setting a delay timer to the IR detector. If any immovable obstacle is present on the track, the IR sensor generates a voltage that is sent as a control signal to the microcontroller unit and it activates the XBee transceiver at the gate.

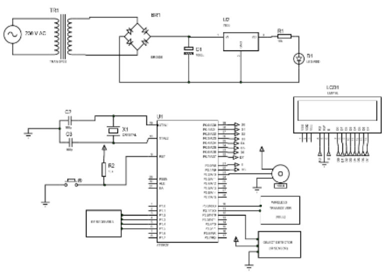

Fig-15. Gate Side Circuit Diagram

(ii) Signal Side

The XBee transceiver 1 fixed at the gate communicates with the microcontroller unit through XBee transceiver 2 located at the railway signal. The XBee transceiver 2 attached to the railway signal receives the data and changes the signal (LED) and alerts the train to stop.

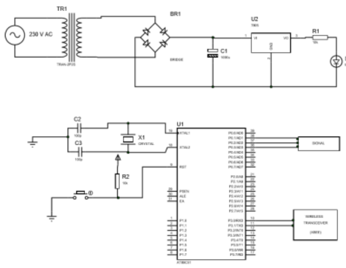

Fig-16. Signal side Circuit Diagram

If there is no obstacle, the train passes through the level crossing. The RF transmitter 2 attached with the back end of the train sends a signal code to the RF receiver fixed with the gate. On reception of signal from RF receiver 2, the microcontroller unit at the gate sends control signal to the DC motor driver and the gate opens.

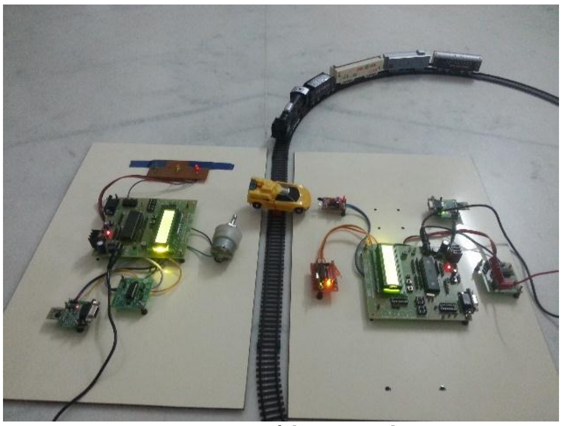

Fig- 17. Prototype of the proposed system

VII. CONCLUSION

The above method was experimentally verified and it will gradually decrease the effects of railroad accidents and improves safety in unmanned level crossings at less expenditure. Hence more lives were saved by the advent of the project.

VIII. REFERENCES

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