Academic Science

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 4
April 2017

An Arduino based Method for Detecting Cracks and Obstacles in Railway Tracks

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ABSTRACT

Indian Railways is the fourth largest railway network in the world. Although there is a tremendous growth in Indian Railways, this system is still plagued by a number of problems which require immediate attention. In this paper we are considering the major problems that lead to accidents. Major problems include obstacles entry on to the track and cracks on the tracks. To overcome this have proposed a testing train which uses ultrasonic sensor with a range of 100cms and delay is 30 cm.Based on the distance between obstacle and the train, the train slows down. When the train is at a distance of 20cm we increase the delay in order to slow down the train and finally when it reaches to a distance of 15cm the train automatically stops.During summer and winter seasons the tracks may expand and contract due to which cracks may occur. The LED and photodiode setup is placed to testing train to detect cracks. Here we are using arduino microcontroller. After crack detection the testing train stops and the longitudinal and latitudinal positions are sent via SMS to GSM and GPS.

Keywords—Arduino microcontroller, Light Emitting Diode(LED), Liquid Crystal Display (LCD), Global System for Mobile (GSM) and Global Positioning System (GPS).

I. INTRODUCTION

In today's world, transport, being one of the biggest drainers of energy, its sustainability and safety are issues of paramount importance. In India, rail transport occupies a prominent position in quenching the ever burge owing needs of a rapidly growing economy. However, in terms of the reliability and safety parameters, global standards have not yet been truly reached. Though rail transport in India is growing at a rapid pace, the associated safety infrastructure facilities have not kept up with the mentioned proliferation. The principal problem is the lack of efficient and cost effective technology to detect problems in the rail tracks and the lack of proper maintenance.

Fig.1 Cracks in Railway tracks

Fig.1 shows the cracks occurring in Railway tracks due to expansion and contraction. The proper operation and maintenance of transport infrastructure has a great impact on the economy. In this paper we have proposed a proto type of testing train for detecting obstacles and cracks, which is similar to that of line following testing train.The testing train, gets information from surrounding area through mounted sensors on the testing train. The sensors used for obstacle detection are bump sensor, infrared sensor and ultrasonic

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
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sensor. The ultrasonic sensor is very compact and has a very high performance. The Testing train uses ultrasonic sensors with microcontroller for its movements. Ultrasonic sensor is most suitable for obstacle detection due to its high ranging capability and low cost[1]. It is attached to the front part of the testing train. Whenever the testing vehicle is going on the desired path the ultrasonic sensor transmits the ultrasonic waves continuously from its sensor head. Whenever an obstacle comes ahead of it, the ultrasonic waves are reflected back from an object and that information is passed to the microcontroller. The microcontroller controls the motors left, right, back, front, based on ultrasonic signals. In order to control the speed of each motor, pulse width modulation is used (PWM) [10].

The basic components used in crack detection are IR LED and Photodiode. In this design, the IR LED and Photodiode will be attached to the same side of the track to indicate the condition of the track. If any default is observed it will send the information to the nearby station. The proposed testing train is cost effective, power consumption is low and analysis time is less [2]. With this proposed system the exact location of the faulty rail track can be easily located, so that many lives can be saved.

Objectives of the paper

- To detect the cracks present on the railway tracks.
- To detect the obstacles entry on to the railway tracks.

II. IMPLEMENTATION

A. Block diagram

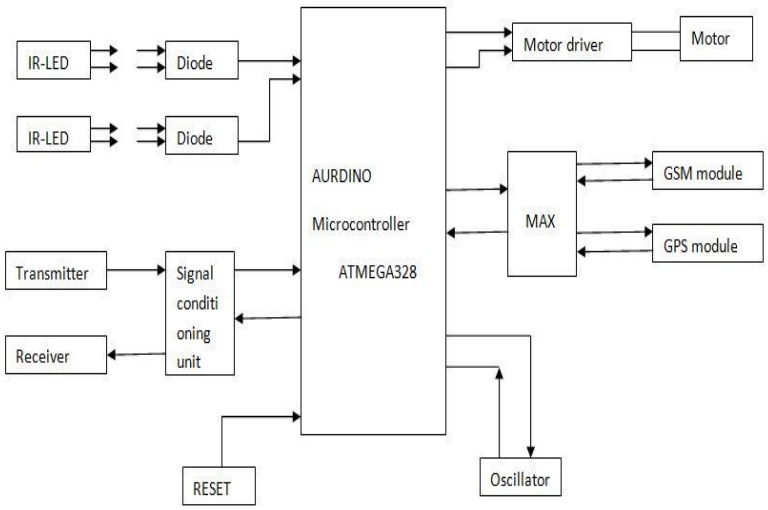

Fig.2 Block diagram

Fig.2 represents the block diagram description of the testing vehicle. The testing vehicle consists of four motors driven by a motor driver [1]. The IR LED, photodiode and Ultrasonic sensor which is connected to the Arduino, which in turn connected to motor driver runs and stops the motor. When the track is in continuous without any cracks then output of IR LED and Photodiode will be high. When this output is high then ultrasonic sensor sends a trigger pulse. This ultrasonic sensor continuously provides pulses until echo is received i.e., the train stops gradually when the echo is received. The time that is received from the echo through PWM counter is converted into centimeters.

The vehicle stops based on the length that we have given. For example if the length is less than 15 and greater than 10 then we set a delay of 20secs and when the vehicle is at a length less than 10 and greater 5 then we a set of about 100secs. If the length exceeds above 5cm then the vehicle stop automatically. These three conditions will be satisfied only when the object is present in its path in a stand still mode. The other condition is when there is crack, then output of IR LED and photodiode will be low and train stops

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automatically and a message is generated using GSM and GPS and will be sent to the nearby station. By using GPS we can determine latitude and longitudinal locations. By this we can display the details of the location to the driver through LCD display.

B. Arduino UNO Microcontroller

The Arduino UNO is a microcontroller board based on the ATmega328.Arduino is an open-source electronics prototyping platform and it is intended for designing, creating interactive objects or environments [3].Arduino boards are relatively inexpensive compared to other microcontroller platforms. A basic Arduino Uno board has been shown in Fig.3

Features

1. Cross-platform

The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems.

2. Simple, clear programming environment

The Arduino programming environment is easy-to-use for beginners and flexible enough for the advanced users.

3. Source and extensible software

The Arduino software is published as open source Open tools, available for extension by experienced programmers. The language can be expanded through C++ libraries.

4. Open source and extensible hardware

Technical Specifications

Microcontroller	: ATmega328
Operating Voltage	: 5V
Input Voltage (recommended)	: 7-12V
Digital I/O Pins 14	:PWMo/p
Analog Input Pins	: 6
DC Current per I/O Pin	: 40 mA
DC Current for 3.3V Pin	: 50 mA
Flash Memory	:32 KB
SRAM	: 2 KB
EEPROM	: 1 KB
Clock Speed	: 16 MHz

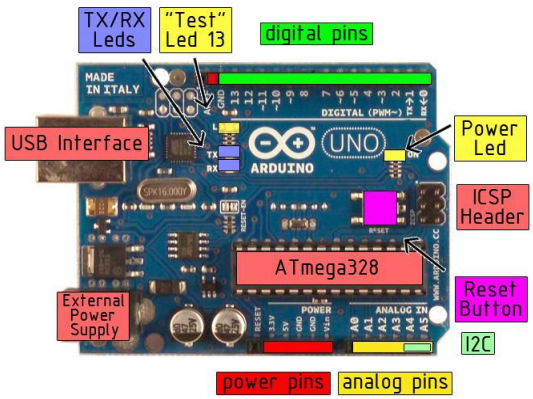

Fig.3 Basic Arduino UNO board

C. Ultrasonic Sensor

The Arduino Ultrasonic Range Detection Sensor with Arduino calculates distance from objects. The output of an LED alters with PWM according to how close an object is to the sensor. So nearer the object the brighter the LED [5]. This Sensor works by sending an ultrasound pulse at around 40 KHz. It then gets the echo back and calculates the time taken in µsec. We can trigger a pulse as fast as 20 times a second and it can determine objects up to 3 meters away and as near as 3cm. It needs a 5V power supply to run. Arduino can be added to Ultrasonic Range Detection Sensor using only 4 pins Power, Ground, Trigger and Echo. Since it needs 5V and Arduino provides 5V, we will use this to power it. There are 2 sets of 5 pins, 1 set we can use, the other is for programming the PIC chip. Supply module with 5V, the output will be 5V while obstacle in range, or 0V if not. The out pin of this module is used as a switching output when anti-theft module [4].

Fig.4 Ultrasonic sensor

Specifications

Working Voltage : 5V (DC)
Working Current : max 15 ma
Operating frequency: 40HZ
Output Signal : 0-5V (Output high when obstacle in range)
Sentry Angle : max 15 degree
Sentry Distance : 2cm - 500cm
High-accuracy : 0.3cm
Input trigger signal : 10us TTL impulse
Echo signal : output TTL PWL signal
Size : 45*20*15mm

Interface

Pin:1 VCC
Pin:2 Trigger(T)
Pin:3 Echo(R)
Pin:4 GND

Module Working Principle

1. Adopt IO trigger through supplying at least 10µs sequence of high level signal,
2. The module automatically sends eight 40 kHz square wave and automatically detect whether receive the returning pulse signal,
3. If there are signals returning through outputting high level and the time of high level continuing is the time of that from the ultrasonic transmitting to receiving.

Test distance = (high level time * sound velocity (340M/S) / 2.

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D. Global System for Mobile (GSM)

A GSM modem is dedicated modem with a serial, USB, Bluetooth connection, or it can be mobile phone that provides GSM modem capabilities. A GSM modem exposes an interface that allows application such as now SMS to send and receive message over the modem interface. The mobile operated charges for this message receive and sending as if it was performed directly on a mobile phone. To perform this task, a GSM modem must support an "extended AT command set" for sending/receiving SMS messages [6].

A GSM modem is specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone [7]. From the mobile operator perspective, a GSM modem looks just like a mobile phone. GSM Modem comes with various interfaces, such as PCMCIA Type 2, USB, and serial. GSM Modem is wireless, while dial-up modem is wired. Some GSM Modems also has GPRS Feature that allows transmission of data over TCP/IP .To transmit data using GSM Modem, there are various methods can be used, such as

>SMS

>CSD

>GPRS/UMTS

Even though a normal mobile phone can be used as GSM Modem, it is highly recommended that a special industrial grade terminal to be used as a GSM Modem due to stability, and reliability [8]. Requirements are

- SMS Gateway that is to send and receive SMS
- Telemetric that is to collect data from remote terminals
- Call-back service for VOIP
- SMS application, SMS solution, or SMS programme.
- Automatic reloading of pre-paid account with STK API machine to machine communication
- Sending SMS from PC
- Automating business process
- Vehicle tracking with cell broadcast feature or with integrated GPS terminal.

Key features

- GSM model
- Dual band GSM 900/1800 MHz
- 160 characters SMS
- Highly Reliable for 24x7 operation with Matched Antenna
- Status of Modem Indicated by LED
- Simple to Use & Low Cost

E. Global Positioning System(GPS)

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth [6] .Each satellite continually transmits messages that include

- The time the message was transmitted
- Satellite position at time of message transmission
- The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites locations are used with the possible aid of trilateration, to compute the position of the receiver. This position is then displayed, with a moving map display or latitude and longitude. Many GPS units show derived information such as direction and speed, calculated from position changes [9].

F. GEARED DC MOTOR

The DC motor works over a fair range of voltage. The higher the input voltage more is the RPM of the motor. In terms of voltage, we can write the equation as
RPM= K1 * V, where,
K1= induced voltage constant
V=voltage applied

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Gears are used to increase the torque of dc motor on the expense of its speed**.** The gear mechanism works on the principle of conservation of angular momentum. The gear having smaller radius will cover more RPM than the one with larger radius. However, the larger gear will give more torque to the smaller gear than vice versa. The comparison of angular velocity between input gear (the one that transfers energy) to output gear gives the gear ratio. When multiple gears are connected together, conservation of energy is also followed.

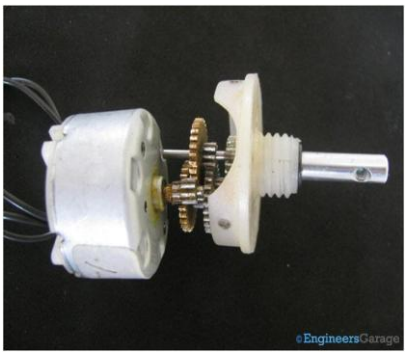

Fig.5 Gear mechanism to dc motor

G. Push-Pull Four Channel Driver

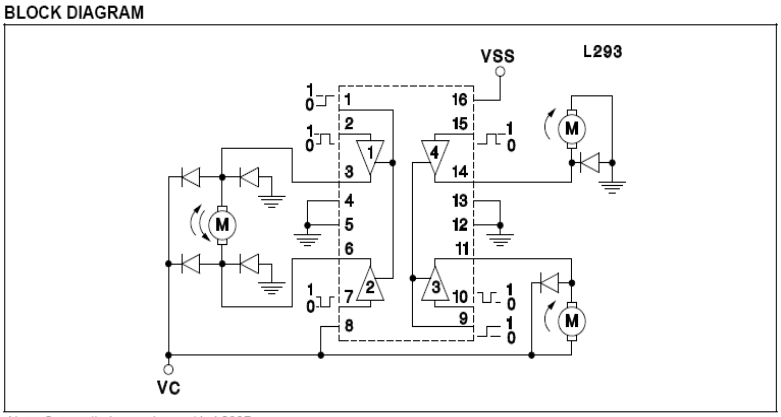

Fig.6 Block diagram of load driver L293

Each channel is controlled by a TTL-compatible logic input and each pair of drivers (a The L293 and L293D are quad push-pull drivers capable of delivering full bridge) is equipped with an inhibit input which turns off all four transistors. Output current is 1A or 600mA per channel respectively. A separate supply input is provided for the logic so that it may be run off a lower voltage to reduce dissipation. Additionally the L293D includes the output clamping diodes within the IC for complete interfacing with inductive loads. Both devices is available in 16-pin Batwing DIP packages. They are also available in Power S0IC and Hermetic DIL packages.

Features

- Output Current 1A Per Channel (600mA for L293D)
- Peak Output Current 2A Per Channel (1.2A for L293D)
- Inhibit Facility
- High Noise Immunity
- Separate Logic Supply
- Over-Temperature Protection

H. Motor Driver

Motor Driver ICs are primarily used in autonomous robotics only. Also most microprocessors operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltages

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and current. Thus current cannot be supplied to the motors from the microprocessor. This is the primary need for the motor driver IC. When the motor is applied positive voltage on both sides then the voltage from both the sides brings the motor shaft to a halt.

Depending upon the values of the Input and Enable the motors will rotate in either clockwise or anticlockwise direction with full speed (when Enable is HIGH) or with less speed (when Enable is provided with PWM). Let us assume for Left Motor when Enable is HIGH and Input 1 and Input 2 are HIGH and LOW respectively then the motor will move in clockwise direction. So the behaviour of the motor depending on the input conditions are shown in table1.

Table 1

Input 1	Input 2	Enable 1,2	Result
0	0	1	Stop
0	1	1	Anti-clockwise rotation
1	0	1	Clockwise rotation
1	1	1	Stop
0	1	50% duty cycle	Anti-clockwise rotation with half speed
1	0	50% duty cycle	Clockwise rotation with half speed

I. Interfacing LCD to Arduino UNO

LCD modules form a very important part in many Arduino based embedded system designs. The 16×2 JHD162A LCD is interfaced with Arduino. JHD162A is a 16×2 LCD module based on the HD44780 driver from Hitachi. The JHD162A has 16 pins and can be operated in 4-bit mode or 8-bit mode. Here we are using the LCD module in 4-bit mode [4].

Pin Diagram of JHD162A LCD Module 16×2.

The JHD162A has 16 pins and can be operated in 4-bit mode or 8-bit mode. Here we are using the LCD module in 4-bit mode. The schematic of a JHD162A LCD module is shown in Fig.7.

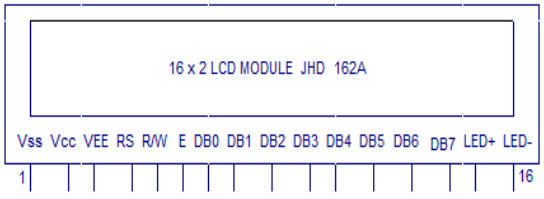

Fig.7 Pin diagram

Circuit diagram

The circuit diagram of interfacing LCD to arduino for displaying a text message is shown in Fig.8. RS pin of the LCD module is connected to digital pin 12 of the Arduino. R/W pin of the LCD is grounded. Enable pin of the LCD module is connected to digital pin 11 of the Arduino. The LCD module and Arduino are interfaced in the 4-bit mode. That means only four of the digital input lines (DB4 to DB7 of the LCD are used). This method is very simple, requires less connections and you can almost utilize the full potential of the LCD module. Digital lines DB4, DB5, DB6 and DB7 are interfaced to digital pins 5, 4, 3 and 2 of the Arduino. The 10K potentiometer is used for adjusting the contrast of the display. 560 ohm resistor R1 limits the current through the back light LED. The Arduino can be powered through the external power jack provided on the board. +5V required in some other parts of the circuit can be tapped from the 5V source on the Arduino board. The Arduino can be also powered from the PC through the USB port.

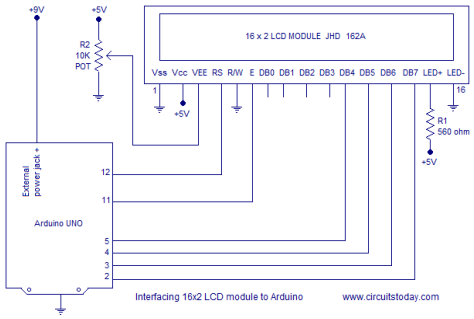

Fig.8 Circuit diagram

III. EXPERIMENTAL RESULT

The prototype of testing vehicle for obstacle and crack detection has been shown in Fig.9

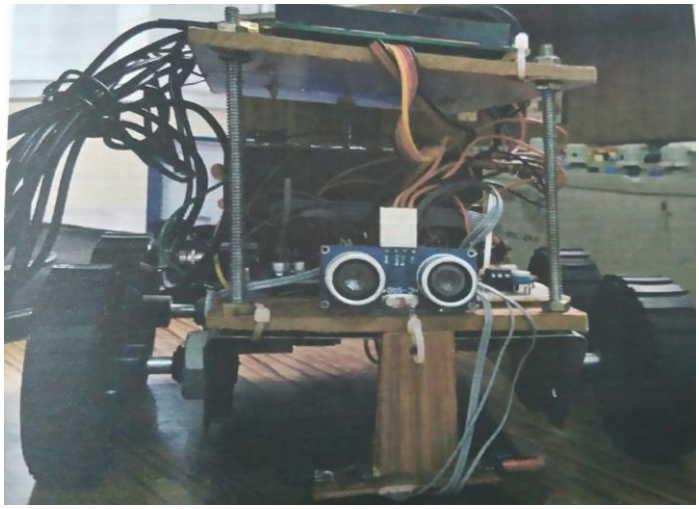

Fig.9 prototype of testing vehicle

IV. CONCLUSION

In this paper we have designed a cost effective, low-power embedded system, which facilitate better safety standards for rail tracks for preventing railway accidents due to cracks and obstacles on railway tracks. The Prototype of testing vehicle can efficiently detect cracks and obstacles on railway tracks. The result shows that this new innovative technology will increase the reliability of safety systems in railway transport. By implementing these features in real time application, we can avoid accidents up to approximately 70%.

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