Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2017
(ICMERE2017) 18 – 20 December, 2017, Chittagong, Bangladesh

ICMERE2017-PI-385

DESIGNING OF AN INTELLIGENT RAILWAY GATE CONTROL SYSTEM USING GSM MODULE

Mohammed Aman Ullah1[1], **Rubaiyet Imtius Chy.2**[2] **and Nipu Kumar Das3**[3]

[1]Department of EEE, Chittagong University of Engineering and Technology, Bangladesh
[2]Department of EEE, Chittagong University of Engineering and Technology, Bangladesh
[3]Assistant Professor, Department of EEE, Chittagong University of Engineering and Technology, Bangladesh
[1]*amanullah1002090@gmail.com, [2]nipu16@gmail.com, [3]imtiusr@gmail.com

Abstract*- Worldwide rail communication is considered as the cheapest and safest mode of transportation. Train accidents are not uncommon in the World. Unfortunately when these accidents happen, people are often critically injured or even killed. Accidents involving trains are often the result of mechanical failures and human error, and often it's a combination of both. In Bangladesh most of the train accidents are taking place at level crossing which is generally controlled by a gate keeper. In this paper an automatic level crossing system (ALCS) has been designed using servo motor and GSM technology in order to reduce the train accident frequency in level crossing. Moreover this ALCS also diminished unwanted traffic jam at level crossing by recognizing the exact position and the speed of the incoming train. The design system is very simple, reliable and easy to manufacture.*

Keywords: Train accidents, level crossing, automatic level crossing system, servo motor, GSM technology, traffic jam.

1. INTRODUCTION

The place where rail track and traffic road intersected each another is known as level crossing. There are two kinds of level crossing available based on operation. One is manned level crossing and the other is unmanned or automatic level crossing [1]-[2]. This paper is concerned of providing an automatic and smart railway gate control system for both level crossings systems. It deals with two things; Firstly, it will reduce the time for which the gate is being kept closed. Secondly it will enhance the safety to the road users by reducing accidents that usually occur due to carelessness of the road users and errors made by the gatekeepers. The system initiates its operation by sensing the arrival of the train using its sensors. Once the arrival is sensed the sensor begun to calculate the velocity of the train. The sensed signal is sent to the signal processing unit via GSM module [3]-[4]. Controller of ALCS becomes activated by getting the signal via GSM [5] and that drives the motor to close the gate. Here the activation and operation time of the servo motor fully depends upon the velocity of the train and is inversely proportional to the train velocity. As a result the operation time of motor or level crossing barrier is optimum.

Again, when the train leaves the level crossing the departure of the train is sensed by another pair of sensors. The signal about the departure is sent to the microcontroller, which in turn operates the motor and opens the gate. Thus, the time for which the gate is closed is less than the manually operated level crossing and also reliability is high as it is not subjected to human error.

The organization of this paper is as follows: In Section 2 level crossing accident scenario of Bangladesh is presented. The methodology of the ALCS is discussed in section 3 with its Practical layout. A prototype model also built to simulate the research work. Practical implementation of the system is discussed in section 4. Result and discussion is presented in section 5. Finally conclusion is drawn in section 6.

2. LEVEL CROSSING ACCIDENT SCENARIO IN BANGLADESH

2.1 Rail Accident From 2006-2015

According to Bangladesh Railway In the year 2006 -2015 the number of train accidents in Bangladesh was 3068 [6]. There were ups and downs in the number of accidents in those years. The number of accident reached its peak with 528 accidents in the year 2006-2007. The number was lowest in 2012-2013 with 151 accidents. Most people were injured in the year 2006-2007 and most people died in 2007-2008. Total 1492 people were injured and 370 people were died during these years due to rail accidents. Among these majorities of the accidents occurred at level crossing.

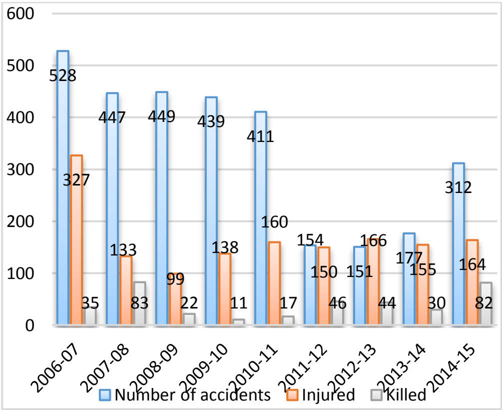

Fig.1: Level crossing accidents from 2006-2015

2.2 Causes of Level Crossing Collisions

In table 1 the Causes of level crossing collisions in Bangladesh is presented. According to the information of Bangladesh railway the traffic rule violation was the major cause of collision at level crossing which repeated itself for 254 times. The second maximum was passing of signal at danger which occurred 45 times. Human involvement was the reason of 98.3% accident at level crossing [7]. It was the reason for 163 deaths. If human can be replaced by automatic system where train detection can be done automatically by sensors then the accidents due to human error can be minimized. Again if the sensors have the capability of predicting train speed, and control ALCS accordingly before train reaches the station then traffic rules violation by people will be reduced in great extent. A system which can perform both discussed in this paper.

Table 1: Causes of level crossing collisions

Major cause of collisions	No of repetition
Traffic rule violation by road user at level crossing	254
Passing of signal at danger	45
Leaving station without line clear	11
Wrong setting of point	8
Handover line clear without ensuring clearance of another station	6
Miscellaneous	6
Careless train operation	4
Under investigation	4
Station rule violation	2
Signal violation and high speed	2
To show signal wrongly	2

3. METHODOLOGY

The total working procedures of the ALCS is described in this section. The reliability of the system is examined by designing and implementing a prototype model.

3.1 Train Detection and Data Transmission Flow Chart

Train detection and data transmission program flow chart is shown in Figure 2. IR sensors are used in this prototype model for train detection because of its lightweight and fast response time moreover it is cheaper than other sensor [8]. IR sensors are able to detect an obstacle at the distances within their usable range with percentage of accuracy between 95% and 99% [9]. The experimental result via prototype model indicated IR sensors are able to provide reliable distance measurements even with different colors and materials of obstacles.

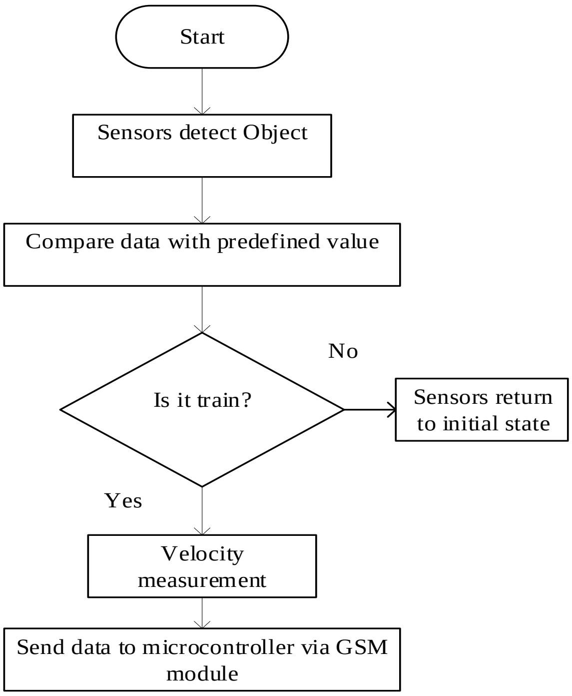

Fig.2: Train detection and data transmission flowchart

3.2 Velocity Measurement

Average velocity v of incoming train is computed by the following formula;

$$v = \frac{dispacement\ between\ sensor}{time} \quad (1)$$

In the prototype model three pair of IR sensors was used for the measurement of velocity. Sensors were kept 15 cm apart from one another for detecting train and its speed. During practical implementation the location of the sensors are very important and it will largely depend upon the rail traffic velocity of that area. Location will be selected by analyzing the speed of the train, and geological condition of that location. In Bangladesh the average speed of the passenger train is 60 km/hr and the speed of cargo train is around 40 km/hr. Hence sensors can be placed 5 km away from the level crossing and the distance between each sensor pair is 50m which will give the system enough time to analyze the data and create response accordingly. Again all of our train which includes both passenger train and cargo train has an average height of 10 to 11 feet. That's why during practical implementation the sensors height from the ground should be at least 9 feet but not more than 10 feet.

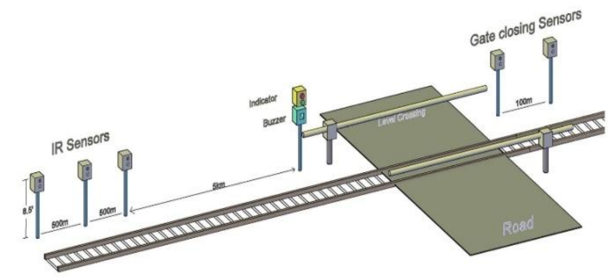

Fig.3: Practical layout of the system

This helps to avoid any wrong detection. Again train needs to pass all 3 of the sensors pair. Otherwise microcontroller of the signal processing module will detect it as a wrong signal. This gives the detection even more accuracy.

3.3 Transmission of Signal

The transmission of signal can be done by using GSM module. GSM is an open and digital cellular technology used for transmitting mobile voice and data services [10]. In the prototype model arduino uno was interfaced with GSM module. The signal transmission time of the GSM module is depended on network operator's signal strength, weather condition etc which is mostly constant. Again GSM is widely available. That's why GSM is considered for signal transmission purpose. In the prototype model "Grameen Phone" was chosen as network operator. The average signal transmission and receiving time using this specific network was found around 8.382 seconds.

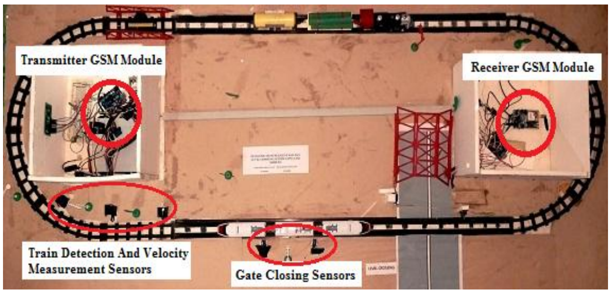

Fig.4: Prototype layout of the system

3.4 Flow Chart for Controlling Level Crossing

In conventional system the gateman receives information about the arrival of the train through SMS or mobile call from the station. He surely does not know when the train will reach the level crossing. Again the train speed varied widely. Hence it becomes impossible to predict the train arrival time at level crossing. As a result gateman kept the gate close for an unnecessary amount of time resulting severe traffic jam. Here this problem is eliminated by controlling the gate driving circuit. The flow chart of driving circuit is shown in Figure 5.

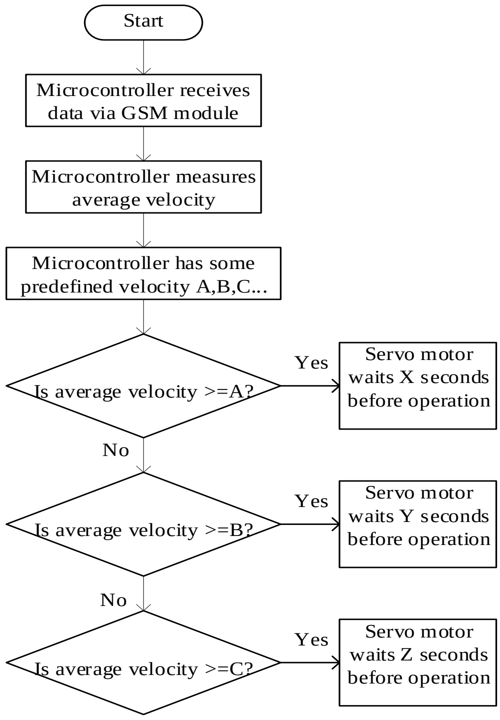

Fig.5: Flow chart for gate driving circuit

There will be some predefined velocity ranges which are kept stored in microcontroller memory. Microcontroller receives train velocity via GSM and compares the received velocity with the predefined one. When the velocity matches with any range category it activates gate controlling motor according to the speed. For example, if the speed of the train is high, gate control operation starts quickly. On the other hand if the speed is low gate control operation waits some time and starts its operation in a way so that gate operation time is minimum and the chance of traffic jam in front level crossing reduce greatly. As a result train speed is used to determine when the motor becomes operational. In this way the level crossing remain close for minimum amount of time.

4. PRACTICAL IMPLEMENTATION

For this we have to decide the motor's required power. The motor will be a servo motor as they are easily programmable, hence easy to control. Servo will control the level crossing gate. This gate will be fixed with the motor shaft and motor will rotate horizontal to 90 degree vertical. First we have to find out the gate's weight in order to find out the motor's required torque. If we use a Hollow cylindrical Aluminium gate which is L=5 meter long and has an inner radius of 4 cm, outer radius of 4.2 cm then its volume would be V= 0.003204 m3. The density of Aluminium is 2700kg/m3. Hence the mass of the gate

$$M = \rho \times V \quad (2)$$
$$= 8.651 \text{ kg}$$
Required moment of inertia $I = 1/3ML^2$ (3)
$$= 1/3 \times 8.651 \times 25 \text{ kgm}^2$$
$$= 72.091 \text{ kgm}^2$$
If the gate has an angular displacement of 90 degree and it requires 10 seconds for this displacement then the angular velocity will be $\omega = \pi/20$ (4)
Hence angular acceleration $\alpha = \omega/10$ (5)
$$= \pi/200$$
As a result the required torque $\tau = I \times \alpha$ (6)
$$= 1.132 \text{ Nm}$$
From any servo motor specification we can find out the required motor size easily using the torque. For our case a 200 watt servo motor is sufficient considering all kind of losses.

For practical implementation we need device like Circuit Breaker, Noise Filter, Magnetic Contactor, Reactor, Regenerative Resistor, Common Mode filter, Servo drive etc. The GSM Module will be connected to the servo drive which has the capability to analyse the upcoming message of GSM Module and take required measurements according to coding.

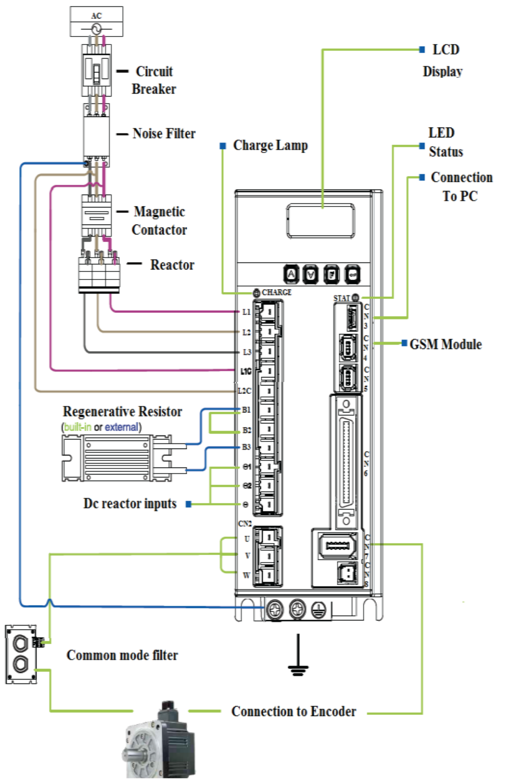

Fig.6: Circuit Diagram for Practical system

5. RESULT AND DISCUSSION

Train accidents are not as frequent as other vehicular accidents, but the severity level of train accident is much higher. Catastrophic train accidents can causes loss of life and damage of huge amount of economy. This paper deals with establishing an automatic and effective level crossing system for railway. This automatic railway gate control system will eliminate level crossing accidents due to human error and ensures time saving of the public by reducing jam without degrading the safety level. Reduction of traffic jam at level crossing will reduce traffic rules violation, brings about improvement in rail traffic system.

6. Conclusion

Level crossing being an important cross section between rail track and traffic road has always been subjected to accidents and traffic jam. Most of the cases human related error causes the suffering of the people. This paper is mainly focused on two problems which are minimizing unwanted accidents at level crossing and reducing level crossing operation time in order to prevent traffic jam at level crossing. This system is capable of solving the both, which will uplift the confidence levels of the road users tremendously.

7. REFERENCES

[1] R.Gopinathan, B.Sivashankar, " Plc based railway level crossing gate control," International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE), ISSN: 0976-1353 Volume 8 Issue 1 –APRIL 2014.

[2] Amitabh Agarwal, "Human Interface in Railway Safety- A New Dimension. [Online] Available: http://www.rssb.co.uk/irsc/Documents/Dublin/24_October_2006_Papers/09_Amitabh_Argul.pdf

[3] Ahmed Salih Mahdi, Al-Zuhairi, "Automatic railway gate and crossing control based sensors & microcontroller," International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013.

[4] Han-Lee Sang, "Automatic vehicle location in cellular communications systems," Vehicular Technology, IEEE Transactions on, vol.43, no.4, pp. 902-908, Nov 1994.

[5] N. K. Das, C. K. Das, Rajesh Mozumder, Jiban Chandra Bhowmik, "Satellite based train monitoring system," Journal of Electrical Engineering, The Institution of Engineers, Bangladesh. Vol. EE 36, No. 2, December 2009.

[6] Bangladesh railway yearbook 2015. [Online] Available: http://www.railway.gov.bd/

[7] Mutamid Billah Azzacy, "Analysis of rail accidents due to collision and their preventive measures in Bangladesh," Department of Civil Engineering, Bangladesh University of Engineering and Technology, March, 2012.

[8] Acy M. Kottalil, Abhijith S, Ajmal M M, Abhilash L J., Ajith Babu, "Automatic railway gate control system," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 2, February 2014.

[9] B. Brailson Mansingh, K.S. Selvakumar, S.R. Vignesh Kumar, "Automation in unmanned railway level crossing," International Conference on Intelligent System and Control (ISCO)2015.

[10] C. Chellaswamy, Srinidhi Srinivasan, R.Ramesh Babu, "A humanitarian Intelligent Level Crossing Controller Utilizing GPS and GSM," IEEE Global Humanitarian Technology Conference - South Asia Satellite (GHTC-SAS) | September 26-27, 2014