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Artificial Railway Safety and Security System

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ABSTRACT

The objective of this paper report is to provide an efficient alternative to many conventional techniques used by the railways in order to decrease accident occurrence incorporating manual operations. This model provides three different control alternative mechanisms automatic gate control, tunnel light control and collision detection system. These systems are designed by using Moc-3021 Optocoupler/Optoisolator to avoid railway accidents and automatic gate control. Pressure sensor mechanism is utilized for advanced tunnel lighting. The system holds potential to provide an intelligent railway management replacement with enhanced hardwired approach. This system furnishes an efficient, reliable, secure alternative for existing railway management systems.

General Terms

Hardwired approach, Optocouplers, Optoisolators, Automatic Barrier control mechanisms, Power Conserving Lighting, and Advanced Collision Detection system.

Keywords

Tunnel light control; Automatic gate control; Moc-3021; LED; Anti-collision device; IR Sensors; BC100P comparator; 555 Timer; reed sensor.

1. INTRODUCTION

Indian Railways is the lifeline of India. To make it a safe and reliable is a challenge. The Railways has the most inter-dependent attributes. Safety on the Railways is the end product of the cohesive fusion of its myriad parts. A single flaw in the 64,600 route kms of track that criss-cross the country, a defect in over 9,500 locos, 55,000 coaches and 2.39 lakh wagons that haul about 23 million passengers and nearly 2.7 million tons of freight every day [1], an incorrect indication on one of the thousands of signals that dot the rail landscape, a mistake or an act of negligence by one of its staff directly associated with train running, even a rash act by one of the millions of road users who daily negotiate around odd level crossing gates spread across the system, an irresponsible act of carrying inflammable goods – any one of these multiple possibilities has the potential to cause a major tragedy. Added to these are the acts of sabotage by misguided elements spanning the whole country. Thus utmost vigil is safety in operations and also security of the traveling public is accorded by the Railways. Railway safety is a crucial aspect of rail operation over the world. The chart below shows the relationship of movement of traffic to that of the occurrence of accidents from 1960 to 2010 [2].

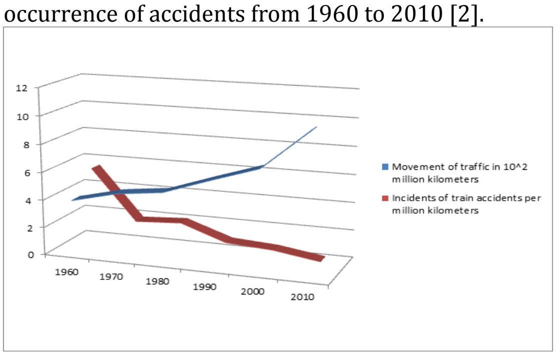

Fig 1: Occurrence of Accidents in Railways

Accidents at railway crossings are mainly due to the carelessness in manual operations or lack of personals. This model deals with two prospects. Firstly, it deals with the reduction of time for which the gate is being kept shut. And secondly, to provide safety to the road users by reducing the accidents that usually occur due to carelessness of road users and at times errors made by the gatekeepers. In order to achieve the desired goal, sensors are placed at some distance from the gate detects the departure of the

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train. 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 compared to the manually operated gates since the gate is closed depending upon the telephone call from the previous station. Also reliability is high, as it is not subjected to manual errors. The peoples of present age are using the fossil fuels very rapidly for electricity generation and for domestic purpose. If with the same rate the fossil fuel is in use then in next 35 to 40 years they are going to be extinct and we are in a deep trouble. The rationale behind this concept is to produce the electrical potential with help of mechanical work. At present, lights of railway tunnels are glowing permanently which is not necessary but by this concept, lights are allowed to glow at the time when it is required. Since there are a large number of railway tunnels in India so by applying this concept large amount of electrical energy can be saved which is generated by non-renewable sources energy like coal.

2. RESEARCH FOUNDATION

ITS (Intelligent Traffic System) is a topic of huge concern to our developing world and a lot of prior research has been done but due to diversities of technologies and fields. The absence of a unified system exists. Acy M. Kottalil et.al proposed a model of Automatic Railway Gate Control System using IR sensors for detection of trains at railway crossings and controlling level crossing gates accordingly [3]. But the system is considered to be very less reliable due to the presence of very highly sensitive IR sensors which is considered to compromise with the sensing in the presence of sunlight. Anjali Jain et.al came up with a Collision Detection and Avoidance System in Railways Using WiMAX the system incorporated 4G WiMAX with GPS for calculation location of equipped locomotives the system is able to clarify the fact that one to one collisions can be avoided by using it however a decrement in one to one collisions is observed with the use of advanced automatic signaling in railways [4]. Since this system might not be able to report collisions at level crossing considering accidents at level crossings are considerably trending the capital invested in the system will not be efficient enough. Another microcontroller based approach was discussed by Krishna et.al using 8952 microcontroller and sensors to sense the location of train and act accordingly to control the movement of level crossing [6]. But the use of a small scale approach for a really complex network will not be sufficient enough to uphold the requirements of railways also the reliability of the system will not be good enough. A PLC based approach was followed by Mahesh Nandaniya et.al with real time monitoring using SCADA the approach is reliable but the capital investment in every level crossing by single PLC will result inefficient in a way since there is a very large quantity of level crossings and controlling every level crossing with a PLC of its own will increase the capital cost by many folds [6]. Subrata Biswas et.al discussed an approach for Pressure Sensed Fast Response Anti-Collision System for Automated Railway Gate Control the system utilized a pressure sensor with IR sensors for the detection of vehicles and the locomotive respectively [7]. However in this system the reliability of pressure based sensing approach is less since the pressure sensor cannot distinguish between vehicles on and around the railway crossing also it cannot function in a potential collision wherein both the vehicle and locomotive are approaching, the determination of presence of a vehicle will be an issue due to the weight of the track also the life of the sensor will not be much due to the movement of heavy locomotives over it. Another model was discussed by Cai Guoqiang et.al on Rail Safety Security System which involved integrating several existing railway safety and security systems on a whole involving monitoring and early warning, risk assessment, predictive control and emergency rescue system [8]. Since the integration of the existing system will be cumbersome task it will also include compatibility issues better several system as they are not designed to work incorporating themselves with each other which will include huge capital investment and the resultant system will be very complex in nature turning out to be very less reliable. Emad Aboelela et.al proposed a model of Wireless Sensor Network Based Model for Secure Railway Operations involving the use of accelerometers and ultrasonic sensors capable enough to detect wear on the rail and breakages in them however the accumulation and detection of WSN requires large amount of time and complex technicalities. In a condition where real time decision making is required the current system will fail to provide solution due to the processing incapability of data from WSN [9].

3. QUANTITATIVE ANALYSIS

The term "accident" covers a wide area of occurrences with or without significant impact on the system, Consecutive train accidents include mishaps with serious outcomes in terms of loss of human life and injury, damage to railway property or interruption in rail traffic. These consequential train accidents include collisions, derailments, fire in trains, road vehicles colliding with trains at level crossings, and certain specified types of "miscellaneous" train mishaps.

3.1 Collisions and Derailments

The graph below depicts the collisions and derailments in Indian railways due to the failure of the staffs from 1965 to 2010 [11].

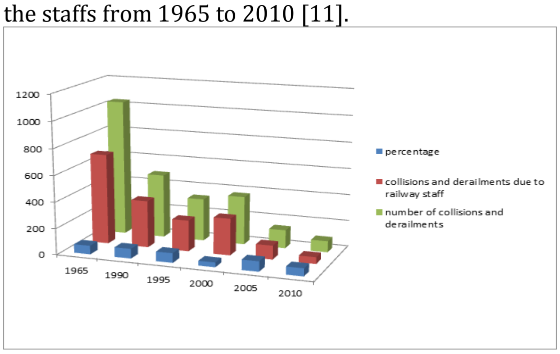

Fig 2: Collisions and Derailments

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3.2 Casualties

The following table indicates the number of passengers killed and/or injured in train accidents. The figures exclude casualties sustained as a result of passengers' own negligence (e.g. footboard travelling, etc.) and casualties involved in case of sabotage [10].

Table 1. Casualties in Train Accidents from 2008 to 2013

Year	Number of Passengers		Total casualties per million carried
	Killed	Injured	
2008-09	209	444	0.094
2009-10	238	397	0.088
2010-11	381	461	0.110
2011-12	319	716	0.126
2012-13 (up to January 2013 (Prov.)	185	317	*

3.3 Railway Crossings

Elimination of Level Crossings is a gigantic task and involves lot of manpower, resources and budgetary support. It is a continuous process and is done as per need, inter-se priority of works, availability of funds and co-operation of State Government, particularly, in getting consent of closure of level crossing and undertaking to maintain road and drainage in future for subways. The details of railway accidents occurred at Level Crossings from the year 2002-03 and onwards are given below [11].

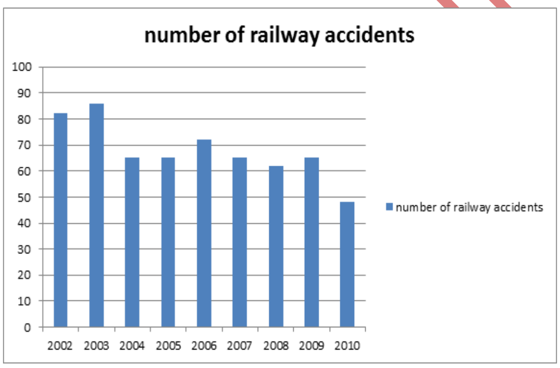

Fig 3: Number of Railway Accidents at Railway Crossings

4. HARDWARE CONFIGURATION

4.1 IR Sensors

The IR Sensor-Single is a general purpose proximity sensor. Here we use it for collision detection. The module consists of an IR emitter and IR receiver pair. The high precision IR receiver always detects an IR signal.

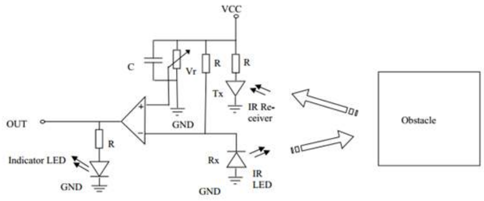

Fig 4: Functional Diagram IR Proximity Sensors

4.2 Reed Switches

The Reed Switch is an electrical switch operated by an applied magnetic field. It is a small electromechanical device having two ferromagnetic reeds that are hermetically sealed in a glass envelope. They range in length from 2.0 inches long to as small as 0.025 inches long. It was invented at Bell Telephone Laboratories in 1936 by W. B. Elwood. It consists of a pair of contacts on ferrous metal reeds in a hermetically sealed glass envelope. The contacts may be normally open, closing when a magnetic field is present; normally closed and opening when a magnetic field is applied; or one normally open and one normally closed [12].

Fig 5: Reed Switch

4.3 MOC 3021

The MOC30XX family of non-zero crossing triac drivers consist of an aluminum gallium arsenide infrared LED, optically coupled to a silicon detector chip. These two chips are assembled in a 6 pin DIP package, providing 7.5KV AC (PEAK) of insulation between the LED and the output detector. These output detector chips are designed to drive triacs controlling loads on 115 and 220V AC power lines. The detector chip is a complex device which functions in the same manner as a small triac, generating the signals necessary to drive the gate of a larger triac such as Fairchild's FKPF12N60. The MOC30XX triacs are capable of controlling larger power triacs with a minimum number of additional components [13].

ijournals International Journal of Software & Hardware Research in Engineering
ISSN No: 2347-4890 Volume 2 Issue 8, August 2014

Fig 6: MOC 3021 Optocouplers

4.4 LM358 low power dual operation amplifier

Utilizing the circuit designs perfected for Quad Operational Amplifiers, these dual operational amplifiers feature low power drain, and common mode input voltage range extending to ground/VEE, and single supply or split supply operation. The LM358 series is equivalent to one–half of an LM324. These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 32 V, with Quiescent currents about one–fifth of those associated with the MC174 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage [14].

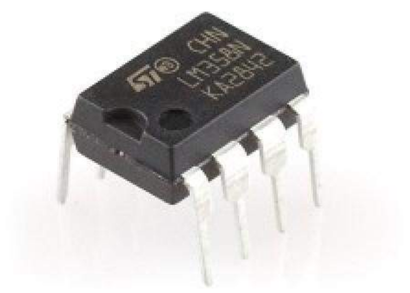

Fig 7: lm358 low power dual operational amplifier

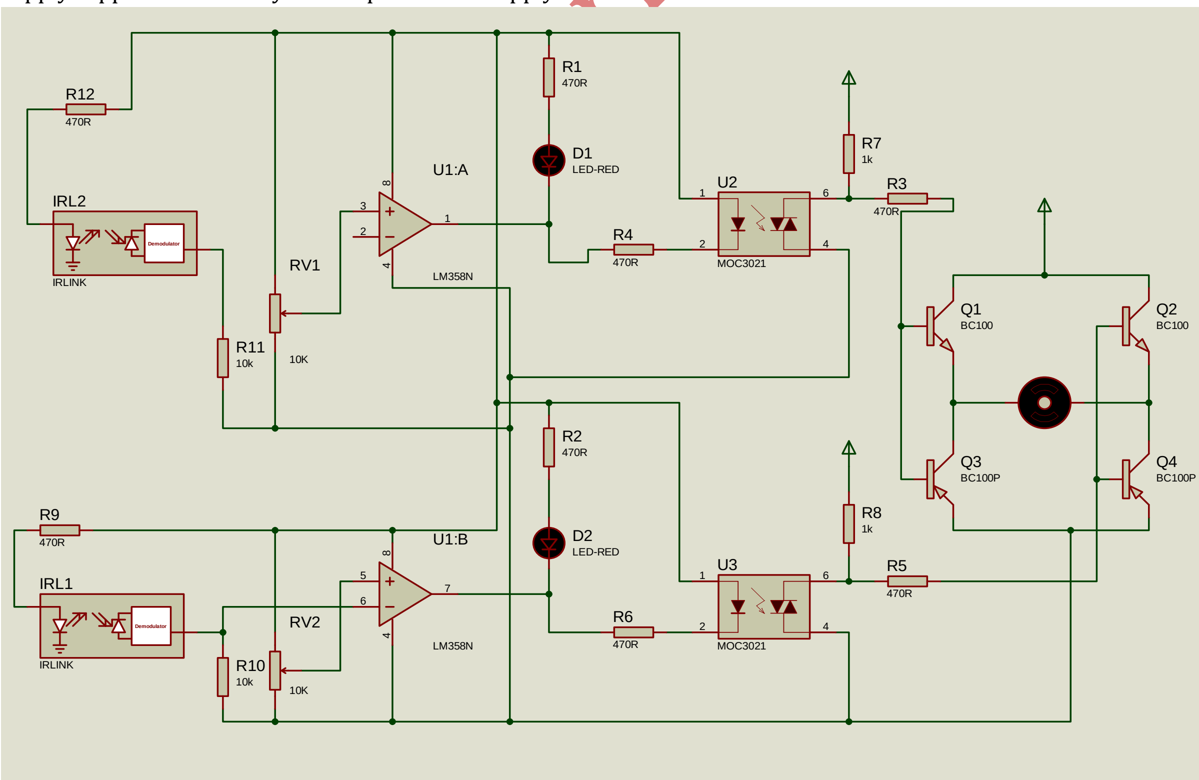

Fig 8: Circuit for ACD (Anti Collision Device)

5. WORKING

The whole System incorporates three sub sections

- ACD (Automatic Collision Detection)
- Automatic Gate Control
- Automatic Tunnel lighting

The system works in compatibility with these subsections which functions together to provide railway a full-fledged railway security and safety mechanism.

5.1 ACD (Automatic Collision Detection)

This system is designed to automatically detect any Collision with other locomotives as well as any obstruction from any other obstruction from vehicles or other objects and level crossings. Anti-Collision Devices have knowledge fixed intelligence. They take inputs from Sensors for proximity updates and take decisions for timely auto-application of brakes to prevent dangerous 'collisions'.

ACDs fitted (both in Locomotive and Guard's Van of a train) act as a watchdog in the dark as they constantly remain in lookout for other train bound ACDs, within the braking distance required for their relative speeds.

5.2 Automatic Gate Control

The use of Automatic Gate Control evolved from the increase in number of accidents at railway crossings. A sensor is placed at certain proximity of railway gate to detect the train. When a train comes it detects the train and displayed it on the monitor and then it controls the railway gate and reduces the railway accident automatically.

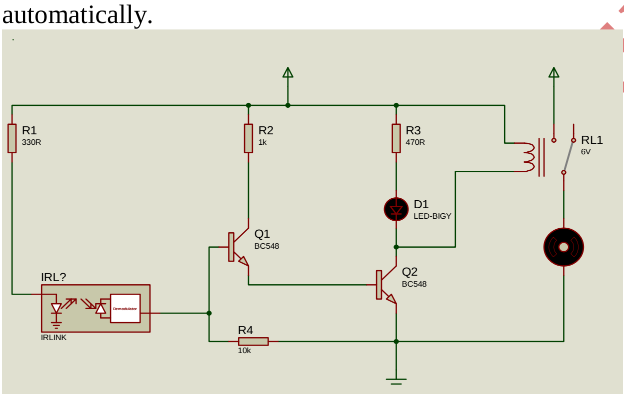

Fig 9: Circuit Diagram for Automatic Gate Control

5.3 Automatic Tunnel Lighting

When the train is passing through the tunnel area then weight of the train is transferred to the switches fitted under the track due to which the circuit completes the current flows through the circuit and the bulb starts glowing under the tunnel. When the train is passed out of the tunnel then weight of the train is removed from the switch and bulb stops glowing.

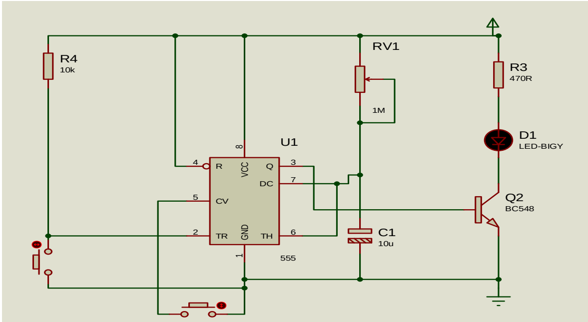

Fig 10: Circuit Diagram for Tunnel Light Control

6. ACKNOWLEDGMENTS

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