Advance Train Detection Technique for Automatic Level Crossing

Surender Kumar [#1], Dr. Y. K. Jain [*2]

[#] *Research Scholar, Mewar University,*
Chittorgarh, Rajasthan, India
[1] Suren001@gmail.com

[*] *Professor, Mewar University,*
Chittorgarh, Rajasthan, India
[2] Pykjain_47@yahoo.com

***Abstract*—Train accidents nowadays, are big problem for any country. These accidents are mainly on the unmanned level crossings. Manning of unmanned level crossings is a costly manoeuvre and hence automatic level crossings are the requirement of time. This can be done by existing techniques or may be tried out some new approaches. Advance train detection technique is one of these new approaches towards making automatic level crossings. In this technique piezoelectric sensors are used to detect the presence of train well in advance to the measurement point and PLC is Used to control the different controlling devices like barriers, warning audio and visual signals and display units at a site location as well as in a remote control room.**

***Keywords*—Advance Train Detection (ATD), Piezoelectric Sensor, Strain Gauge, PLC, SCADA**

I. INTRODUCTION

Advance Train Detection technique is a new approach towards making automatic level crossings at unmanned level crossings as well as at manned level crossings. At present existing techniques uses the method of detecting train at the measurement point means measurement point need train to be physically present on it whereas advance train detection technique uses sound measurement sensors to locate the position of train before the measurement point.

Authors, in this paper, have discussed the existing technique model in brief and presented the advance train detection technique in detail.

II. EXISTING TECHNIQUE MODEL

The model diagram for the measurement of train over the railway tracks is shown in fig. 1. Most commonly used technique is axle detection. In this technique two axles are used to measure the pass over train. The sequence in which train crosses the axle determines the direction of train. Other measurement technique involves the use of IR sensors, radio frequency identification detection (RFID), Track circuit, Train actuated warning devices (TAWD). But all these available techniques use the physical presence of train at the measurement point.

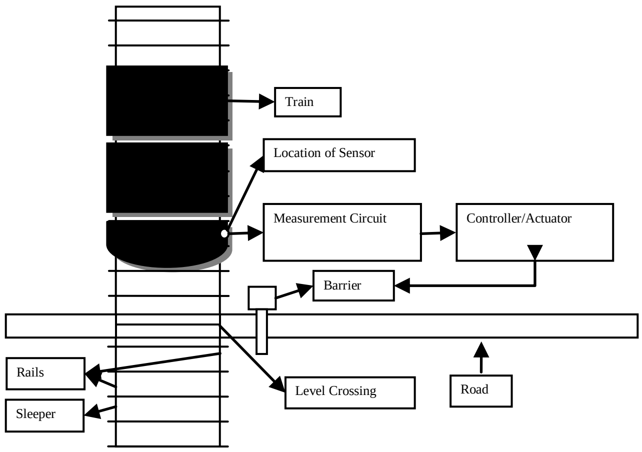

Fig. 1 Existing Technology

III. PROPOSED MODEL

Authors have proposed a new technique which uses the sensor to detect the presence of train well before the arrival of train at the measurement point. This approach is shown in fig.2. This can be done by measuring the acoustic wave induced inside the rails of railway tracks. Acoustic waves are produced due to the rolling noise [1] generated by the rolling of wheels over the railway track. Rolling noise is the prime contributor of propagation of this wave. The impact of rolling noise is given in [1].The speed of sound wave is much more in dense medium than in light dense medium. Sound wave travels 17 times faster in steels than air. This principal is used in locating train well in advance from measuring point. The acoustic signal, produced inside the rails due the rolling noise, will travel much faster than train towards the measurement point. At this location acoustic measurement sensor is placed to record the nature of wave.

Firstly the output of sensor is fed to laptop via electronic circuit for the analyses of behaviour of wave propagation. Secondly this output is connected to the controller and controller is programmed to actuate various devices like barriers, warning lights, warning audio speakers and display units. Thirdly Supervisory Control And Data Acquisition (SCADA) is developed to demonstrate the virtual working of all the system.

Following hardware and software components are used to design proposed model.

1. Hardware Components
   a. Sensor
   b. Electronic circuit
   c. PLC :- Programmable Logic Controller
2. Software Components
   a. CircuitLogic :- Electronic Circuit Designing Software
   b. GoldWave :- Sound Analyzing Software
   c. RSlogix500 :- PLC programming software
   d. RSView32 :- SCADA Software

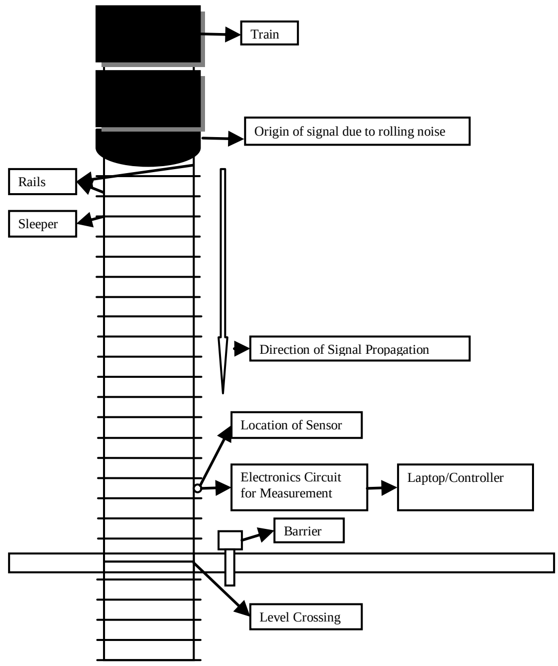

Fig.2. Proposed Technique.

IV. SELECTION OF SENSOR

Two types of sensors are most suitable for the detection of sound wave inside the rails. These are piezoelectric sensors and strain gauges.

1. Principal of piezoelectric sensors

Piezoelectric device [8] is an electronic device commonly used to produce sound. Light weight, simple construction and low price make it usable in various applications. Piezoelectric sensor is based on the principle of piezoelectricity discovered in 1880 by Jacques and Pierre Curie. It is the phenomena of generating electricity when mechanical pressure is applied to certain materials and the vice versa is also true. Such materials are called piezoelectric materials. Piezoelectric materials are either naturally available or manmade. Piezoceramic is class of manmade material, which poses piezoelectric effect and is widely used to make disc, the heart of piezoelectric sensor and is shown in fig. 3.

Fig.3. Piezoelectric sensor

2. Principal of Strain gauge

The strain gauge [6] has been in use for many years and is the fundamental sensing element for many types of sensors, including pressure sensors, load cells, torque sensors, position sensors, etc. The majority of strain gauges are foil types, available in a wide choice of shapes and sizes to suit a variety of applications. They consist of a pattern of resistive foil which is mounted on a backing material. They operate on the principle that as the foil is subjected to stress, the resistance of the foil changes in a defined way.

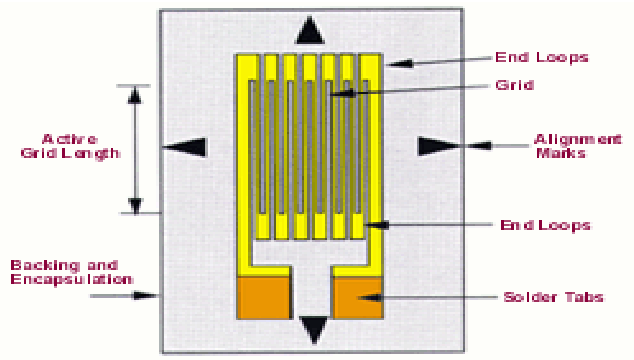

Fig.4. Strain Gauge

The strain gauge is connected into a Wheatstone Bridge circuit with a combination of four active gauges (full bridge), two gauges (half bridge), or, less commonly, a single gauge (quarter bridge). In the half and quarter circuits, the bridge is completed with precision resistors.

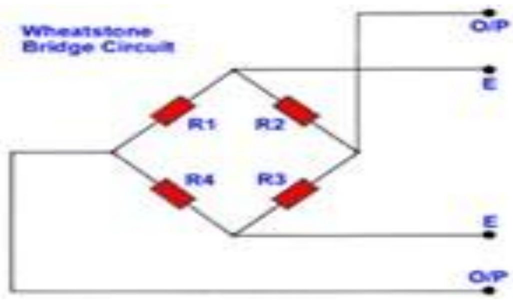

Fig.5. Wheatstone bridge

The complete Wheatstone bridge is excited with a stabilized DC supply and with additional conditioning electronics, can be zeroed at the null point of measurement. As stress is applied to the bonded strain gauge, a resistive change takes place and unbalances the Wheatstone bridge. This results in a signal output, related to the stress value. As the signal value is small, (typically a few millivolts) the signal conditioning electronics provides amplification to increase the signal level to 5 to 10 volts, a suitable level for application to external data collection systems such as recorders or PC Data Acquisition and Analysis Systems.

Authors have selected the Piezoelectric Sensor as it is easily available and can be easily pasted on the side wall of rails whereas strain gauge is required to be cemented on the walls of rails, which is not under the scope of authors.

V. DEVELOPMENT OF ELECTRONIC CIRCUIT

The output of piezoelectric sensor provides electric variation of very low voltage hence an electronic circuit is required to amplify this low voltage signal. circuitLogic software [9] is used to develop and study the waveform of electronic circuit. Fig.6 shows the developed circuit in CircuiLogic environment and the waveform produced at output port.

Actual circuit is then designed on the PCB board and is placed near the railway track as shown in fig.7. The output from this circuit is inputted to the GoldWave Analyzing Software for studying the behavior of wave inside railway tracks via microphone input of laptop and simultaneously to the PLC controller for the controlling of various devices like barriers, warning sound and light signals etc

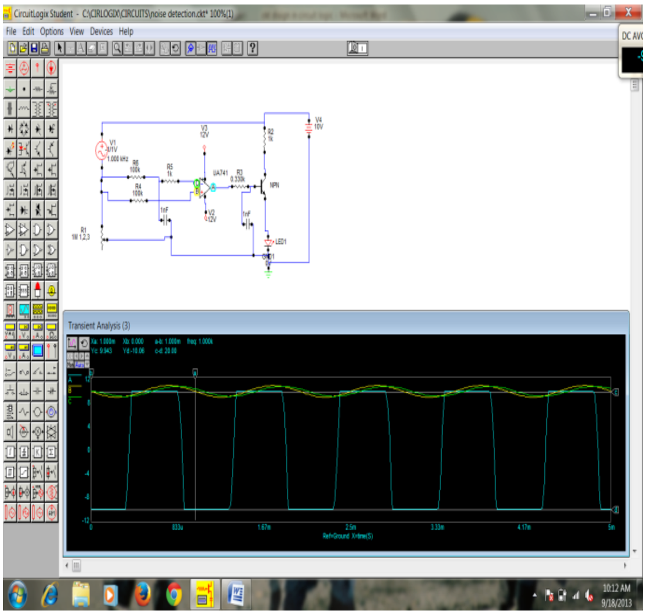

Fig.6. Circuit Designing in CircuitLogic

Fig.7. Placement of Sensor Circuit

VI. PROGRAMMABLE LOGIC CONTROLLER (PLC)

PLC [3] is a very powerful controller for handling different applications. The abbreviation "PLC" and the term "Programmable Logic Controller" are registered trademarks of the Allen-Bradley Company (Rockwell Automation). PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

Authors have not used actual PLC, but used PLC emulator RSLogix [3] Emulator 500 and selected the virtual PLC MicroLogix 1000. Working on actual PLC is same as working on virtual PLC except that the hardware can directly be connected to the actual PLC.

VII. PLC PROGRAMMING

PLC cannot work by itself. It is required to be programmed and hence programming software is needed. RSLogix500 is programming software compatible to program MicrLogix 1000 PLC. Programming of PLC can be done in following three different ways;-

1. Ladder Diagrams
2. Statement wise
3. Block diagrams

Programming of PLC is done in Ladder Diagrams. Fig. 8 shows the program used to control the different controlling devices.

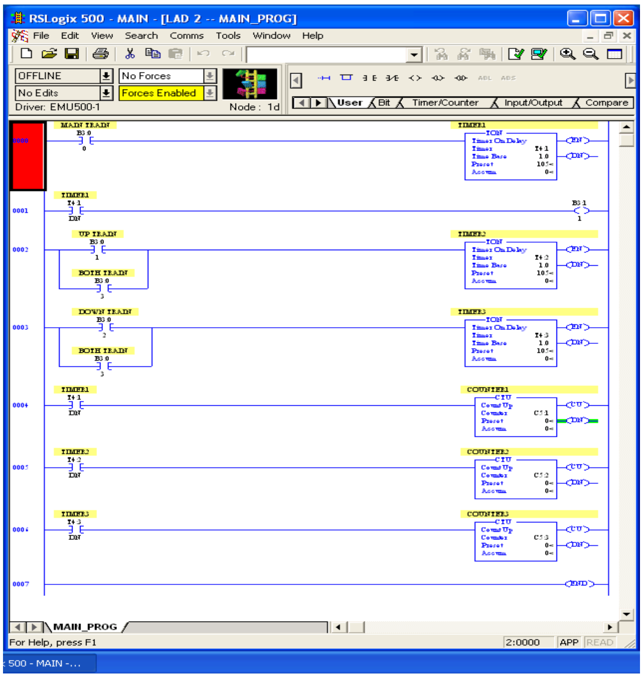

Fig.8. PLC Programming using Ladder Diagrams

VIII. DESCRIPTION OF PROGRAM

In this program timers are used for the animation of train and other vehicles in SCADA [5] environment and counters are used to display the total number of trains passed during the day or in other words number of passed train on up side and down side can also be displayed out.

Normally open contacts are similar to open switches and become normally closed in operating condition similar to closed switches. These switches are used to enable or disable the timers and counters.

IX. TAG MANAGEMENT

Tags are required for the communication between PLC and SCADA. Basically tags are addresses of different components used like switches, timers, counters etc. Complete description of tags is stored in tag management database like whether it is a analog tag or digital tag. Tag for gate open is shown in fig. 9

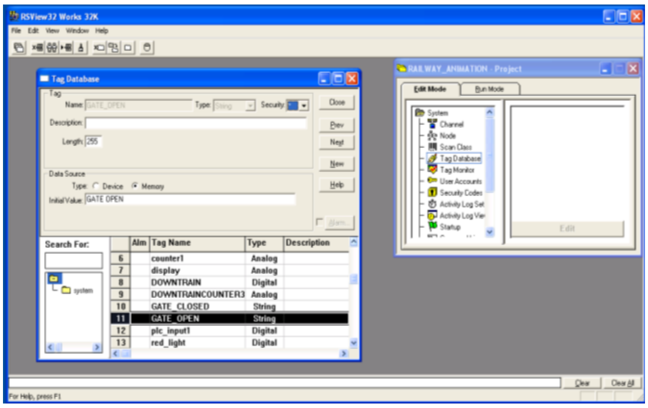

Fig.9. Tag Management

X. SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

SCADA (supervisory control and data acquisition) is a type of industrial control system (ICS) [5]. Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the physical world. SCADA systems historically distinguish themselves from other ICS systems by being large scale processes that can include multiple sites, and large distances.

RSView 32 [4] SCADA software has been used to demonstrate the application of sensor system and controlling of various devices like barriers, warning audio and visual devices and various display devices on the site and also in the control room at remote location. Fig. 10 shows the SCADA for single track.

In this screen it is easily clear that train is coming towards level crossing or towards sensor. At this location gates are open and warning devices are green. In control room status of barrier is gate open and time taken by train to approach level crossing is zero.

In the screen of fig. 11, train has approached a location from where sensor started to record the wave induced due the rolling noise and this signal is sent to PLC controller for actuation of devices. At that point PLC closed the gate and started audio signal that is “Stop Train is coming” message and turned the red light on. Control room status showing that gate is closed and time taken to reach level crossing is 31s.

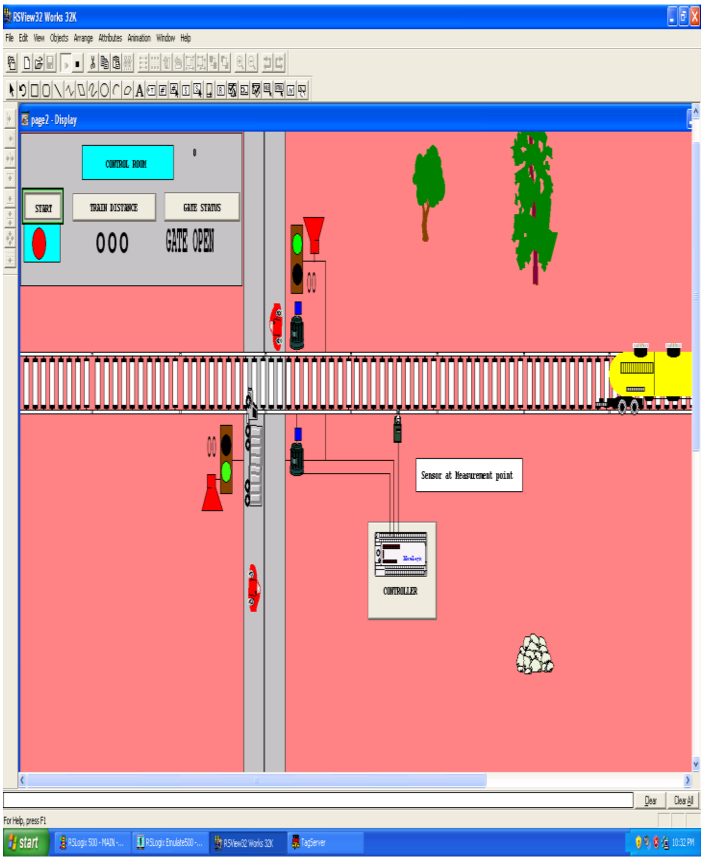

Fig.10. SCADA Screen1

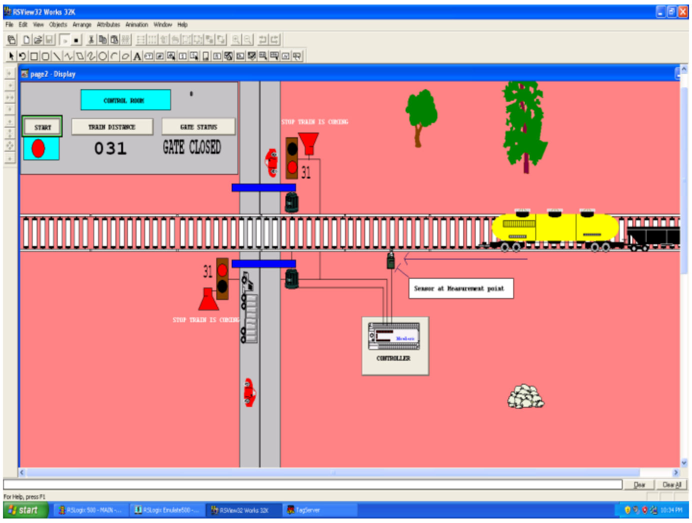

Fig.11. SCADA Screen 2

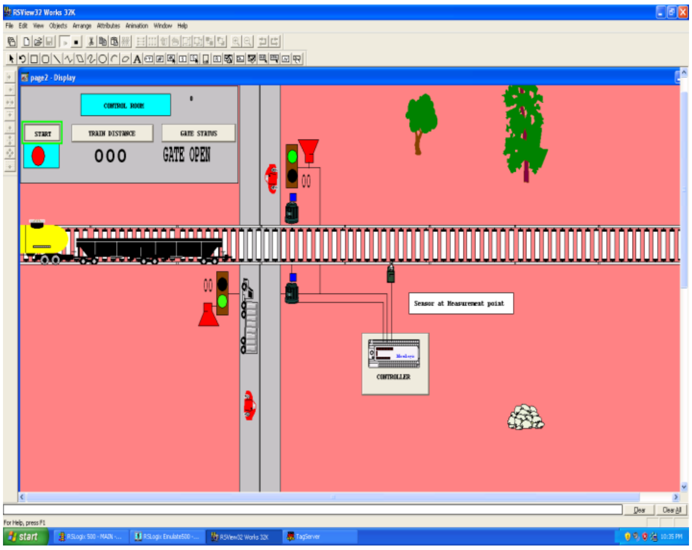

Fig.12. SCADA Screen 3

In the screen of fig. 12, it is shown that train has past the level crossing and status of various devices changed to normal condition. SCADA in fig. 13 is used to demonstrate the working of system on both the tracks.

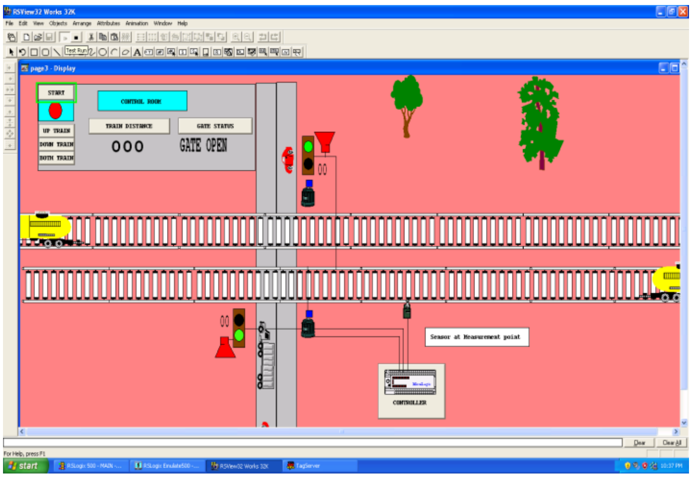

Fig.13. SCADA Screen 4

XI. CONCLUSION

In this paper the designing of advance train detection technique is discussed and this new approach towards detecting train before the arrival of train at measurement point can be used alone for the construction of automatic level crossings or may be used in the combination with existing technique to enhance the performance of level crossings.

REFERENCES

[1] P J. Remington, The control of wheel/rail rolling noise at the source, Journal: International Journal of Heavy Vehicle Systems 2000 - Vol. 7, No.1 pp . 1 – 21

[2] Surender Kumar, Dr. Y.K. Jain “Measurement of Noise by Sensor Technology for Automatic Level Crossings”,Vol. 3, Isuue 9, IJCST sep. 12.

[3] http://www.rockwellautomation.com/rockwellsoftware/design/rslogix500/overview.page

[4] http://www.rockwellautomation.com/rockwellsoftware/performance/view32.html

[5] http://en.wikipedia.org/wiki/SCADA

[6] http://www.sensorland.com/HowPage002.html

[7] http://en.wikipedia.org/wiki/Axle_counter

[8] http://www.engineersgarage.com/insight/how-piezo-buzzer-works

[9] http://www.circuitlogix.com