

## Analysis of automatic train control

Ihedioha Ahmed C

Enugu State University of Science and Technology Enugu, Nigeria

### Abstract

This paper is on Analysis of automatic train control. The Automatic Train Stop (ATS) system based on the Automatic Warning System (AWS) with checking limit speed pattern, signal checking and obstacle sensing system is proposed as an upgraded railway signaling system. The features of the automatic train warning system were explained. Oriented data was used for the coding of graphs. Track circuit showing direction of current flows for both unoccupied and occupied conditions were showed.

**Keywords:** Train control, Automatic Train Stop (ATS), Automatic Warning System (AWS), Track circuit

### 1. Introduction

A Good Transportation System is the index of development of any country. It is the essential requirement of any citizen in the country to travel and transport their goods fastest, safest and economical way. That too in a very big country like Nigeria, transportation plays a vital role because the distance between various places is more.

One of the most widely used and comfortable modes of transportation system is the train.

For over a hundred years train control has been largely distributed, but occasionally, accidents occur due to collisions as well as other reasons such as wrong signal passing and over speed [1]. It is very difficult to stop such accidents due to collisions and other reasons because of speed of moving trains, which need a lead distance to stop. Collisions happen due to human errors and/or faulty equipment. Therefore we place protection equipment for the safe running of the trains.

To prevent collisions, railway track systems were divided into a series blocks ranging in length from a few miles to tens of miles, and a signaling system was developed to constrain movement of trains between blocks.

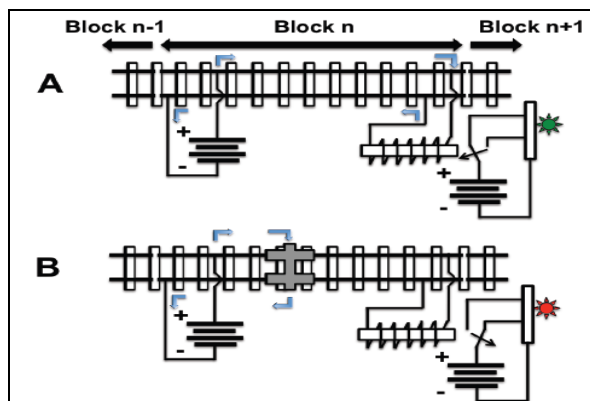
The imprecise nature of position information afforded by the block-oriented system required as a general rule that no two trains were allowed to occupy the same block [2].

#### 1.1 Conventional Locomotive Location Hardware: The Track Circuit

The *track circuit* has traditionally been used to detect occupancy

of a track block by a locomotive or other rail rolling stock and to signal the state of occupancy to any train operators in adjacent blocks [3]. Invented by Dr. William Robinson in the 1870s, the classic track circuit shown in Figure 1 utilizes the two track rails as an integral part of an electrical circuit that controls block occupancy signals. A voltage source such as a battery supplies an electric potential between the two rails. The signal relay solenoid coil is also connected across the two rails such that it remains energized (conducting electricity) when there is no train located on that section of the track. With the solenoid energized, the signal relay presents the track-clear signal to oncoming trains.

When the axle of a locomotive or roll stock enters the block, the axle electrically shorts the two rails together, de-energizing the solenoid coil resulting in display of the track occupied signal. The classic track circuit requires adjacent blocks to be electrically isolated from each other. Modern variations of the track circuit allow for the use of non-isolated welded rails [4]. It is important to note that track circuit occupancy signaling is automatic and decentralized, requiring no human intervention to set the occupancy signals. The track circuit also plays a key role in the event of an accident or during track maintenance since work crews may deliberately create an electrical short between the rails to force display of the track-occupied signal to block entry of a train into a particular block. The simplicity and reliability of the track circuit has made it a key element of modern block signaling systems for over 100 years and to this very day.



**Fig 1:** Track circuit schematic showing direction of current flows for both (A) unoccupied and (B) occupied conditions [5].

## 2. General Description of Train Protection and Warning System

The Train Protection and Warning System (TPWS) is a train protection system deployed across the passenger railway network. It automatically activates brakes on any train that has passed a signal at danger or is over speeding or about to collide. It is fitted at selected sites, including some lines where Automatic Train Protection (ATP) is installed.

### 2.1 General Requirements

TPWS covered in this specification works on the principle of target distance and target speed. The TPWS equipment shall consist of following:

#### A) Track side equipment comprising of

- Balise; both fixed and transparent/ switchable data balise
- Line side Electronic Unit (LEU)

#### B) On board equipment comprising of

- On Board Computer (OBC)
- Drivers' indication and control panel (MMI) consisting of switches, push buttons, indication lamps and horn/hooter
- Balise antenna and its transmission module
- Speed and distance measurement unit (impulse generator)
- Brake interface
- Power supply arrangement
- Valves for service and emergency brakes
- Isolating Unit

The system shall be capable of working satisfactorily up to required speeds.

The system shall be suitable for single, double or multiple track sections.

The ground and on-board equipment shall not infringe the broad gauge schedule of dimensions followed by Indian Railways.

#### The system shall be capable of being linked to:

- Air brake system.
- Electro-pneumatic braking used on Indian Railways.

#### It shall have two levels of braking

- Emergency brake.
- Service brake.

### 2.2 Functional Requirements

#### Healthy Condition of System

A steady lit lamp indicating that TPWS is in working condition shall be available on the driver's indication-cum-control panel. This TPWS healthy indication lamp shall extinguish when fault is detected by TPWS and immediately "TPWS faulty" lamp shall be lit and audible alarm shall sound to attract attention of driver [6]. Audible alarm shall stop on pressing of Acknowledgement Button by the driver. However, "TPWS faulty" lamp shall remain lit till such time fault persists.

#### Data from Balise

TPWS shall receive and act on the data when it passes over balise. This data shall consist of maximum permissible speed, target distance, target speed, balise linking distances and topography of track section ahead.

#### Calculation of Speed Profile

On board computer shall calculate the valid speed profile for the track section ahead based on data received from balise and data available on board of train characteristics.

#### Calculation of Permitted Speed

Based on all relevant data, the TPWS must calculate warning speed, a service braking curve and an emergency braking curve. TPWS must calculate the permitted speed for the train for all locations on the line.

#### Release Speed Calculation

A release speed must be calculated onboard to allow the train to approach the target and it must ensure that the train will stop before reaching the danger point. The release speed shall be calculated on board based on safety distance (overlap) and deceleration performance of the train.

#### Audio Visual Warnings

Visual and audio warnings to the driver about possible intervention from TPWS must be given to enable the driver to react and avoid TPWS intervention. Visual indications to the driver must be clear and unambiguous. Audible indications must be capable of being heard in the driver's cab in non-air-conditioned environment and distinct Audio Warning shall be provided for different functionalities. If the indication fails, this will not affect the supervision provided by TPWS.

#### Monitoring of Speed

TPWS shall continuously compare the current speed with the maximum permitted speed. A warning must be given to driver to enable him to react and avoid intervention from TPWS at least 5 seconds before the intervention of service brake. If current speed exceeds the maximum permitted speed by 5 kmph, intermittent audiovisual warning shall be sounded. As soon as the speed of train again drops below the threshold speed, warning lamp shall extinguish and the audible warning shall stop. This speed overshoot shall not be recorded in the train memory. If the current speed exceeds by 0 kmph over the permitted speed, brake shall be applied in addition to continuous audiovisual warning to driver. The train shall be braked to a standstill. This speed overshoot shall be recorded in the memory [7].

#### Train Trip

TPWS shall apply emergency brake in case train passes stop signal at ON irrespective of the speed of train. It shall be possible to suppress train trip function when passing auto signal or defective signal at ON.

#### Passing of Auto Signal at ON

In automatic signaling territory, when the automatic signal with "A" marker showing a red aspect is passed, a visual indication shall be lit up on the indication panel and it shall remain lit up until it passes the balise connected to next signal. This indication reminds the driver that he should proceed ahead cautiously at speed not exceeding 15 kmph. If the train speed exceeds 15 kmph but is less than 20 kmph, an audible alarm shall sound intermittently. If the speed exceeds 20 kmph, the audible alarm shall sound continuously and brakes shall be applied by the system to reduce the speed below 20 kmph. Thereafter, the brakes shall release

automatically but the sound of the audible alarm intermittently shall continue till the speed of train is brought within 15 kmph by the driver. Provision should be made in the system to adjust the speed limit of 15 kmph to any value at a later date to comply with the changes in Operating Rules [8].

**Passing of Manual Stop Signal at ON**

The TPWS equipment shall have provision to enable passing of manual stop signal at ON by pressing suitable bye-pass button provided in the panel for this purpose. This operation shall only be possible at 0 kmph. Train trip function shall be suppressed. The override control must be protected against inadvertent operation. This action shall be recorded.

**Balise Linking**

The TPWS equipment shall be capable of identifying missing balise, giving suitable indication to driver and reducing the

speed of train to predefined level.

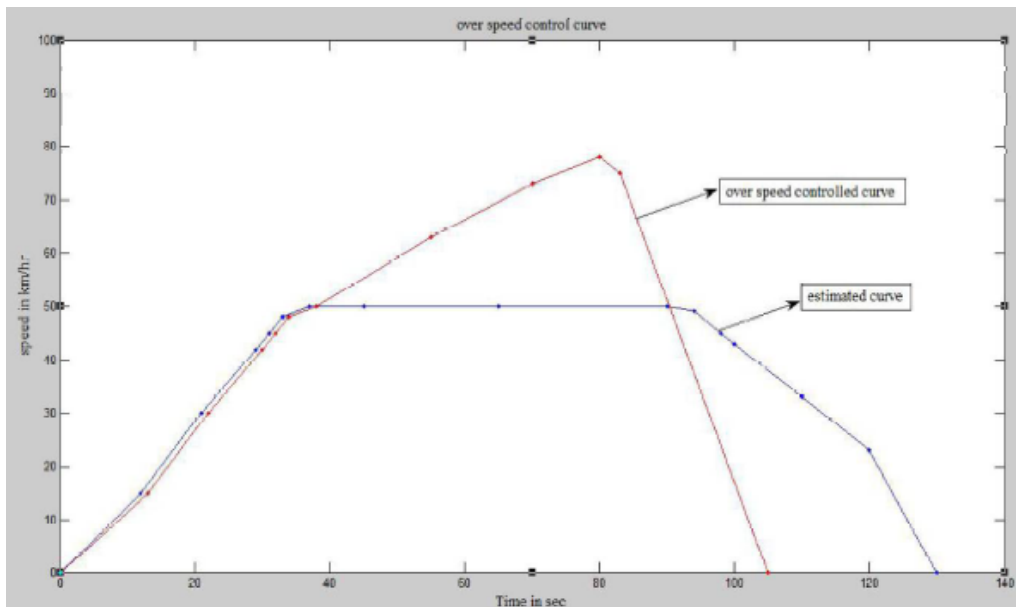
**Brake Application**

In case of emergency brake application, it shall not be possible to release brake until the train stops. In such cases, the brakes can be released by pressing a reset button. A record in the form of counter reading shall be maintained regarding the pressing of reset button and this record shall not be affected by interruption of power supply.

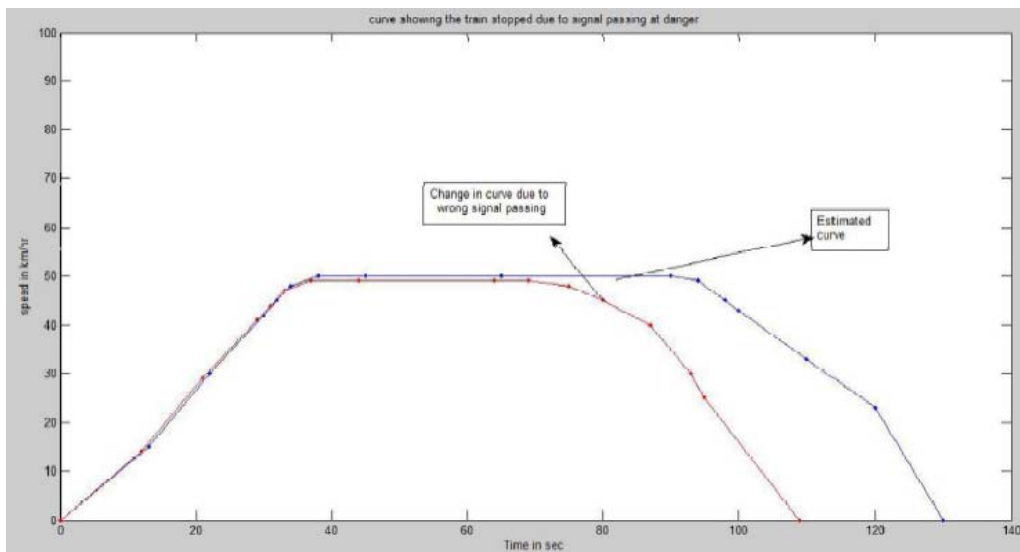
**The counter should be non-resettable.**

- It shall not be possible to mute the warning and automatic brake applications by prior operation of button on the panel.
- It shall not be possible to cancel the brake application by switching on and off of the power supply.

**3. Results**



**Fig 2: Automatic over Speed Control of a Train**



**Fig 3: Signal Passing at Danger**

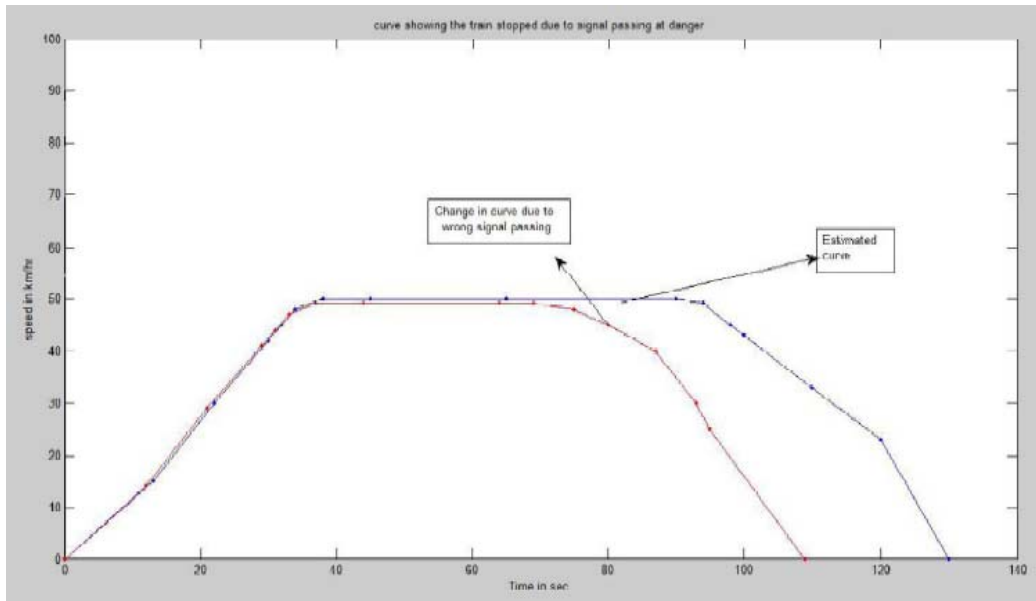


Fig 4: Anti Collision Graph

**4. Conclusion**

By implementing the program for specific energy consumption, the energy used can be reduced. And the graphs represent the indication of the train control which plays a vital role in the protection aspect to protect from accidents. The two measures considered above were satisfied the necessary requirements for optimal and safe running of the service.

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