Automatic Radio-Based Train Control System for Protection

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Abstract : Automatic train protection is a primary function of train control system which helps prevent collisions with speed restriction and applying brakes. Safety analysis and evaluation of automatic train protection with simulation is needed to improve the system usability in the business area. If both the trains in the same track means, both the transmitters and receivers will send the same track no and immediately buzzer will give alert on both the sides. In the paper, we design automatic train protection simulator for radio-based train control system, and present an algorithm of automatic train protection, system configuration of the simulator and experimental results.

Keywords- Automatic train protection; radio-based, Train control system

I. INTRODUCTION

Radio-based train control system (TCS) has many advantages compared with existing track circuit based train control system, continuous bi-directional communication, high throughput, and real-time train location report between onboard and wayside, and so on. The key functional requirement of TCS is train interval control between the preceding and following trains based on real-time train location information. Automatic train protection (ATP), a primary function of TCS prevents train collisions with speed restriction and applying brakes. Safety analysis and evaluation of automatic train protection with simulation is needed to improve the system usability in the business area. Therefore, in order to improve practical usability in the business, safety analysis and evaluation of train control system and train control related core technologies are needed. In this paper, we design ATP simulator of radio-based train control system for evaluation of the protection algorithm. The onboard ATP of each train reports its position to wayside ATP periodically. The wayside ATP provides limit of movement protection, known as movement authorities, ahead of each train, and static speed profile(SSP) calculated with the permanent and temporal infrastructure and train speed limits, and then the onboard ATP calculates dynamic speed profile(DSP) by using both limit of movement protection and the SSP, authorized speed as a function of train location. With the DSP, the onboard ATP protects the train from the train collisions. The rest of the paper presents the system configuration of the simulator, and ATP algorithm, experimental results of the simulation, and some concluding remarks and possible extension of the simulator. In this project we are going to prevent the train collision using MIWI communication. Transmitter will send a data (track1) from transmitter side and receiver receives the same data at receiver side. If the receiver is in another track the engine driver will send a data (track2) through transmitter and received by the receiver. So no problem will occur. Thus the train collision is prevented. More over there is vibration sensor that will be passed over the track if there is over vibration there is a signal once again to inform the engine driver about the crack to avoid the accident.

II. SYSTEM CONFIGURATION

The system configuration of the ATP simulator to evaluate the protection algorithm. Wayside equipment is consisting of wayside ATP and access point (AP), onboard equipment is consist of onboard ATP and data communication system (DCS). In the simulator, wayside Automatic Train Supervision (ATS) and Electronic Interlocking Equipment (EIE) are excluded to make system simple.In the system, the wireless communication connectionbetween onboard ATP and wayside ATP is not essentialrequirement in order to simulate protection algorithm. Insteadof wireless LAN, we use wired Ethernet communication tomake reliable communication. In addition, track and trains areprogrammed and composed of virtual environment.As shown the figure, train is operated in a PC-basedprocess, and the maximum number of train is five. Each train iscomposed of independent PC unit and connected to real motor, a small size traction motor. Onboard ATP gives the authorizedspeed limits to motor and read the value of the motor responsespeed, and control train speed. Wayside ATP displays thesimulation track environment, and provides onboard ATP withlimit of movement protection and track information, such ascurve, gradient, and so on.

III. ALGORITHM OF AUTOMATIC TRAIN PROTECTION

For efficient and safety train operation, all the trains shalloperate in accordance with prescribed velocity profile in traincontrol system. To meet the requirement, ATP calculates speedprofiles with limit of movement protection, train and trackinformation. In general, ATP profile can be configured in twocomponents, SSP and DSP. Wayside ATP calculates limit ofmovement protection with train data, its position and length,and SSP with calculated limit of movement protection andtrack data. Onboard ATP calculates DSP using the receivedinformation. Based on the relevant data, onboard ATPcalculates braking curves.

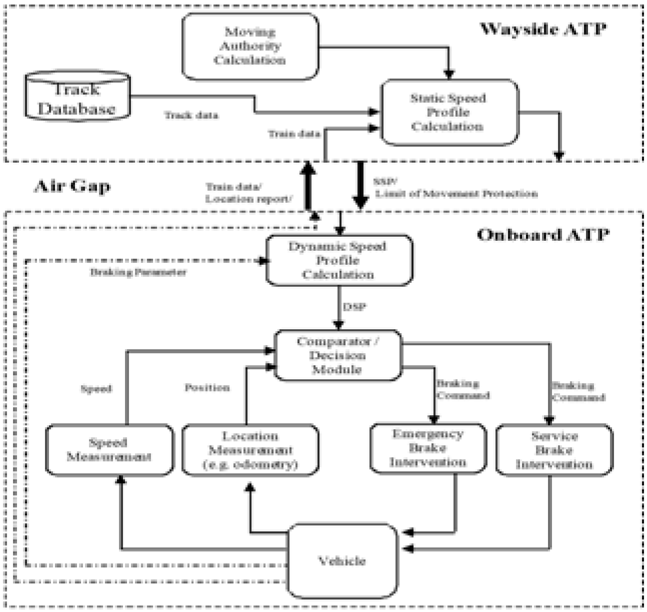

Fig 1 Processing procedure b/w wayside ATP and onboard ATP

3.1 Static Speed Profile Calculation

SSP is a step function, relationship between train speed anddistance. To calculate SSP, the wayside ATP considers variousstatic speed restrictions and train limits of movement protection,temporary and permanent infrastructure speed limits, temporary and permanent train speed limits, and temporary speed restrictions from ATS.Speed restrictions used in the simulator to determine staticspeed restrictions are described as follows:

- Fixed Speed Restrictions (FSR)
- Temporary Speed Restrictions (TSR)
- Maximum Train Speed (MTS)

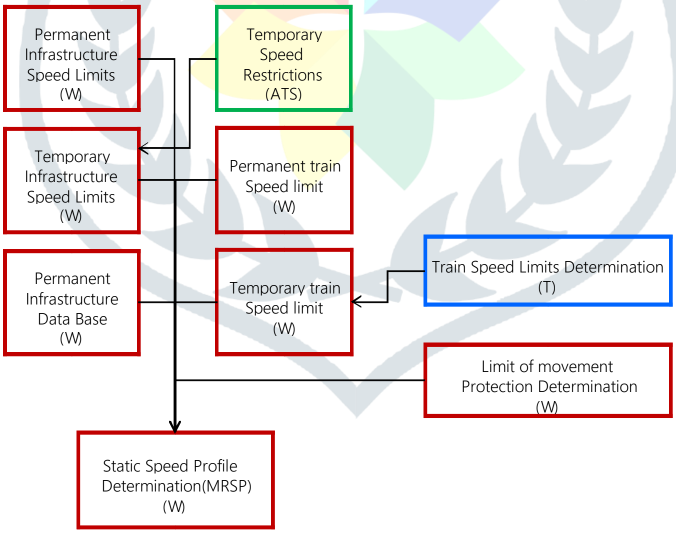

Fig .2 a general's process of ssp calculation

Calculation of SSP is a selection of most restrictive speedprofile from each section based speed limits by using thefollowing equation:

$V\_MRSP = MIN (V\_FSR, V\_TSR, V\_MTS)$

Now the speed limit, derived in each section shouldconsider the length of train in acceleration section. If the statictrain speed profile decrease, the train speed must be reduced tothe lower value before the leading vehicle passes the point ofdecrease.SSP calculated in the wayside ATP, and transmitted to thetrain through track to train transmission.

3.2 Dynamic Speed Profile Calculation

DSP means a speed increase or decrease of the train, whichis based on SSP.In the simulator, DSP is calculated in onboard ATP withSSP and limit of movement protection received data fromwayside ATP, as shown in Fig. 4. The calculated DSP is usedin the simulator, DSP is calculated in on board ATP with SSP and limit of movement protection received data from wayside ATP, as shown in Fig. 3. The calculated DSP is used to determine authorize speed of train and ATO profile calculation.

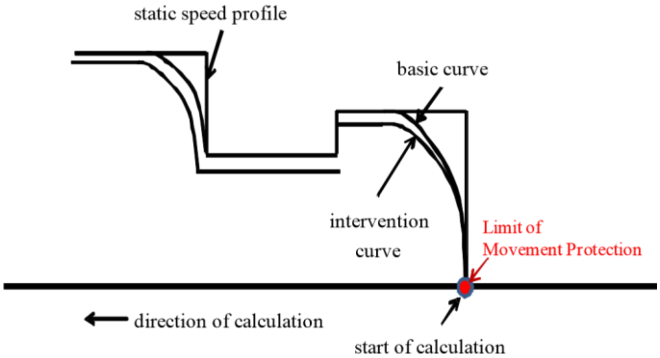

Fig 3. an example of calculation of dsp

Fig 4 shows calculate DSP, train breaking model is need. Changing to a lower level, the front end of the train must respect the DSP. However, when changing to higher speed level the rear end of the train must respect the SSP.

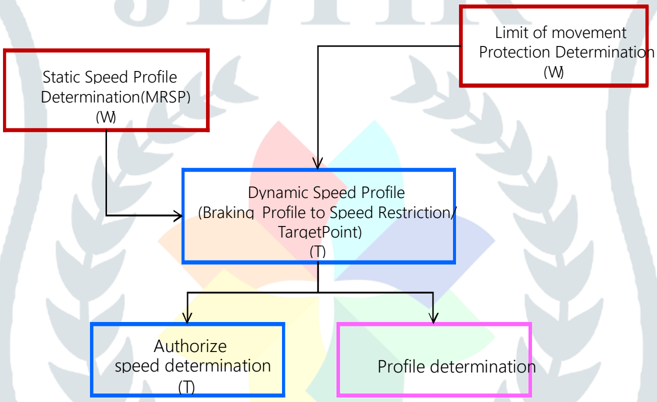

Fig 4 A general's process of dsp calculation

IV. RELATED WORK

This paper describes an efficient method using simulation for developing and analyzing train brake curvecalculation methods for the on-board computer of the ETCS system. An application example with actual measurements isalso presented .The specifications for the trackside equipment'sare now clear, strict, well developed and documented .The ultimate aim ofthe ETCS system - the full interoperability is stillFar off. The major reason for this comes from"Vehicle" side: all interoperable railway vehicles

Will have to be equipped with an ETCS on-board

Computer (EVC) ,The specifications for the trackside equipment's are now clear, strict, well developed and documented .Nowadays, many railway companies and institutes in Europe use simulators for designing and testing various railway equipment's, including station interlocking systems and train-on board computers,The most important basicfunction of the EVC is the speed supervision, which forces the train to keep the maximum allowed speedlimits., Simulator Technology has evolved from physical/analogue simulators (HVDC simulators, TNA's) for electromagnetic transients and protection and control studies, to hybrid TNA/Analogue/Digital simulators with the capability of studying electro-mechanical transient behaviour ,To achieve this high transmission rate, current commercial solutions use radio modems working at high carrier frequencies, between 2 and 6 GHz , For some industrial suppliers, the radio modems are very close to the existingWireless Local Area Network (WLAN) standards i.e.IEEE 802.11 a, b/g, but could migrate, when available, to the IEEE 802.11p standard (WAVE 1) .

V. CONCLUSION

In this paper, we design ATP simulator for radio-based train control system for evaluation of the protection algorithm. With the real-time limit of movement protection of the train and track information, SSP and DSP are calculated, and train speed is regulated by the calculated profiles. We verify the system performance with simulation. The simulation results shows that the ATP algorithm is done well by using SSP and DSP based train speed regulation. However, the system is still needed long-term evaluation in the business time and modification although it has good test results because robustness is most important factor in railway.

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