A Study of Tilting Train Signal System for Conventional Rail Speed-Up

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Abstract: This study is a kind of preliminary research in order to propose and suggest the plan of performance improvement for the speed-up through the examination of operational condition on the field for signal system facility on the conventional railway, in order to obtain the elemental technology from the technical development for utilization of high speed train which will be run on the Korea Conventional Line and, finally, in order to propose the specification of signal system using for high speed and the scheme of establishment for the optimal signal system.

Keywords: Signal system, Conventional Rail Speed-Up

1. Introduction

Railway signaling system is facilities that show velocity, track information and controling direction and generalizing train operation. Therefore signaling system is essential for guaranteeing accurate and safety service, also for developing transportation efficiency. Especially signal system is very important for realizing safety, accuracy, and fixed time that was required speed-up, high density, and mass transportation. In 21C, Europe has been invested in efficiency of railway transportation and technology development of railway system. ERRI accomplished signal standardization and modernized signal system in Europe. Through RTRI, Japan research for conventional rail speed-up. In Korea, it is developing 180km/h tilting EMU. In this paper, we suggest performance direction on based conventional rail investigation. And specification signal system as conventional rail speed-up.

2. Analysis of signalling system for conventional rail speed-up

2.1 The signalling system on the conventional railway

The domestic signalling system including the equipment of CTC, ATC, ATS, automatic block, interlocking, signal, switch and safety equipment of railroad crossing are using on 3,123km rail for 53 lines including Gyeongbu line, Honam line, jungang line, etc. through the development and change for more than 100 years since the arm signal has been used with the opening of line between norangjin and jaemulpo in 1899. The rolling stock and track must be always on the normal condition and the accurate decision and control by a crew for operating situation should be done for safety. the signal system facility is a kind of equipment for offering the information about the operating situation of train to crews and devising for the safe operation of train. The ATS devise as an auxiliary devise for a driver keeps the safety of a train by preventing the mistake of operating control by a driver.

There are three kinds of ATS devise on the rolling stock as the spot control type using on the 3 signal indication section, the 4 signal indication cab speed check system type using on the metro railway section and the 5 signal indication cab speed check system type using on the interstate high-speed railway section. Table 1 shows the number of train with the ATS device installed on the rolling stock for various types of trains.

Table 1. Installation Status for ATS devise on rolling stock

Division		total	Diesel locomotive	Diesel train	electrical locomotive	electrical train
point signal system	3signal	163	65		94	4
cab speed check system	4signal	320				320
	5signal	582	390	192		
total		1,065	455	192	94	324

There are so many kinds of signal system applying in Korea conventional rail. Therefore, The technical specifications of signal system applying on the conventional line for Gyeongbu line, Honam line, janghang line, jungang line, etc. are analyzed for the optimal construction of signal system influencing directly to the operation of train on the conventional line by considering the interfaced part between the high-speed system and the conventional system. The ATS devise consists of the equipments on rolling stock and on ground. The cab-antenna of on-vehicle equipment receives the data from the ground-antenna of on-ground equipment and controls the trains with them. As the transmitted data is reflecting the information displayed on the railroad signal, the frequency assigned for various information displayed on the railroad signal is sent by the ground-antenna installed on the track and collected by the cab-antenna on the rolling stock when the train passes by the ground-antenna. The collected

frequency includes the information corresponding with the displayed signal about the limit speed on the track and is analyzed by the receiver on the vehicle. Therefore, if the running speed of train is over the limit value transmitted from the ground-antenna, the alarm system will be worked immediately. In addition, if the brake system is not engaged by a driver in a moment, the emergency brake system will be operated automatically. Now, the whole lines of intercity railway excluding the urban railway are applying the step-velocity signal scheme. This scheme is that the driver identifies by vision the displayed signal on the signal apparatus installed on every block section and operates the brake, acceleration or deceleration system manually by his decision.

When the train with ATS devise is running below the speed limit, there is no output from the ATS device. For the case that the running speed of train is over the speed limit for the displayed signal on YG, Y and YY sections, the train should be decelerated below the speed limit by setting the brake control lever on the normal braking condition for all vehicles within 5 seconds. If the driver does not control a brake lever in 5 seconds, the emergency brake system will be operated automatically, the alarm system will work and the red signal light will be on. Once the emergency brake system is operated on YG, Y and YY sections, the brake will be released by setting the brake control lever on the normal driving condition after the train is stopped totally.

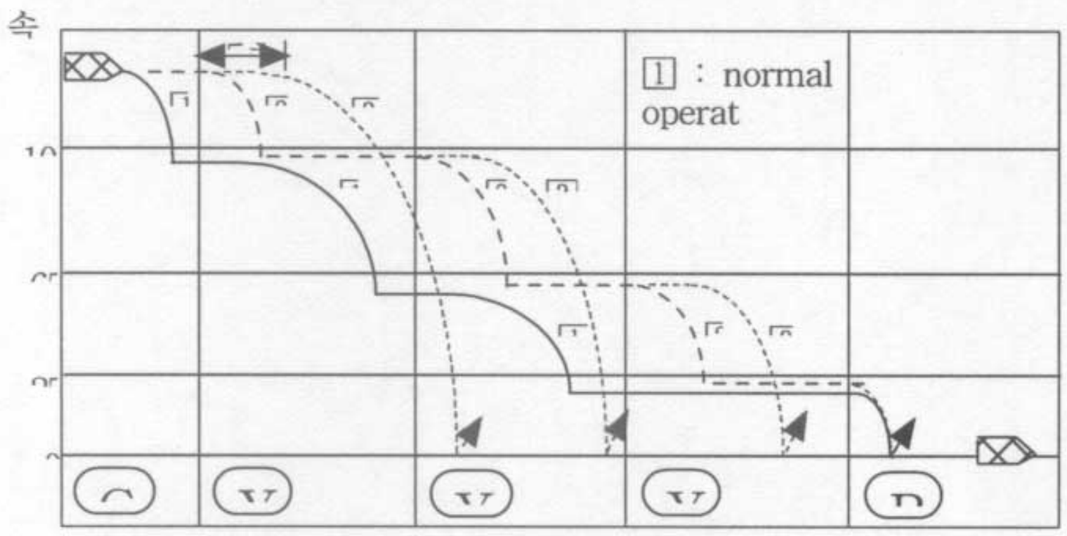

Figure 1. Driving control curve of ATS devise with 5 types display

2.2 Study of field testing for signalling system on conventional rail

The ATS devise is classified to the receiving part, the part of signal analysis and the part of signal interface relay according to the function of part. The main role of a receiving part in the circuit can be divided into two roles. The first one is the interface for impedance between the ATS cab-antenna installed under a bogie and the ATS receiver. The second one is the filtering of received signal by the BPF.

The matching of impedance plays an important role to decide the standard frequency when the cab-antenna and receiver generate the standard frequency together, and plays a critical role to decide the level of received signal for receiving the signal with LC resonance. In addition, the BPF plays an important roles to pass only assigned range of frequency in order to analyze the necessary signal by cutting off the external noise. The part of ATS signal analysis is a part of circuit to select and decide the necessary signal by analyzing the received signal. The method of signal management can be classified by the analogue method and digital method. The analogue method has a simple circuit and a good resistance for the shock of a strong energy from the exterior, but requires several circuit boards. The digital method using more popularly than analogue one has a good advantage to be able to manage and analyze the signal accurately and increase the reliability of a signal through logical circuit composition. As the part of signal interface relay is a part of interface to transmit the ATS signal to the Speed Checker and the others for signal control part, the operating time of relay and the durability of the contact point is very important for the part of signal interface relay.

The test of analyzer by the response tester is to inspect the normality or abnormality of ATS using the LC resonance frequency of frequency variation(98khz,---130,khz). The signal for inspection is created by generating the continuous LG resonance frequency or by applying a current for 10 ms which is the resonance time inputted(memorized) in a response tester. In additon, the test will be apply to the daily, monthly or regular inspections, because it is possible that the arbitrary test in order to confirm the normality or abnormality of ATS will be carry out before driving.

If the ATS devise was inspected by the response tester in advance, the abnormal operation of ATS devise due to the loss of performance and the damage of parts can be managed in advance. In addition, the planned and preventative management can be done by the regular inspection. As mentioned above, the relation of signal transmission for the various frequency level can be confirmed at a glance.

The ATS cab-antenna consists of the first side coil and the second side one. Two coils has a one-way flow. The ideal oscillation is induced by the resonance inside a receiver occurred when the current from the first coil flows to the second coil. The control board plays a role to control the amount of current induced from the first coil to the second one. Therefore, if the current of the first coil is induced to the second coil directly without a control board, the operation of ATS devise should be unstable since the abnormality oscillation point is disturbed according to increasing of the amount of induction magnetic flowed to the second coil. Thus, the role of control board is very important and the excessive induction magnetic phenomenon or the minute induction may bring about the unstable operation of devices as

mentioned about the character of cab-antenna linkage value.

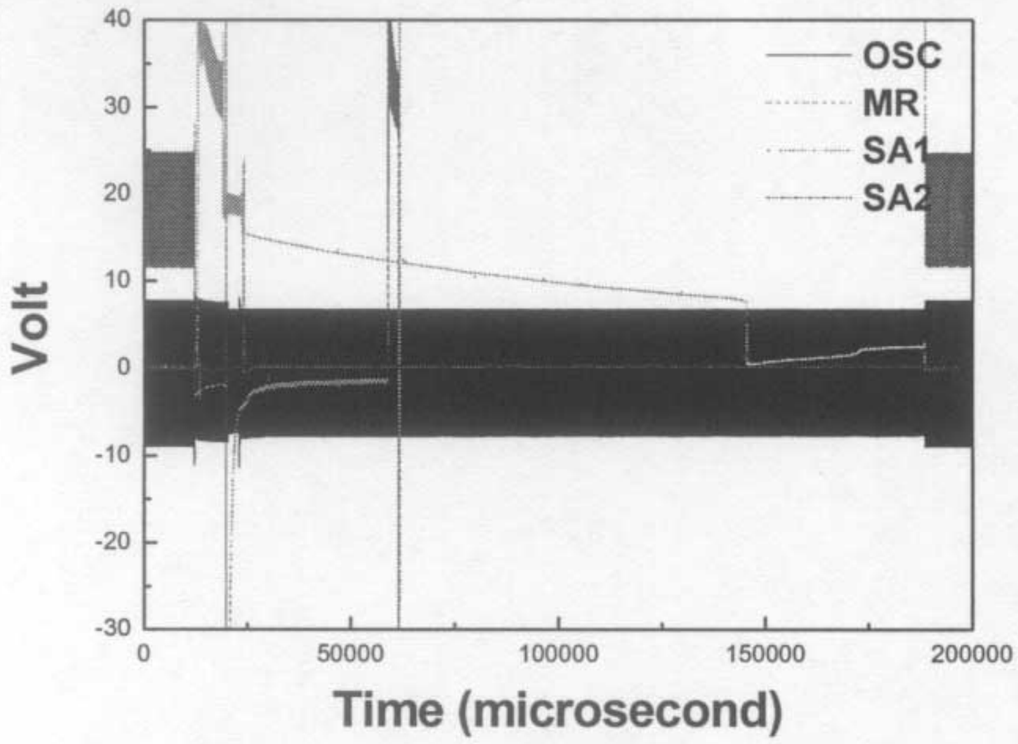

Figure 2. The data for frequency at 98 kHz

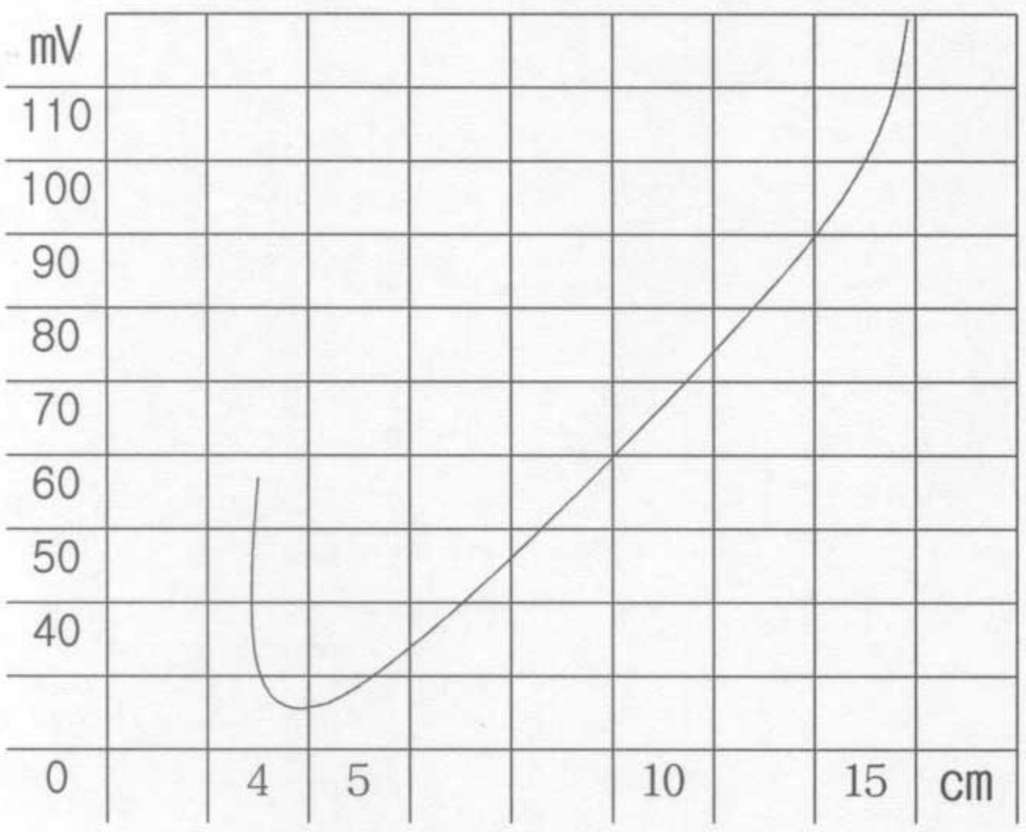

Figure 3. The characteristic curve of ATS cab-antenna

The Q value of ground-antenna should not be over 170 and it may affect the train running on the opposite-way track in case of 170. The level of induced frequency for the Q value of ground-antenna will be able to be decreased according to the band of resonance frequency. The resonance frequency of ground-antenna is calculated by folloeing equation,

$$f_0 = \frac{1}{\sqrt{2\pi LC}}.$$

Figure 4 shows the response characteristic of Q value of resonance frequency. The signal of band of resonance frequency after a stopping signal is decreased by character of ground-antenna due to variation of gain rate of Q value based on fo. On connecting a ground-antenna and a cab-antenna, the possibility of effective signal management will be increased only if the most suitable gain rate of frequency variation keeps more than -5dB. In general, there are some difference between a resonance frequency of a ground-antenna and frequency variation.

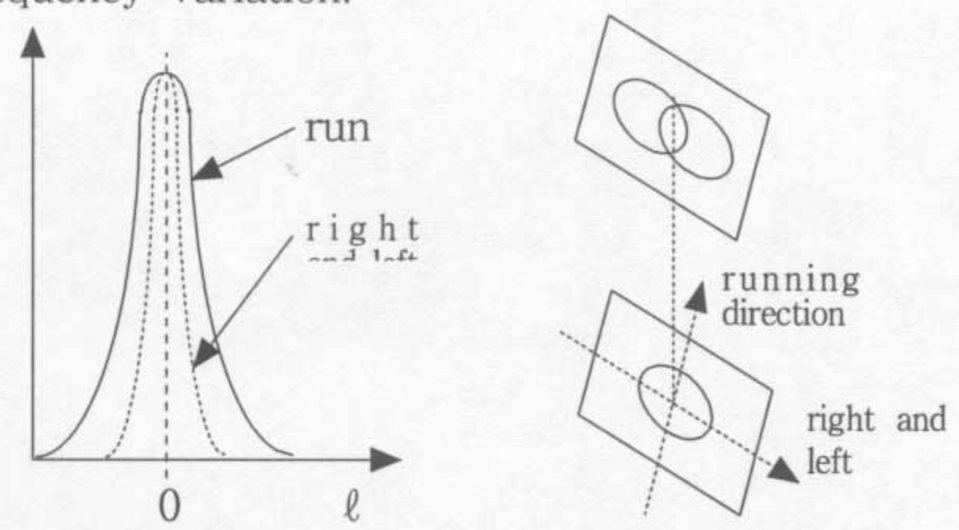

Figure 4. Characteristic graph of ground-antenna Q

This trend not only is decided by internal character of a oscillator but also is influenced by the condition on connecting with ground-antenna. It is also affected by factors about a Q value of ground-antenna, the gap between ground-antenna and cab-antenna, a power voltage of a oscillator and surrounding temperature. In general, the differential degree is small in case of a large Q value of ground-antenna, but it mainly depends on the combination of several factors. As mentioned above, because there are so many factors and appearances to cause the decreasing of frequency variation, we got from this study that the special effort is required to keep the stable level in order to obtain the delicate frequency variation.

2.3 Improvement of signal equipment for speed-up on conventional rail

We examined whether a cab signalling system type and a ground signalling system type will be used in parallel for speed-up on conventional railway, and we examined the technical requirement in order to judge the possibility of signal management on a high-speed train. For speed-up on conventional rail, we grasped the improvability of ATS and the limitation of maximum speed of ATS signal equipment. Through this investigation, we got a result that it is so important that the operation of ATS signalling system should be established with restriction in case of 160 km/h running speed, and that considering the use of a automatic train protection facilities, the interchangeability for the existing equipments and the possibility to use the signal control equipment together with the automatic train protection facilities should be checked for smooth signal management system. In case of using the signal control equipment together with the automatic train protection facilities, the signal interruption for receiving the signal from ground should be checked carefully, and we tried to establish the counter-plan for this interruption by investing the frequency range of interruption. In case of increasing the running speed with conventional ATS signalling system, we try to decide the set-up location of ground-antenna by estimating a recognizable distance for the displayed signal on ground by driver and by predicting the total braking time from the recognization of

displayed signal on ground to the stop by engaging a brake system. The block diagram for improved signalling system is shown on figure 5.

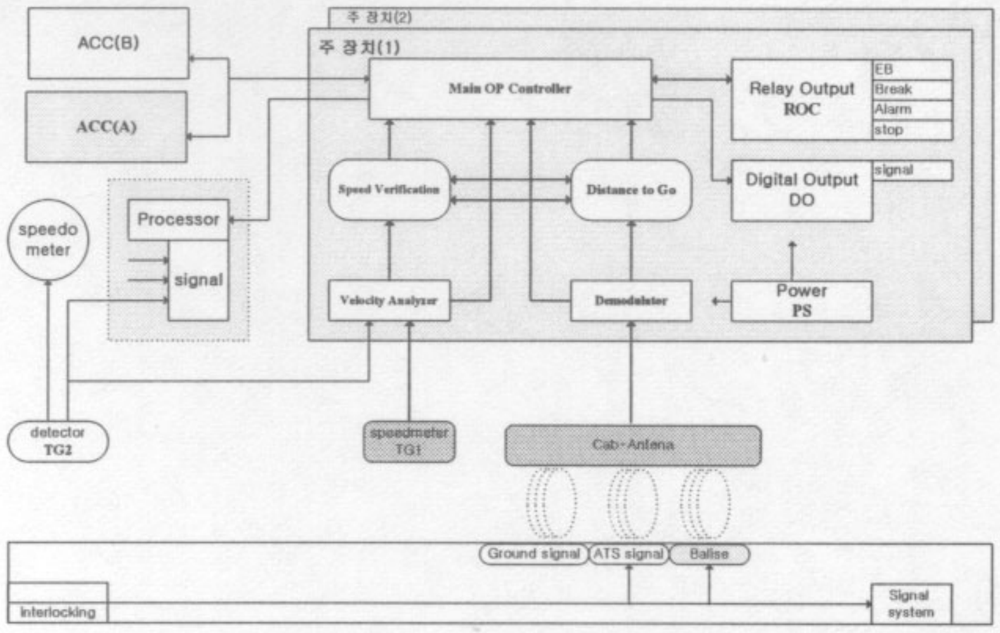

Figure 5. The block diagram for up-graded signalling system

3. Conclusion

In this study, we evaluated and examined the conventonal ATS equipment for speed-up on the conventional line and had done a test and a research in order to check the reliability and safety for speed-up. Through this test and research we obtained the result that the on-ground facilities of convetional ATS devise will be able to be used by 160 km/h running speed and the modifying for first analysis part and logical determination part will be inevitable. The ATS device is being used in many countries all over the world and the manufacturing methods of it are so various and the advantages and disadvantages by each manufacturer.

The ATS system applying on a subway becomes so stable through many tries and errors and modification. However, for high speed trains the conventional ATS system using the signal on ground may be so unstable and cause a railroad accident because there are so many obstacle factors to recognize and decide the signal on ground by the driver's eye sight. Therefore, we recommend the cab signalling system using the ATS devise together with the function of on-vehicle signal.

Because it must be impossible to change the whole signal system on conventional track at the same time, it will take long period to change them with signal equipment on velicle. If the signal system being acceptable two signal types together can be applied, the speed-up on the conventional line and the construction of renovation will be able to be advanced step by step.

[Reference]

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