Study on the Procedure of the Emergency Brake in Driverless Mode of the Korean Radio-based Train Control System

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Abstract: - The Communication Based Train Control (CBTC) system performs real-time train position report and movement authority transmission through wireless communications networks between a wayside control center and vehicle on-board computers. And it has increasing effects of railway capacity by allowing the high-density train control through a high information transmission amount between the wayside and the on-board. Also, it reduces the maintenance cost because it does not use the existing track circuits. This paper deals with the procedure of the fault code and set/release of emergency braking that occurs during driverless operation in Korean Radio-based Train Control System (KRTCS). Also, the KRTCS is being developed for localization of train control system that driverless operation is possible.


1 Introduction
Railroad performs its functions as multiple systems such as vehicles, tracks, signals and so on. Therefore, co-operative operations between each subsystem are essential. Especially, railroad signal or train control system is in charge of ensuring safe railroad operation and improving efficiency of railroad operations by maintaining a safe separation of a preceding train and a following train [1].

Among them, urban rail system is a complex system that provides driverless operation by integrating of ground railroad, rolling stocks, railroad signals and railroad communications etc. Therefore, co-operative operations between each subsystem are essential.

Also, the train control system is comprised of automatic control technology, vital S/W technology, wire-wireless information communication technology, system engineering technology focus on safety etc.

Currently, signal systems installed to the railroads in Korea and abroad are Automatic Train Stop (ATS) using track circuit generally, Automatic Train Control (ATC), balise (or transponders) and Automatic Train Protection(ATO) using track circuit.

In case of improvement or expansion of existing train control system, interface between a system supplier and a new supplier shall be coordinated closely, but the interface is impossible by technical problems.

Therefore, the railroad operating agency has a lot of interest to ensure interoperability through standardization of the train control system.

Communications Based Train Control (CBTC) system introduced in Korea recently is a railroad signal system that based on communications and information technology and it is comprised of subsystems such as Automatic Train Operation (ATS), ATP, Automatic Train Operation (ATO), Electronic Interlocking (EI) and Radio Complex Networks (RCN) etc. Of these, ATP/ATO is a core subsystem of the signal system, and it covers safe operation of urban rail and automatic operation of trains.

This paper deals with fault code processing and procedure of emergency brake applied by ATS command or vehicle errors which are subsystem of Korean Radio-based Train Control System (KRTCS) for urban railroad that driverless operation is possible.

2 KRTCS

The KRTCS is comprised of ATP to ensure the safe separation of trains, ATO to provide a high quality ride and an automatic operation in both directions,
ATS to monitor trains powerful and flexible and EI which is responsible for logic integration route.

Figure 1 shows a system configuration of the KRTCS on-board system including the ATP/ATO based on the wireless communication.

Fig.1 KRTCS onboard system diagram

KRTCS is national R&D project that intended to development and commercialization of Korean train control system for driverless operation. From December, 2012 to June, 2014, and 3rd year assignment of the project is currently performing.

Also, for verification of KRTCS, test line was established in Illo station ~ Daebul station 11.5 [km] lengths and a synthesis performance test is performing about ATP/ATO. Illo ~ Daebul test line that KRTCS synthesis performance test performed is shown in figure 2.

Fig.2 The Illo ~ Daebul test line for KRTCS synthesis performance test

3 KRTCS EB and Fault Code procedures

3.1 EB (Emergency Brake) and Fault Code

EB code is defined as a subset of Fault Code, and vehicles manage all the DB. After EB is applied (Set), if the cause disappeared (Reset), onboard ATP of the train deletes the corresponding items on the list.

Fault code does not need onboard ATP/ATO manufacturer is all same, but ATS shall have all DB that submitted by onboard ATP/ATO manufacturer for the Fault Code display. It shall be determined by prior consultation as not same Fault Code assigned for different failure.

Also, EB application created by ATS/EI, wayside ATP, onboard ATP and displayed as Fault Code, release is possible only EB Release command of ATS.

ATS displays failure data that related to EB from the Fault Code List as ‘EB table’.

Figure 3 shows ATS, wATP(wayside ATP), oATP(onboard ATP), delivering relationship of EB and Fault code.

Fig.3 EB applied and released procedures

3.2 EB set/release procedures

3.2.1 EB set by ATS

① ATS commands ‘EB set’ by ATS through Q_EB Set(01) of #33 message, Emergency Brake Set/Reset Command. (Event system)
② Wayside ATP transmits EB type(M_EBTYPE(k)) and status information(Q_EB(k)-Set) that EB by ATS through #107 packet, Emergency Brake Set/Reset of N_ITER/M_EBTYPE(k)/Q_EB(k) set to onboard ATP. (Polling system)
③ Onboard ATP sets EB to the vehicle.
After set EB to the vehicles, set Q_EB of Train Status Report, #203 packet, add correspond item to N_ITER/M_FAULTCODE(k) and inform to wayside ATP that EB by ATS.

④ Wayside ATP transmits(By Pass) #225 packet(Train Status Report) received from onboard ATP to ATS. (Polling system)

⑤ ATS identifies EB is set to vehicles through Q_EB of #225 packet(Train Status Report), and identifies EB through M_FAULTCODE(k) by ATS.

3.2.2 EB set by onboard ATP

① If EB set by error or failure of vehicles, onboard ATP displays EB status by setting Q_EB of #203 packet Train Status Report, informs error or failure type to wayside ATP through N_ITER/M_FAULTCODE(k). (Polling system)

② Wayside ATP transmits(By Pass) #225 packet(Train Status Report) received from onboard ATP to ATS. (Polling system)

③ ATS identifies EB set on the vehicle through Q_EB of #225 packet(Train Status Report), identifies EB type through M_FAULTCODE(k) occurred on the vehicle. (Polling system)

3.2.3 EB release that set by ATS

① If Q_EB of #225 packet(Train Status Report) set, ATS identifies EB set by ATS through M_FAULTCODE(k).

② ATS commands 'release EB creation cause by ATS' to onboard through N_ITER/M_EBTYPE(k)/Q_EB that is transmitted from wayside ATP to onboard ATP.

③ Wayside ATP transmits #225 packet(Train Status Report) received from onboard ATP to ATS.

④ ATS identifies EB set is maintained to the vehicle through Q_EB of #225 packet(Train Status Report), and identifies EB set by ATS through M_FAULTCODE(k) is deleted on the list. (Polling system)

⑤ 'EB release command' is transmitted to wayside ATP through #37 message Emergency Brake Command of ATS.

⑥ If wayside ATP has received 'EB release command' from ATS,

ⓐ Wayside ATP stops cyclonic transmission of 'release EB creation cause by ATS' to #107 packet, Emergency Brake Set/Reset of N_ITER/M_EBTYPE(k)/Q_EB that is transmitted from wayside ATP to onboard ATP.

ⓑ Wayside ATP changes from Q_EBRELEASE value of #11 message, ATP Wayside Message to EB_Release(01) and transmits onboard ATP. Wayside ATP shall change from Q_EBRELEASE value to Normal(10) and transmits onboard as soon as identify the EB has been released from the vehicle. (Polling system)

⑦ If Q_EBRELEASE value is received as EB_Release(01), after release EB of the vehicle and change from Q_EB of #203 packet, Train Status Report to Reset(10) and report to onboard ATP. (Polling system)

3.2.4 Release EB set by onboard ATP

① If Q_Eb of #225 packet(Train Status Report) is set, ATS identifies EB type through M_FAULTCODE(k).

② If EB creation cause that set in onboard ATP was deleted, onboard ATP informs to wayside ATP after delete EB item(Fault Code) by ATS between N_ITER/M_FAULTCODE(k) while maintaining Q_EB Set of Train Status Report, #203 packet.

If it is deleted item already, onboard ATP ignores it.

③ Wayside ATP transmits #225 packet(Train Status Report) received from onboard ATP to ATS. (Polling system)

④ Onboard ATP informs to wayside ATP after delete EB item(Fault Code) by ATS between N_ITER/M_FAULTCODE(k) while maintaining Q_EB Set of Train Status Report, #203 packet.

Also, confirms EB creation cause is removed from the M_FAULTCODE(k) items. (Polling system)
ATS transmits 'EB release command' to wayside ATP through #37 message Emergency Brake Release Command.
If EB creation cause by onboard ATP is not deleted all, depending on the EB type, ATS decides whether operate the vehicle through 'EB release command' or send a staff to the vehicle. (Event system)

If wayside ATP received 'EB release command' from ATS, change from Q_EBRELEASE value of ATP Wayside Message, #11 message to EB_Release(01) and transmit to onboard ATP.

As soon as identify that EB is released, change Q_EBRELEASE value to Normal(10) and transmits to onboard.

If onboard ATP received Q_EBRELEASE as EB_Release(01), after release EB, changes from Q_EB of Train Status Report, #203 packet to Reset(10) and transmits to onboard ATP. However, if 'EB release command' is given in state EB creation cause is not removed, onboard ATP deletes EB-related item forced from the M_FAULTCODE(k) list. (Polling system)

However, if 'EB release command' is given from ATS in state EB creation cause is not removed, process as follows.

a. Wayside ATP is able to release EB to the vehicle by stopping EB set command transferring EB by wayside ATP to N_ITER/M_EBTYPE(k)/Q_EB(k) of #107 packet Emergency Brake Set/Reset that is transmitted to onboard ATP.

b. After deletes EB-related item from the M_FAULTCODE(k) list, Wayside ATP releases EB of the vehicle.

4 Conclusion

Communications Based Train Control (CBTC) system introduced in Korea recently is a railroad signal system that based on communications and information technology and it is comprised of subsystems such as Automatic Train Operation (ATS), Automatic Train Protection (ATP), Automatic Train Operation (ATO), Electronic Interlocking (EI) and networks etc. Of these, ATP/ATO is a core subsystem of the signal system, and it covers safe operation of urban rail and automatic operation of trains.

Korean Radio-based Train Control System (KRTCS) which is being progressed as a national R&D and is possible for driverless operation is being performed on Illo ~ Daebul test line.

This paper deals with Fault Code display and applied and Emergency Brake set and release processing by an error several functions of KRTCS.

References:

