Design Study on the Distributed Electronic Interlocking of Korean Radio-based Train Control System

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Abstract: - The Communication Based Train Control (CBTC) system reports the real-time train location report and transmits the movement authority through radio communication, and it shall increase railway capacity by allowing the high-density train control through high information transmission amount between the wayside ATP/ATO and the onboard ATP/ATO. Also, it shall reduce the maintenance cost because it does not use the existing track circuits. This paper deals with the distributed Electronic Interlocking (EI) which is the subsystem of the Korean Radio-based Train Control System (KRTCS) which is developing for the purpose of the driverless operation. The difference between the EI system of KRTCS and the EI of the existing Fixed Block System (FBS) is receiving the train location information through the ATP and decentralized structure which is separated a central device and a station device. Also, the EI system of KRTCS is designed for the immediate applying to the KRTCS through minimal changes of the existing EI.

Key-Words: - Korean Radio-based Train Control System, Electronic Interlocking, Automatic Train Protection

1 Introduction
The railways perform their each function as multiple systems such as vehicles, tracks and signals etc. Therefore, co-operative operations between each subsystem are essential. The railway signal or the train control system is in charge of ensuring safe and improving efficiency of railway operations by maintaining a safe separation of a preceding train and a following train [1].

The signal systems installed in Korea are the Automatic Train Stop (ATS), the Automatic Train Control (ATC), the balise (or transponders) and the Automatic Train Protection (ATP) using the track circuit.

The Communications Based Train Control (CBTC) system which is introduced in Korea is a railway signal system based on communications and information technology, and it is consists of subsystems such as the Automatic Train Supervision (ATS), the ATP, the Automatic Train Operation (ATO), the Electronic Interlocking (EI) and networks.

Of these, the interlocking is a safety system only if there is no disturbance in the train route to output a signal which allows entering of the train by interconnecting branching and signal branch within the stations[2].

This paper deals with the distributed EI design as a subsystem of the CBTC (Communications Based Train Control) system that driverless operation is possible as urban rail.

![Fig.1 KRTCS onboard and wayside system diagram](image)

2 Distributed electronic interlocking
In the evolution of interlocking, it used to electrical relaying using an electric from mechanical, but with the electronic technology development, based on reliability and safety of parts improvement, recently electronic interlocking (EI) is mainly used. And it is evolving into a form of distributed processing based on optical communication by development of the communication technology (ensuring speed and safety) [2].
Especially, in urban rail, changing to the distributed interlocking could be advantageous in terms of cost or maintenance aspects since it is a structure that way stations or un-staffed stations are increased rather than large stations.

Fig. 2 Block diagram of distributed Electronic Interlocking of Korea Radio based Train Control System (KRTCS)

The radio based MBS (Moving Block System) is used in the KRTCS. There are differences between train location detection and existing Korean railroad Fixed Block System (FBS). Therefore, the EI of the KRTCS was applied with minimal modifications from the electronic interlocking (EI) for FBS so that it could take full advantage of the logic to be used with the existing FBS.

Differences on the configuration of the existing interlocking and the distributed interlocking are follows.

Existing unit is processing data centralize CPU, communication module (connecting with optical communication), IFU and input-output module on the interlocking part via VME bus. However, in the distributed unit, the interlocking processing part is processed in central unit, input-output processing part is processed in station unit through communications, display and control information related with the distributed unit send and give data through the NIU (Network Interface Unit).

Figure 3 represents the difference between the existing EI configuration and the distributed EI controlling and configuration.

2.1 Receiving train location information through the ATP

The difference between the interlocking from the existing FBS and the interlocking from the MBS could be divided into two.

First is receiving train location information through the ATP. In the existing FBS, the train occupancy information was processed the train location (track occupancy information, block units) through the input-output modules (input module) of the interlocking from the track circuit equipment. However, in the KRTCS, the train location information processing is changed to handled by the EI as receiving the train location information units...
subdivide in blocks (segments) through interface with the ATP.

In other words, it sets virtual block logically and converts location information for segments to the virtual block occupancy information to be able to use the existing interlocking as it is.

The changes of the received location information could be summarized as follows.
- Adding an interface with the ATP: It receives information such as the MA (Movement Authority) and traveling direction information with the Fail-Safe Protocol based on dual LAN communication.
- Set the virtual block: It sets virtual block logically and converts location information for segments to the virtual block occupancy information to be able to use the existing interlocking as it is.

![Fig. 4 The flow of the track input and Train position information](image)

### 2.2 Separation the central unit and station unit

The second difference between interlocking from the MBS and interlock from the existing FBS is a separation structure of central unit and station unit.

It is intended to separate the central unit (interlocking logic) and station unit (input-output processing) for local control of the station where there is no onboard ATP. However, if the local unit is in the same area as the central unit is, it is possible to separate the station unit and the central unit and put same area, or it is also possible to configure the existing interlocking installed in the same rack.

The changes to distributed structure could be summarized as follows.
- The central unit and the station unit shall process the data through a (optical) communication.
- The module (NIU) shall add to communicate with the station unit on the central unit.
- Adding the CPU module on the station unit: The input-output processing part which was performed on the existing interlocking CPU is transferred to the station unit CPU, and establish communication with the central unit using the Fail-Safe Protocol.

It is possible to combine the NIU functions and the processing is in the same method as the interface between the ATP-EIS.

![Fig. 5 The flow of Indication/control information](image)

### 2.3 Characteristics and advantages and disadvantages of the distributed interlocking

Table 1 shows characteristics of the distributed interlocking, and table 2 shows advantages and disadvantages of the existing system and the distributed system of the KRTCS.

<table>
<thead>
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<th>Table 1 Characteristics of the distributed interlocking device</th>
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| Cost saving | - For large station, the route is 200 to 400, but in the case of way station and unmanned station, the route is usually less than 20.  
- In future trend, the branch office controls around the stations, in this case, the distributed form is effective in terms of cost. |
| Remote Control of way station or unmanned station | - It is the form which is the appropriate configuration of the distributed system.  
- It could be configured easily with the development of communications facilities and systems. |
| The scalability of the system Configuration | - The system could be extended easily when add a way station or an intermediate station by adding the basic hardware.  
- Maintenance of the system is easy. |
several stations as one System) -If the protocol of communication sets, the interface with other systems and using the data are easy because the system configuration is network form.

The use of optical network -As the use of optical network, it is not affected by the impulse or the around interference.

- The reliability and safety about the information are improved.

Table 2 Comparison of merits and demerits of EIS

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<tr>
<th>Division</th>
<th>The existing system</th>
<th>The distributed system</th>
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<tr>
<td>Forms</td>
<td>The electronic interlocking system installed each station.</td>
<td>Several stations are composed as a one system and as a small CTC form.</td>
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<tr>
<td>Advantages</td>
<td>* It is installed each stations, so operational limitations are minimal when a fault occurs.</td>
<td>* Maximize the effectiveness of the interlocking * Flexibility of the system configuration * Facilitates of the system scalability * Centralized configuration is possible. * Installed to fit the circumstances of the field is possible. * The cost is saved if there are many way stations, unmanned stations and small stations. * Configured in network form, easy to interface with other systems.</td>
</tr>
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<td>Disadvantages</td>
<td>* For way station and unmanned station, the basic cost is high * If the station is large, there are limits to the</td>
<td>* The extra building is needed when separation and installation to the on-site. * Operating disability is great</td>
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</table>

3 Conclusion

This paper deals with the distributed Electronic Interlocking (EI) which is the subsystem of the Korean Radio-based Train Control System (KRTCS) and driverless operation is possible.

The difference between the EI and the existing FBS electronic interlocking (EI) are divided into two.

First, in the existing FBS, the EI calculate the train location information directly based on the track circuit, but in the KRTCS, calculate and transmit the train location information to the EI by communicating with onboard and wayside.

Second, the existing EI is processing centrally the interlocking logic and the input-output control in interlocking part, but the EI of the KRTCS which is the distributed structure, interlocking processing part is processed in the central unit, and the input-output processing part is processed in the station unit through the communications.

In addition, the EI of the KRTCS, for the immediate applying the existing EI to the KRTCS, is designed the EI of the KRTCS through minimal changes.

References:


