Development of on-board ATC system for Maglev Vehicle

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ABSTRACT: This paper gives an overview and developing status of the on-board Automatic Train Control (ATC) System employed to control the Urban Maglev vehicle in Korea. In the construction of demonstration line for Urban Maglev Program, the Daewoo Engineering Company (DEC) has participated as a supplier of the whole ATC System since 2009. According to the contract with Korea Rail Network Authority (KRNA), DEC is under progress for the development of the whole ATC system including Safety Integration Level (SIL) assessment from the ISA, which is followed by the international standards IEC62278, IEC62279, and EN50129. Once the Urban Maglev Program is completed successfully in 2013, the developed system will be the first localized whole ATC system which has SIL assessment and commercial operation experience in Korea.

1 INTRODUCTION

This paper gives an overview and developing status of the on-board ATC System employed to control the Urban Maglev vehicle in Korea. In the construction of demonstration line for Urban Maglev Program, DEC has participated as a supplier of the whole ATC System since 2009. According to the contract with KRNA, DEC is under progress for the development of the whole ATC system including SIL assessment from the ISA, which is followed by the international standards IEC62278, IEC62279 and EN50129. Once the Urban Maglev Program is completed successfully in 2013, the developed system will be the first localized whole ATC system which has SIL assessment and commercial operation experience in Korea.

1.1 Overview of the Demonstration Line

The overview of the demonstration line is as follows:
. Location: Youngjong-do, Incheon-city, Korea
. Route length: 6.113 km (Mainline-double track), 0.750 km (Lead in track-single track)
. Station: 6(Island platform:5, Opposite platform:1)
. Depot: 1

Figure 1. Route map of Maglev in youngjong-do, Korea

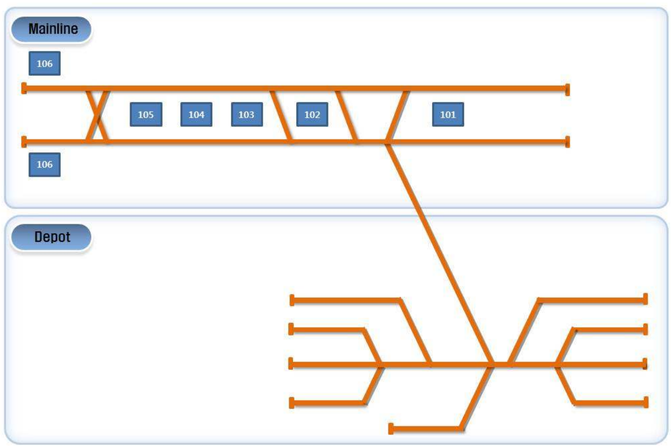

Figure 2. Line map of Maglev in youngjong-do, Korea

2 OVERVIEW OF THE ATC SYTEM

2.1 System Performance

The performance of ATC system for the demonstration line is as follows:
. Operation Type: ATO Driverless Operation
. Signaling Type: Cab signal system
. Minimum Headway: 90 seconds
. Scheduled Speed: 36km/h and over

2.2 System Configuration

The ATC system for Urban Maglev Vehicle consists of three major sub-systems: Automatic Train Protection (ATP) sub-system, Automatic Train Operation (ATO) sub-system and Automatic Train Supervision (ATS) sub-system. The system configuration is seen in Figure 3.

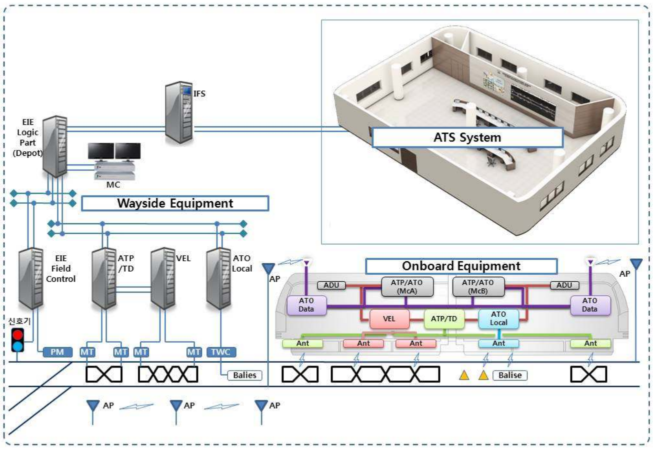

Figure 3. System configuration of ATC system

2.3 System characteristics

The System Characteristics of the ATC system for Maglev Vehicle is as follows:
. Train Detection using Check-in/Check-out signal by Onboard Equipment
. Contactless Velocity Detection using wayside Loop and onboard antenna
. Distributed Electric Interlocking Equipment

2.3.1 Train Detection using Check-in/Check-out signal by Onboard Equipment

We adopt the check-in/check-out method for detecting location of trains because there are no wheels and no rails, and it is similar to traditional method for detecting train location. Onboard ATP/TD equipment sends check-in signal from front-end of vehicle while sending check-out signal from rear-end of vehicle.

If the wayside ATP/TD equipment detects the check-in signal through the ATP/TD loop installed on the wayside, the wayside ATP/TD equipment recognizes that a vehicle is occupied the block.
In the other hand, if the wayside ATP/TD equipment detects is that there is no check-out signal in the block and detects check-in signal in the front block, the wayside ATP/TD equipment recognizes that a vehicle is not occupied the block.

2.3.2 Contactless Velocity Detection using wayside Loop and onboard antenna

Because a maglev vehicle cannot be used tachometer as a vehicle has wheels, so we adopt contactless transmission using wayside velocity loop and onboard velocity antenna for detecting velocity and distance.

Velocity loop installed on the wayside is repeated an opening and closing parts at intervals of 30cm, and an velocity antenna installed on the onboard has three coils which have at intervals of 20cm. As a vehicle runs on the wayside velocity loop, each onboard coil in the onboard velocity antenna gets a signal at intervals of 30cm, and the signal between coils is at intervals of 20cm. As these three signals are combined, the onboard equipment gets 10cm signal per an edge.

The principle of velocity detection is seen in Figure 4.

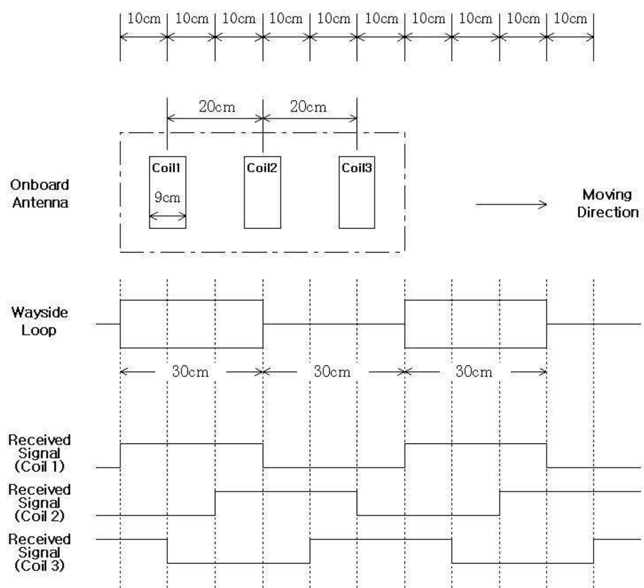

Figure 4. Principle of Velocity detection

2.3.3 Distributed Electric Interlocking Equipment

We adopt distributed Electric Interlocking Equipment (EIE) because it gives several advantages.
Logic part of EIE is installed in interlocking stations, and local control part of EIE is installed in non-interlocking stations. All interlocking logics are processed by logic part of EIE, and the data processed is transmitted to local control part the by fiber-optic network. Local control part controls the point machine and signals installed in the wayside.
If it is necessary to extend or change the line, the distributed EIE can cope effectively with that situation more flexibly.

The system configuration of Electric Interlocking Equipment is seen in Figure 5.

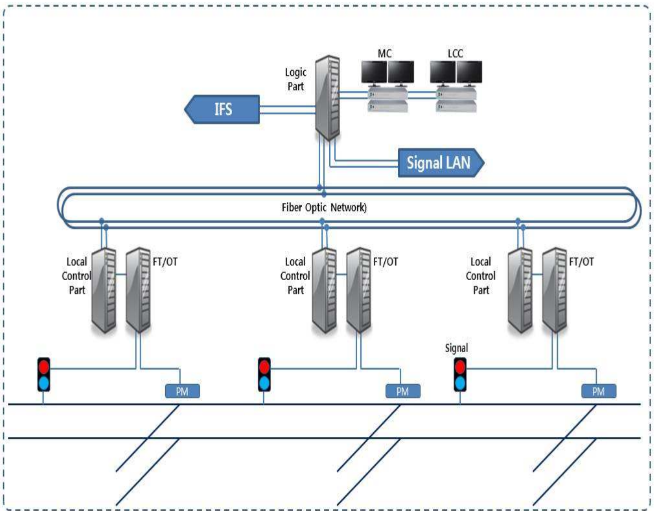

Figure 5. System configuration of EIE

3 ONBOARD ATC SYSTEM

3.1 System configuration

Our onboard ATC system consists of following equipment:
. ATP/ATO Equipment
. ATP/TD Equipment and ATP/TD Antenna
. Velocity Detection Equipment and Velocity Antenna
. ATO Local Equipment and ATO Local Antenna
. ATO Data Equipment and ATO Data Antenna
. Man-Machine Interface (MMI) Equipment

Onboard ATC system is designed redundancy architecture. If there are any system failures in the master system, it is changed to the slave system automatically. Onboard ATC system is designed to have high reliability and safety after changing the slave system.

The system configuration of Onboard ATC system is seen in Figure 6.

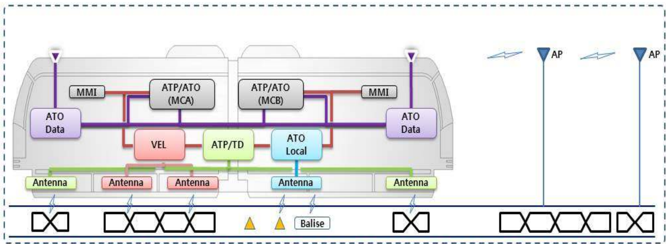

Figure 6. System configuration of Onboard ATC system

3.2 ATP/ATO Equipment

ATP/ATO Equipment is a main controller of onboard ATC system, which has ATP such as over-speed protection, door enable control and so on, and ATO function such as automatic speed regulation, automatic precision stop and so on.

ATP/ATO equipment consists of the following module:
. CPU module, which is in charge of calculation of ATP/ATO logic
. IO module, which is in charge of vehicle interface
. Communication module, which is in charge of serial communication such as CAN, MVB and so on
. PWM module, which is in charge of sending PWM signal to vehicle for ATO operation

3.3 ATP/TD Equipment and ATP/TD Antenna

ATP/TD equipment is in charge of demodulation of ATD signal sent from the wayside ATP/TD equipment, and modulation of check-in/check-out signal to be sent to the wayside ATP/TD loop via ATP/TD antenna. The wayside ATP/TD equipment uses 20 kHz for ATP signal, 15 kHz for check-in signal, and 11.8 kHz for check-out signal.

3.4 Velocity Detection Equipment and Velocity Antenna

Velocity Detection Equipment is in charge of demodulation of velocity signal sent from the wayside velocity loop via velocity antenna. The wayside velocity equipment uses 27 kHz to send the velocity signal.

3.5 ATO Local Equipment and ATO Local Antenna

ATO Local equipment is in charge of communication with the wayside ATO local equipment, which transmits and receives the information for ATO operation. For this communication, onboard ATO local equipment uses 3.0 MHz for transmitting the information to wayside, 1.7 MHz for receiving the information from wayside, and 256 kHz for transmitting power to the wayside balise via ATO local antenna.

3.6 ATO Data Equipment and ATO Data Antenna

ATO Data equipment is in charge of transmitting vehicle status to ATS system and receiving non-vital control information from ATS system.

3.7 Man-Machine Interface Equipment

MMI is used for exchanging the information between onboard ATC system and drivers.

4 ONBOARD ATC DEVELOPMENT SHEDULE

Onboard ATC system has completed the prototype currently as shown Figure 7, 8 and 9. We plan to perform Factory Acceptance Test in September, 2011, and static/dynamic test in mainline from beginning of 2012 to middle of 2013. After completing the mainline test, developed ATC system will be operated from the middle of 2013.

Figure 7. Prototype of Onboard ATC Rack

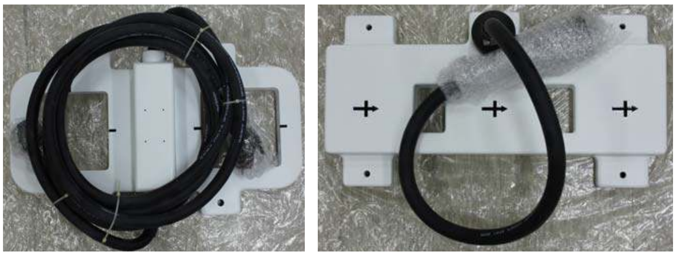

Figure 8. Prototype of ATP/TD(Left) and Velocity(Right) Antenna

Figure 9. Prototype of ATO Local Antenna(Left) and MMI(Right)

5 INDEPENDENT SAFETY ASSESSMENT

The whole ATC system including onboard ATC system is performing independent safety assessment (ISA) from Lloyd's Register who is international safety assessor and its head office is located in England.

ISA has performed according to international standard IEC 62278 (System RAMS), IEC 62279 (Software) and EN 50129 (Safety Assurance).

6 CONCLUSIONS

In case of successfully completing the construction of demonstration line and developed ATC system achieved SIL4 assessment from ISA, it will be first case to achieve SIL4 assessment about ATC system in Korea.

7 REFERENCES

IEC 62278, “Railway application – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)”

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