KYOSAN

Signaling system
Busan subway Line 3

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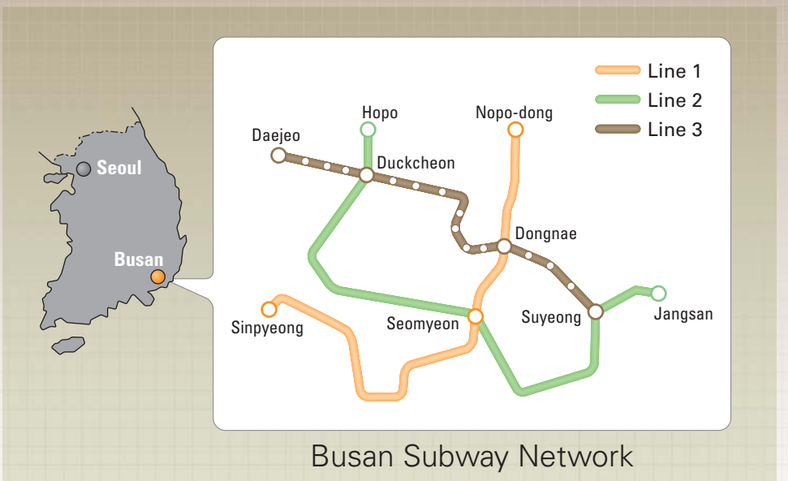
Busan subway Line 3 Signaling system

Overview

On November 28, 2005, Busan subway Line 3 was opened for urban traffic, thus connecting the section of about 20 km between Suyeong Station in Busan (Korea's second largest city) and Daejeo Station (depot).

The signaling system used for this line mainly consists of ATP equipment using digital signals to shorten the operating time, improve riding comfort, and provide complete support information for drivers (previous notice signal for forward track circuit, next station arrival platform No. information, etc.).

ATP digital signals sent from wayside equipment can be used to generate an optimum train control pattern for preceding train position on on-board equipment. ATO equipment controls train operation between stations. At each terminal station, an auto turn-back function (ATB) that enables automatic turn-back operation is provided.



Busan Subway Network

Overview of the line

Length of the line	Approx. 20 km	Operation headway	150 sec.
No. of stations	17 stations + depot	Max. operating speed	80km/h
No. of operating train	20 trains	Operation method	Single-person operation
Train formation	4 vehicles / 1 train		

The signaling system mainly consists of SINPL ATP equipment using digital signals.

SINPL : **S**imple , **IN**tegrated & **P**aralle**L**

System configuration

There are seven signal equipment rooms at six interlocking stations and one centralized station. Each interlocking station is provided with ATP/TD equipment, EIE equipment, and ATO/TWC equipment; the centralized station is provided with ATP/TD equipment and ATO/TWC equipment.

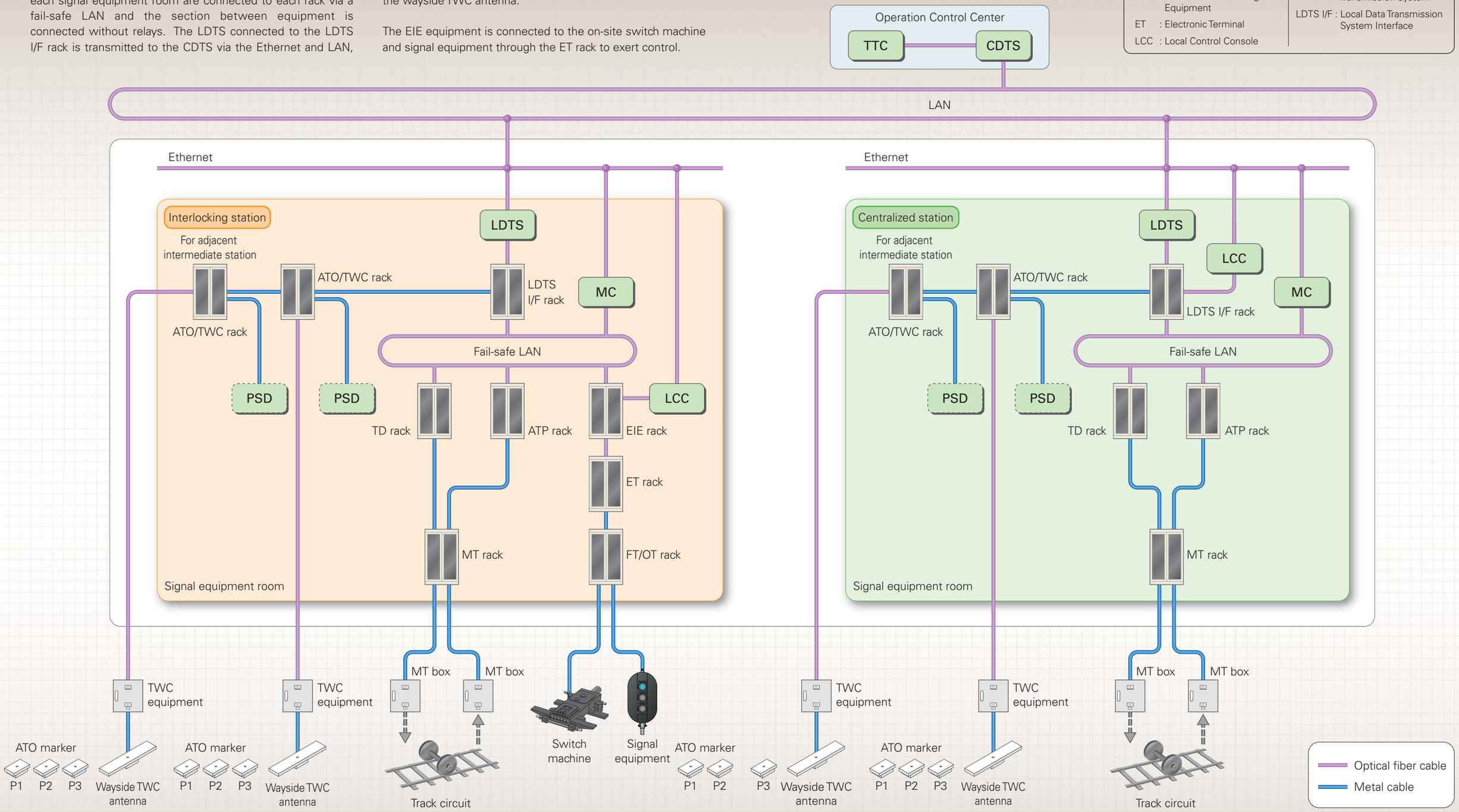
The ATP rack, TD rack, EIE rack, and LDTS I/F rack equipped in each signal equipment room are connected to each rack via a fail-safe LAN and the section between equipment is connected without relays. The LDTS connected to the LDTS I/F rack is transmitted to the CDTS via the Ethernet and LAN, and then connected to the TTC equipment in the Operation Control Center.

The ATP/TD equipment transmits information to the on-board equipment via an on-site MT box and track circuit . The ATO equipment sends and receives bidirectional information to and from the on-board equipment via on-site TWC equipment and the wayside TWC antenna.

The EIE equipment is connected to the on-site switch machine and signal equipment through the ET rack to exert control.

The on-site ATP/TD and ATO equipment consists of a rail to send and receive ATP/TD signals, the MT box to match the signal equipment, and ATO markers for ATO distance correction and other functions in a simple configuration.

ATP	: Automatic Train Protection	MC	: Maintenance Console
TD	: Train Detection	FT/OT	: Fuse Terminal / Output Terminal
MT	: Matching Transformer	TTC	: Total Traffic Control
ATO	: Automatic Train Operation	CDTS	: Central Data Transmission System
TWC	: Train Wayside Communication	LDTS	: Local Data Transmission System
PSD	: Platform Screen Door	LDTS I/F	: Local Data Transmission System Interface
EIE	: Electronic Interlocking Equipment		
ET	: Electronic Terminal		
LCC	: Local Control Console		



ATP/TD (Automatic Train Protection/Train Detec tion)

Improving functions through the digitization of ATP signals

The train control system mainly consists of ATP equipment using digital signals to shorten the operating time, improve riding comfort, and provide complete support information for drivers (previous notice signal for forward track circuit, next station arrival platform No. information, etc.).
This ATP equipment is based on the **SINPL** series that monitors the track circuit that has been delivered to accommodate more than 4000 tracks.

SINPL : Simple , INtegrated & ParalleL

SINPL is intended to improve cost performance by adopting a **S**imple method/configuration with **In**tegrated functions installed and multi-track **P**aralle**L** send/receive processing implemented.

Reduction of equipment accommodation space
Reduction of equipment and work expenses
Improvement of maintainability

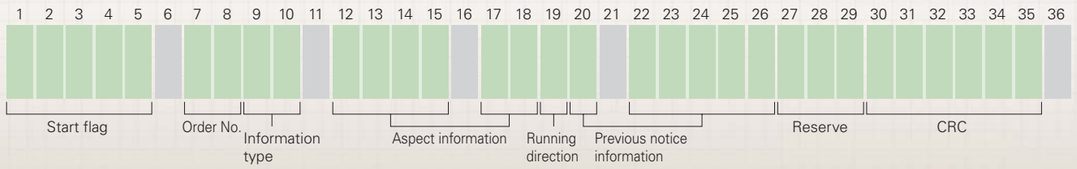
Features of the ATP/TD equipment

- ATP of digital signaling system
- The ATP code of the main line is pattern-controlled at 5 to 80 km/h
- Pattern control protects against overruns, thus reducing overrun length
- The previous notice signal for forward track circuit and the next station arrival platform No. are displayed on the operating panel
- For equipment-to-equipment connection, we adopt a high-reliability, high-speed optical LAN that has been actually used
- Cab signal indication at shunting
- Units are added in accordance with the No. of track circuits
- In an emergency, pressing a button in the station or Operation Control Center can stop a train

Example of ATP bit format

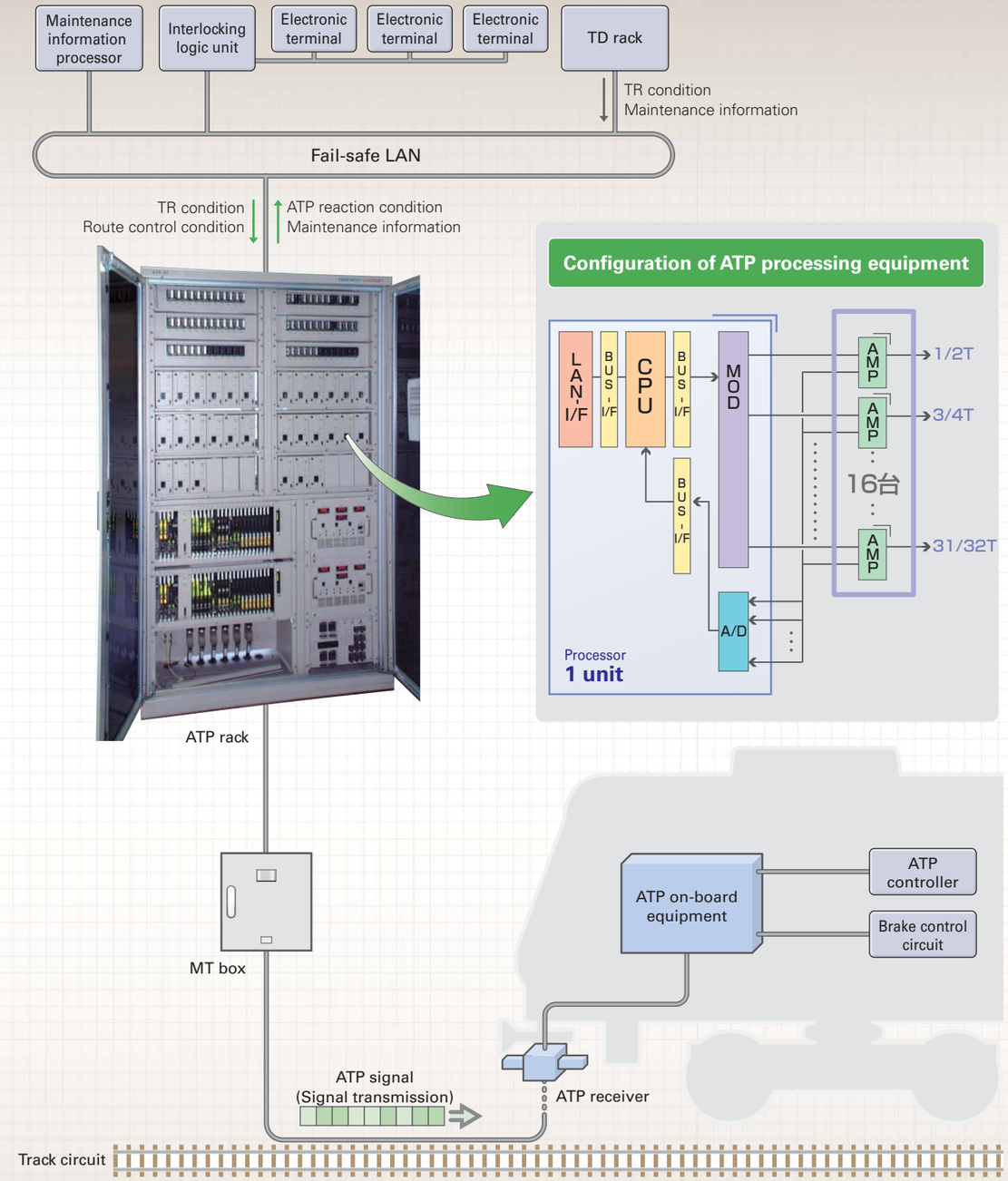
The ATP signal wave is generated by MSK modulation and the frame information consists of 36 bits. This bit allocation is applicable to a train control system using digital ATP and to next-generation train control systems.

MSK : minimum shift keying



Configuration of ATP/TD equipment

A configuration based on SINPL-ATP and a fail-safe LAN through which data is shared between equipment is adopted.
The on-board equipment is applicable to LRT system, provided that the ATP receiver is replaced by an on-board antenna.



ATO/TWC (Automatic Train Operation / Train W ayside Communication)

Performs automatic operation control safely and precisely for train operation

The ATO/TWC equipment operates trains automatically without operator intervention, thus enabling driverless operation or single-person operation. For driverless operation, all operations ranging from starting up the train power to train arrival at a station, and including the opening and closing of train doors and the PSD (Platform Screen Door), are automatically controlled. For single-person operation, fixed-position stop control and controlling the opening and closing of train doors and the PSD at a station are performed through a man-machine interface.
The trains on Busan subway Line 3 are usually run through single-person operation, but use of this equipment also permits driverless operation.

Functions of the ATO/TWC equipment

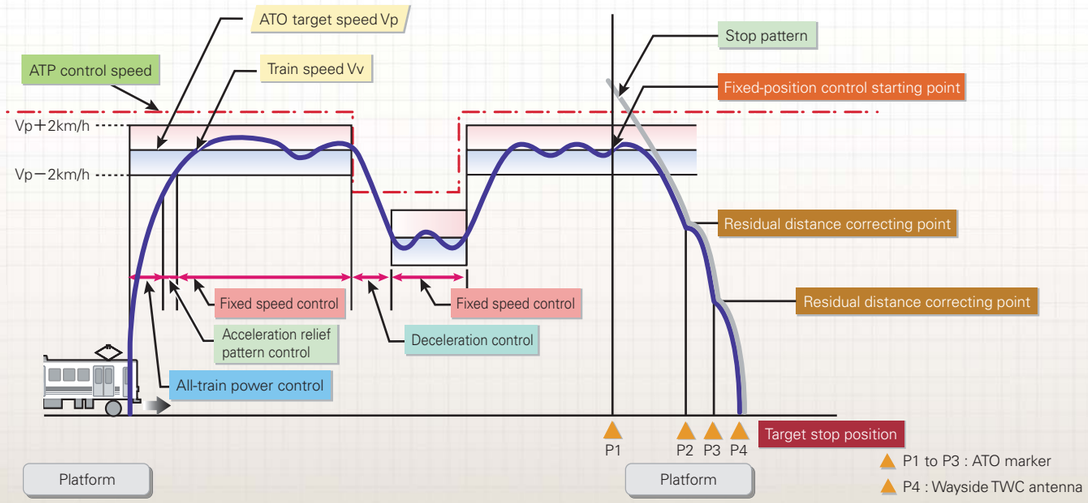
- Automatic operation : Accelerates or decelerates the train according to the target speed
- Fixed-position stop control : Controls braking so that the train can stop at the fixed position
- Door open/close control : Controls the opening and closing of train doors and the PSD after the train stops

Features of the ATO/TWC equipment

- The accuracy of fixed-position stop control is ±350 mm or less.
- PSD control is matched to each mode upon switching between Open Auto/Close Auto, Open Auto/Close Manual, and Open Manual/Close Manual at the driver's discretion.
- This equipment is applicable to ATB (Auto Turn Back) mode in which driverless train shunting is performed on the draw-back track.
- If operation failure occurs, this equipment can change the running direction from train stop status at the originating or destination station to enable operation to resume under PSD control and through ATO operation. This is called STB (Station Turn Back) mode.

Station-to-station running pattern under driverless operation

The following figure shows the train control running pattern under driverless operation. The target speed of ATO is set as the ATP control speed, with train power control, fixed speed operation, and fixed-position stop control performed based on this target speed.



Configuration of ATO/TWC equipment

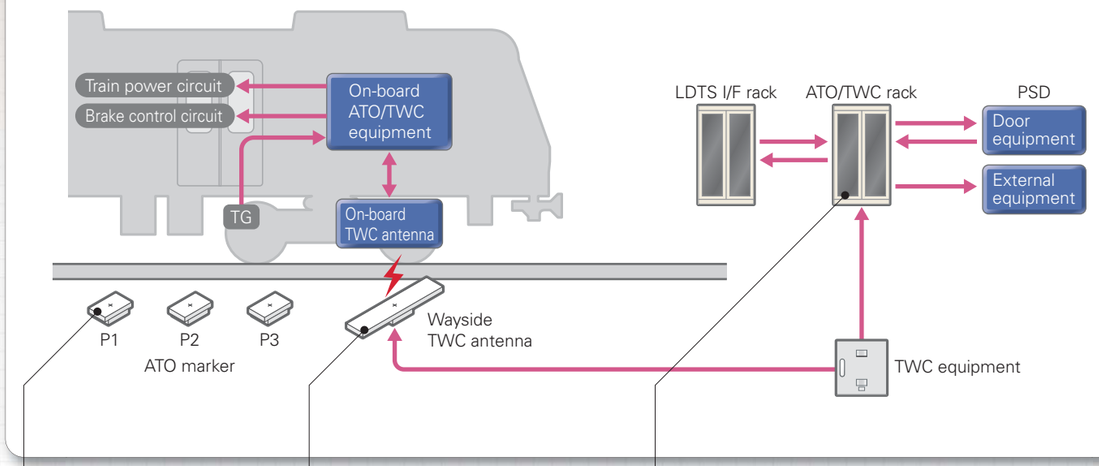
The ATO/TWC equipment consists of wayside equipment and on-board equipment. ATO markers P1 to P3 are wayside equipment used for distance correction for fixed-position stop control, for which the distance correction information of the ATO markers is transmitted to the train. The bidirectional transmission of information is performed between the wayside TWC antenna and on-board TWC antenna.

Train control information and PSD display information are transmitted from the wayside TWC antenna to the on-board antenna.

Train display information and PSD control information are transmitted from the on-board TWC antenna to the wayside TWC antenna. Information is also exchanged with the PSD.

The 3.0 MHz band is used for transmitting information from the on-board TWC antenna to the wayside TWC antenna; the 1.7 MHz band is used for transmitting information from the wayside TWC antenna to the on-board TWC antenna. FSK modulation is used as the modulation system. The on-board TWC antenna always transmits an unmodulated wave of 256 kHz (power wave) to supply ATO marker driving power.

FSK : frequency shift keying



Wayside TWC antenna

ATO/TWC rack

ATO marker

EIE (Electronic Interlocking Equipment)

Overview of the EIE equipment

The EIE equipment is interlocking equipment provided with a fail-safe function, and consists of electronic units. This equipment installed in the signal equipment rooms provided at five interlocking stations and one depot to control the switch machine and signal equipment in the interlocking stations.

The PC-type control panel or LCC (Local Control Console) is connected to the EIE logic unit for performing route control and point control. The LCC is connected to the ATO/TWC equipment from the EIE logic unit via the fail-safe LAN and then the LDTS I/F for performing train control.

The EIE logic unit receives track circuit (TD) information from the TD equipment via the fail-safe LAN. The ATP transmission code information created from the TD information and route control information by the connecting type of LDC (Logical Data Compiler) is output to the ATP equipment via the fail-safe LAN.

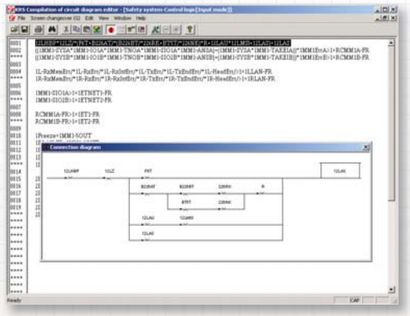
EIE rack

Features of the EIE equipment

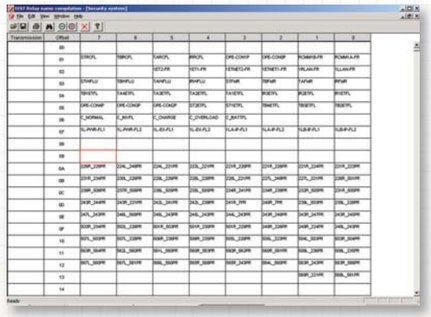
- As high-safety and high-reliability electronic interlocking equipment, the electronic interlocking equipment of the K5B series that has already been put to practical use is adopted.
- The interlocking logic function is created with a relay connecting-type image by using the LDC (Logical Data Compiler).
- Connecting between the ATP/TD equipment and EIE logic unit via the fail-safe LAN increases processing speed and improves the sharing of data, unlike the existing relay type of contact.

LDC (Logical Data Compiler)

The LDC is a software design tool that allows the designer to create the interlocking logic on a Boolean logic basis, which is easily interchangeable with relay circuit diagrams as to logic expression. In addition, the LDC is outfitted with an automatic data comparison feature that identifies modified portions of the logic on the display for easy verification of the modified design.



LDC Diagram



Relay Library

Supply records

The K5B series has been actually supplied at least 300 domestic stations and 200 overseas stations.

LDTS I/F (Local Data Transmission System I/F)

Overview of the LDTS I/F equipment

The LDTS I/F equipment serves as an interface connecting the central TTC and each unit of signal equipment, and consists of the same hardware as that of the logic unit of electronic interlocking equipment. Accordingly, this equipment creates LDTS I/F logic by using the LDC just like that of the EIE logic unit.

The LDTS I/F equipment is connected to each unit of equipment (ATP/TD and EIE equipment) having a fail-safe function connected to the fail-safe LAN, and performs relay transmission using non-fail equipment (ATO/TWC and LDTS equipment).

Related equipment

TTC equipment (Total Traffic Control)

Installed in the Operation Control Center to perform route control and train control based on the diagrams and operation control for the entire line.

CDTS equipment (Central Data Transmission System)

Installed in the Operation Control Center to perform relay operations between the LDTS of each signal equipment room and the TTC equipment.

LDTS equipment (Local Data Transmission System)

Transmits route control information from the TTC equipment to the EIE equipment and train control information to the ATO/TWC equipment. Also outputs display information from each unit of signal equipment to the TTC equipment. Should the TTC equipment fails, train control can be performed from the LDTS equipment in the same way as by the TTC equipment.

MC equipment (Maintenance Control)

Performs maintenance for the entire system connected to the fail-safe LAN, and also monitors the fail-safe LAN itself.