ATP equipment using system administrator

K. Kubota¹, K. Kumagai¹, S. Nishida² & J. Arai³
¹ Central Japan Railway Co., Japan.
² Kyosan Electric Manufacturing Co., Ltd., Japan.
³ The Nippon Signal Co., Ltd., Japan.

Abstract

The new Automatic Train Protection (ATP) equipment for improving the operational functions of the Tokaido Shinkansen consists of a network that uses a System Administrator. The new ATP system has power-synchronous two-frequency combination ATP functions of the present ATP method, and ATP functions of the digital coding scheme. That is, this system is designed so that it can be updated while a train having the functions of the present ATP method only and a train with new functions run along the same track. The new ATP system can provide a line connected equipment interface using a great number of signal protection units, including processor interlocking units and 125Mbps LAN. In the new ATP system, the System Administrator that functions as the core of the system components carries out central management of ATP data, test support, and operation status monitoring. In this way, the new ATP system not only ensures advanced functions and a high level of safety but also has functions of labor saving of remodeling and maintenance of the equipment.

1 The Tokaido Shinkansen

The Tokaido Shinkansen opened in October 1964 as the first Shinkansen (High-speed Railway Line) in Japan. This railway line runs between Tokyo and Osaka (552.6km), which is called the Pacific Belt Zone, covering the Tokai Industrial Zone of the Pacific Coastal Area. Therefore, the social demand on the line is high and the number of passengers has increased each year. Currently, the line, which is operating in an excessively concentrated schedule of 12 trains per hour, is an important route that can be a transport artery of Japan. This railway is evaluated highly worldwide as a very safe railway for its record of no major accidents since opened. New Shinkansens based on the Tokaido Shinkansen are shown in Figure 1.
2 Purpose of updating the equipment

The ATP equipment of the Tokaido Shinkansen has been updated once and has been improved many times during the last 36 after the first installation. This extremely safe and stable safety equipment has supported safe operation of trains for the period. However, since the equipment was designed based on the technology of early 1960s, it has become difficult to satisfy the latest requirements.

The equipment cannot satisfy the requirements of this new era such as through service with other sections, running of various vehicles, increase of the number of trains due to reduction of operation heads, quick recovery from time delay, and reduction of arrival time. The cause of the inability to satisfy these requirements is that the block section is determined to be able to operate with a vehicle of the lowest performance and the wayside device uniformly determines the aspect of the block. To solve this problem the present ATP equipment was installed concurrently and the ATP equipment is updated by switching to the new ATP equipment as required.

3 Functions of the new ATP

The new ATP equipment applies a digital transmission method, uses a track circuit for train detecting, and sends to the on-board computer data such as the number of traffic restored sections to the preceding train, track circuit ID, and limited speed section information through the track circuit. On the train, the own train position is determined from the database and data from the wayside, the on-board oriented ATP that sets a brake as required by the performance of the train is installed in order to achieve flexible vehicle operation and improvement of comfort.
As shown in Figure 2, the new ATP performs control through a non-step brake. In the present ATP, brakes are applied in multiple steps according to the stages of speeds, accumulating an idle running distance and a margin running distance and ultimately requiring a longer braking distance.

![Figure 2: Non-step brake control by new ATP](image)

In the non-step brake, the vehicle sets the brake information by calculating the position at which the train is to be stopped so that no excessive braking distance is required. Since each vehicle determines the brake beginning position according to its own brake performance, efficient operation can be achieved [1].

### 4 Configuration

Figure 3 shows the configuration of the new ATP equipment. Information is exchanged between the devices by configuring a network (ATP-LAN) of ATP equipment for each maintenance range of stations that is installed by distributing to the Main Signal House (MSH) and intermediate equipment room (ISH).

All the devices that are connected to ATP-LAN are configured by the fail-safe CPU and secure the fail-safe feature of the entire system.

- SAD (System Administrator)
- TSRB (Track Send Receive Block)
- ESRB (Emergency Send Receive Block)
- IFS (Interface Standard)
- IFC (Interface Control)
- PLM (Pilot Measure)
- TL-A (Transfer LAN ATC: Repeat unit)
- TL-E (Transfer LAN Ei: Repeat unit)
- SfB (Safety Bay)

The new ATP equipment can handle changes such as ATP signal decision logic and the interface conditions with other facilities by changing data of each device. SAD centrally manages these data items.
Maintenance range of station A

Entire line

Maintenance range of station B

Maintenance range of station C

Figure 3: System configuration

Figure 4: Configuration of the ATP System Administrator
(1) Configuration and role of SAD

Figure 4 shows the configuration of SAD.

SAD consists of a supervisor block, a test block, a monitor block, and a LAN monitor block. The supervisor block consists of a supervisor control block that is equipped with a fail-safe CPU and a general-purpose personal computer that performs status display, etc. The test block must be normally separated from ATP-LAN since it outputs simulated information to ATP-LAN instead of other devices at testing. Therefore, the test block is connected to ATP-LAN via the optical switch. The test block also consists of a test control block with a fail-safe CPU equipped and a general-purpose personal computer. Since the monitor block and the LAN monitor block consist of a general-purpose personal computer only, they are connected via an optical turnout to ensure the fail-safe feature of ATP-LAN.

5 Role of SAD

(a) Data management
SAD collectively manages data (loading data) such as the ATP signal decision logic and setting information stored in each device that is connected to ATP-LAN to enable the quick handling of improvements. When changing ATP signal decision logic as a result of change of a track circuit length, SAD will load the data of all the devices via ATP-LAN collectively. SAD also supervises the versions of loading data that is output to ATP-LAN from each device to ensure the validity of data stored in each device.

(b) Operation status monitoring (maintenance support)
SAD centrally monitors the operation status of each device that is connected to ATP-LAN to achieve labor saving of efficiency, and improvement of maintenance management and preventative maintenance. SAD constantly monitors the operation status of each device and specifies the faulty section when a fault occurs and at the same time, SAD detects a fault at an early stage through measurement data limit value monitoring. SAD automatically records operation statuses and analyzes faults by restoring the statuses.

(c) Test support
SAD automatically adjusts and tests each device through remote operation to improve the efficiency at installation or maintenance of the device.

(2) Functions of the send/receive

The track circuit send/receive block (TSRB) to transmit ATP signals and the stop signal send/receive block (ESRB) are built in the same frame rack. Each block consists of a control logic block, a digital send/receive block, an analog send block, a power amplification block, a receive input block, a measurement display
block, a frame lower block, and a relay block. One frame rack can control up to 6 track circuits.

Figure 5 shows the flow of ATP signal processing in TSRB.

TSRB creates pattern creation information corresponding to the new type vehicle and the speed signal corresponding to the current vehicle based on the ATP signal decision logic from the ATP signal creation information (train position, route, etc.) that was input from ATP-LAN. Pattern creation information is converted to a digital signal after being MSK-modulated by the digital send/receive block. A speed signal is converted to an analog signal after being SSB-modulated using a pilot frequency. Each signal is sent to a track circuit after being overlaid by the power amplification block. The train detection is carried out by the level detection of each track circuit by inputting a digital signal from the receive input block. The result is output to ATP-LAN as train position information.

![Figure 5: Flow of ATP signal processing in TSRB](image)

(3) Function of the interface device

(a) IFS

IFS handles input and output of control information, supervisor information, fault information, and monitor information between ATP-LAN of the station section and other devices installed in the station section (train number device, substitute block system, etc.)
(b) IFC
IFC handles input and output of control information, supervisor information, fault information, and monitor information between various protectors that are not directly connected to ATP-LAN (train approaching warning device, train protection and clearance disorder alarm device, switchboard, sectioning controller, etc.).

(c) PLM
PLM measures the pilot frequency and pilot voltage required for power synchronization and outputs the information. One PLM unit can measure four types of pilots.

(d) TL-A
TL-A relays transmission of control information, supervisor information, and fault information on the boundary of the neighboring ATP-LAN.

(e) TL-E
TL-E relays transmission of control information, supervisor information, and fault information on the boundary of the neighboring Ei-LAN.

(4) Functions of Safety Bay (SfB)

SfB ensure insulation pressure endurance by carrying out impedance coordination between the external transmission cable and indoor devices and installs an arrester for protecting the devices from lightning strike. The ATP signal are switched and sent by the Send Direction Switch Relay (SWR) according to the train operation direction.

Figure 6: Configuration of the send/receive circuit
Comprehensive performance
See Table 1 for the comprehensive performance.

### Table 1: Comprehensive performance table

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Track circuit length</td>
<td>1000m</td>
</tr>
<tr>
<td>2</td>
<td>Leak conductance</td>
<td>0.3S/km</td>
</tr>
<tr>
<td>3</td>
<td>Cable length</td>
<td>10km</td>
</tr>
<tr>
<td>4</td>
<td>Distance between devices</td>
<td>10km</td>
</tr>
<tr>
<td>5</td>
<td>Signal mode</td>
<td>General track circuit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loop track circuit</td>
</tr>
<tr>
<td>6</td>
<td>Frequencies used</td>
<td>Power supply synchronous SSB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Main signal 4CH Sub-signal 2CH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSK digital signal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pilot</td>
<td>60Hz, 100V</td>
</tr>
<tr>
<td>8</td>
<td>Output power</td>
<td>For each signal 40dBm</td>
</tr>
<tr>
<td>9</td>
<td>Input power</td>
<td>0dBm</td>
</tr>
<tr>
<td>10</td>
<td>Power supply</td>
<td>24VDC and 100VDC</td>
</tr>
</tbody>
</table>

### 6 Update switching

The new ATP equipment and the current ATP equipment are switched without stopping the operation of the Shinkansen as the following procedure.

1. Replace the impedance bond (IB) and the matching transformer (MT2) of the site to those of the new model.

2. Update the cables.

3. Subsequently, install the new ATP equipment concurrently. Test and verify the switching of the new equipment and old equipment during nighttime when no train operation is performed.

4. When all the tests are completed, switch simultaneously.

Figure 7 shows the image of switching.

### 7 Conclusion

In the present situation where many types of vehicles are running on the Tokaido Shinkansen, the track operational efficiency is deteriorating. The installation of new ATP equipment is inevitable to recover the efficiency. In order to realize this, ATP equipment has been developed out for a long time. In the future, we may encounter a difficult problem in installation such as live line construction. However, we will make the utmost effort to build safe and comfortable Shinkansens by overcoming each difficulty.

Finally, we would like to express our gratitude to the people who supported us for this development.
Present ATP equipment

New ATP equipment

Figure 7: Images of the switching circuit

Reference