Introduction of the Network Signaling to the Keiyo Line

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JR East is introducing the network signaling system to the Keiyo line as a project to simplify and integrate the signaling facilities of the Keiyo line. This system is developed to reduce the laying, wiring and connection tests of signal cables, and to prevent service disruption caused by installation errors. The system for station yards has been put into practical use at Ichikawaōno station of the Musashino line. Development of the network signaling system for automatic block sections was also completed, and monitor run tests have been carried out to verify the system's long-term operability in preparation for its practical use. Since the tests have finished in success, installation of both systems for station yards and automatic block sections is being planned. This article gives an overview of the project and the various evaluation tests that have been conducted to prepare for the introduction of the network signaling system to the Keiyo line.

1. Overview of the project to simplify and integrate signaling facilities of the Keiyo line

Many of the electronic interlocking equipment and ATS-P equipment of the Keiyo line have been in use for over twenty years. In conjunction with the replacement of the obstacle one, the equipment will be upgraded and the signaling facilities will be improved to facilitate future transport.

In concert with the replacement of obsolete equipment, the network signaling system will be introduced. The network signaling system (Type 303 electronic interlocking frame) for station yards will be installed at Shin-Narashino station (including the Keiyo car maintenance center) and Soga station, where there are many routes. The conventional Type 602 electronic interlocking frame will be installed at the other stations where there are fewer routes. In addition, the network signaling system for automatic block sections will be installed throughout the entire 43-km section between Tokyo and Soga (Fig. 1).

The replacement process will be in phases, starting with the phasing out of obsolete interlocking equipment and replacement with new one at station yards in FY 2012, followed by upgrading to the Network signaling system for automatic block sections and revamping of station yards to improve transport. The Keiyo line will be divided into five sections for installation of the network signaling system for automatic block sections. The installation will be carried out in phases and is scheduled to complete by March 2016.

2. Overview of the network signaling system

Currently signal cables (metal) are laid from a signal house to signals on site. The signals, track circuits, and electric switches in station yards are controlled by voltage. Therefore, when installation works are carried out to add transport capacity or to replace obsolete equipment, considerable amount of cables have to be laid from a signal house to signals on site. Connection tests have to be conducted to verify if the cables are laid correctly. Thus, the installation and testing of connection require a long work period. Large scale replacement, such as upgrading of the interlocking equipment in a station yard with many routes, becomes very complicated. Installation error is one of the reasons causing service disruption.

The network signaling system was developed to resolve these issues and to achieve steady transport.

Benefits from introduction of the network signaling system and an overview of the system are given below.

① Increase reliability by using duplex configuration (including cables)
② Reduce the laying and wiring of cables
③ Prevent service disruption caused by installation errors

This system uses optical cables to connect the control equipment in a signal house with facilities on site. It controls facilities on site by using an IP (Internet Protocol) network to transmit information. The logic units are installed in a signal house. They control the signaling equipment via a passive optical network (PON), which is the optical transmission part, and a field controller (FC), which is embedded in the signal on site or attach to it (Fig. 2). The system for a station yard was introduced to Ichikawaōno station of the Musashino line in February 2007. It has been operating steadily ever since.

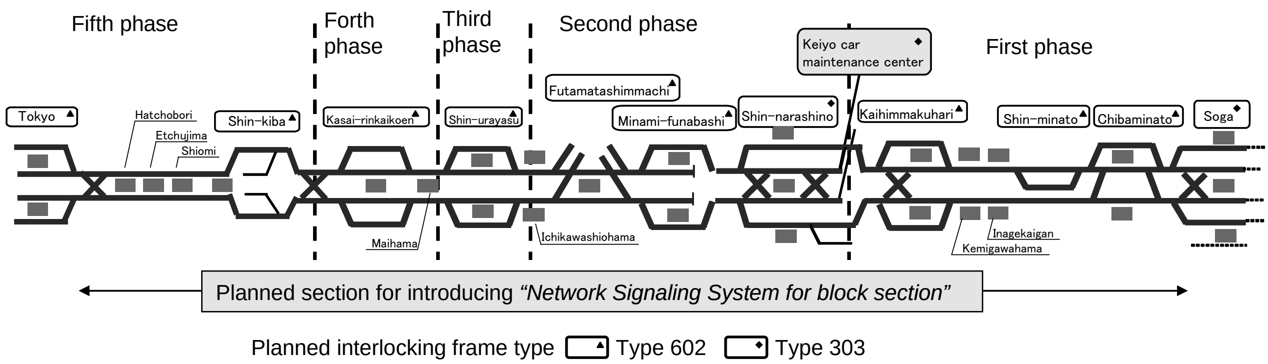

Fig. 1 General description of the network signaling system for the Keiyo line

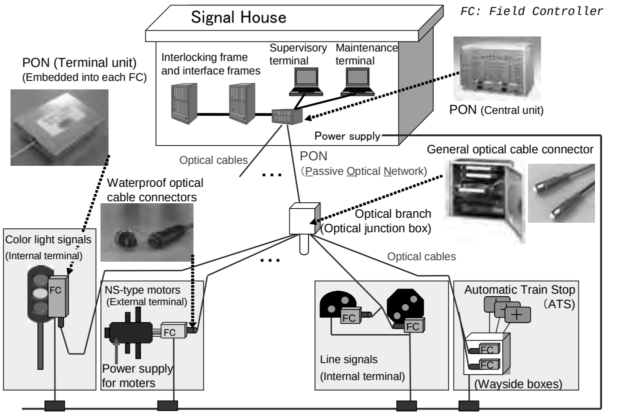

Fig. 2 System configuration of the network signaling system for station yards

3. Developments of the network signaling for the Keiyo line

The following developments have been conducted to prepare for the introduction of the network signaling system to the Keiyo line:

(1) Improvement of the network signaling system for station yards

1) Increase of facilities controlled by the network signaling

The network signaling controls signals by transmitting information over optical cables, therefore, the larger the number of signals to control, the greater the relative cable reduction effect. Ichikawaōno station uses color light signals, switches, and ATS control. Besides these devices, the Keiyo line also uses position light signals (repeating signal, shunting signal) for control (Table 1).

Table 1 Implementation type of FCs

Implementation type	Applied field devices
Embedded into signals	Color light signals
	Shunting signals
	Repeating signals
External	General use (Can be applied to ATS-S, which will not be used in the Keiyo line)
	Motors

2) Route/rail indicator control

The rail indicator-type shunting signs (rail indicator) and route indicators require many signal cables. The introduction of the network signaling has tremendous cable reduction effect. The FC embedded in the main signal (color light signal/shunting signal) of a multi-route indicator/route indicator (2-route indictor/3-route indicator) uses RS-485 interface to control the indicator. Since the indicator can be controlled by simply mounting an additional RS-485 board to the FC embedded in the main signal, this can achieve considerable cost reduction compared to the installation of another FC to the indicator. The rail indicator does not have a main signal unit; therefore, the indicator is controlled by a FC for rail indication (Fig. 3).

(2) Development of the network signaling system for automatic block sections

The network control technology developed for the station yard system was applied to the control of signaling facilities between stations, leading to the development of the "network signaling system for automatic block sections." An overview of the system is given below (Fig. 4).

① All the control logics for the block signals, track circuits, ATS-P, and so on are consolidated in one logic controller for automatic block sections, which is installed in the signal house.

② Since the on-site facilities are dispersed throughout a station yard, a FC used to be installed to each piece of the equipment. However, because many Network signaling facilities are consolidated by block signal, it is sufficient to just install a field controller for automatic block sections next to a block signal for the control of all signaling facilities.

③ Similar to the network signaling system for a station yard, the transmission between the logic controller and the field controller for automatic block sections is via a PON. The transmission procedure is also the same. An optical cable from the signal house is connected to an optical branch in an optical junction box set up next to the block signal where it is branched out to the field controllers for automatic block sections.

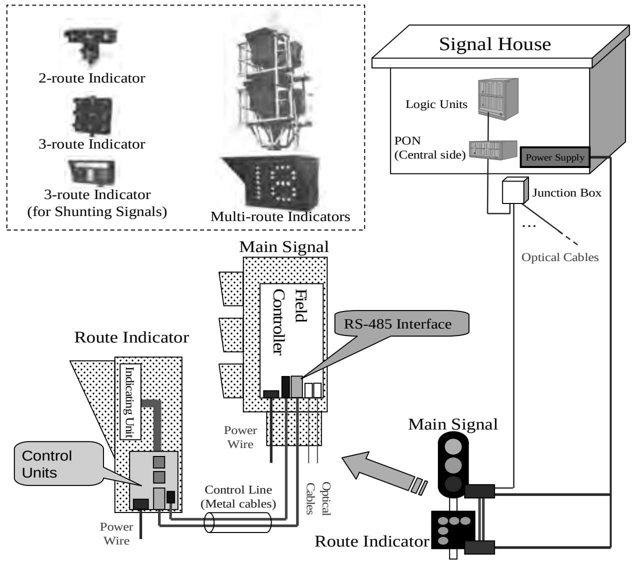

Fig. 3 Configuration of a signal with route indicator

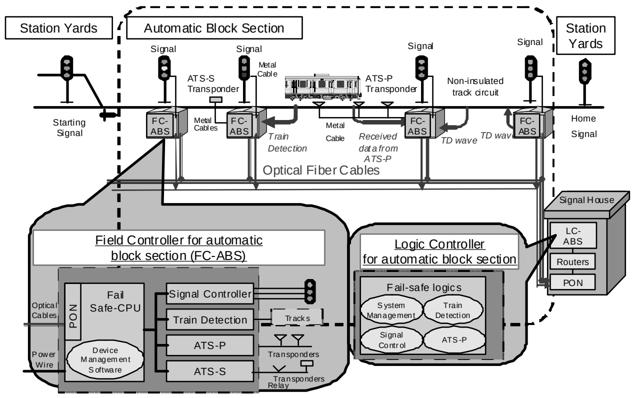

Fig. 4 System configuration of the network signaling system for an automatic block section

4. Validation before Introduction to the Keiyo line

The products developed so far were validated and assessed to prepare for the introduction of the network signaling to the Keiyo line.

(1) Monitor run tests of the network signaling system for automatic block sections

A prototype system was set up between Chibaminato station and Soga station of the Keiyo line in order to evaluate the control, transmission, and other functions as well as the reliability and environmental resistance of the network signaling system for automatic block sections for long-term operation in the actual environment. Monitor run tests were conducted from December

2009 to January 2011. The conditions of a station yard signals for the interlocking equipment at Chibaminato station were inputted via a field controller for automatic block sections to create the configuration for controlling the block signals, repeating signals, and ATS-P of two blocks based on the detection conditions of a non-insulated track circuit, which duplicated the existing track circuit. Two units of the logic controller for automatic block sections, each from a different manufacturer, were installed (Fig. 5).

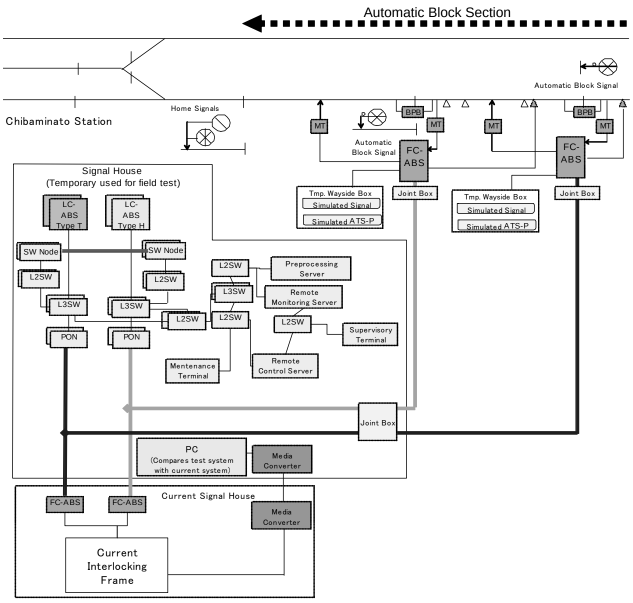

Fig. 5 System configurations for field test

1) Evaluation for long-term reliability

To validate accuracy of the system's control, the system's control timing of trains operating in the test section during the monitor run test period was compared with that of the existing equipment. The result confirmed that the logic processing of the logic controller for automatic block sections was consistent with the current control. Furthermore, there were no incidents requiring control of unsafe conditions or stopping of the control systems of the logic controller and field controller. (The operation rate of the control units was 100 %.)

2) Evaluation of environmental resistance

As almost the entire Keiyo line is on elevated tracks, the vibration is expected to be more severe than a ground section. For this test, evaluation was conducted by installing two field controllers for automatic block sections in an elevated section (Fig. 6). Throughout the test period, the field controller had not stopped working due to vibration, temperature, electromagnetic noise, or other external causes. The temperatures measured inside the container of the field controller in the summer are shown below.

➢Temperatures inside the container of the field controller for automatic block sections were measured between July 24, 2010 and September 17, 2010.

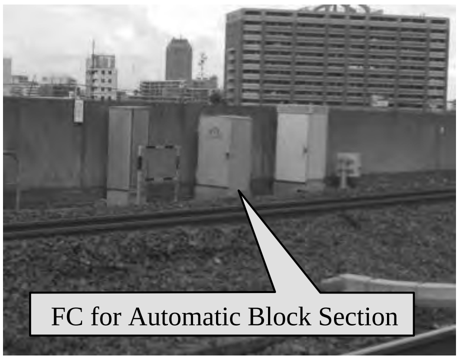

Fig. 6 Installation of FC-ABS on the wayside of elevated tracks

➢Relative to the weather data (highest) of 35.9ºC, temperature inside one field controller for automatic block sections was 53.1ºC on August 16 at 15:03 (Fig. 7) and 52.3ºC on another on August 16 at 15:05. Since the temperature inside the container of the field controller for automatic block sections was less than the specification's 60ºC, it did not reach the upper temperature limit even in the summer.

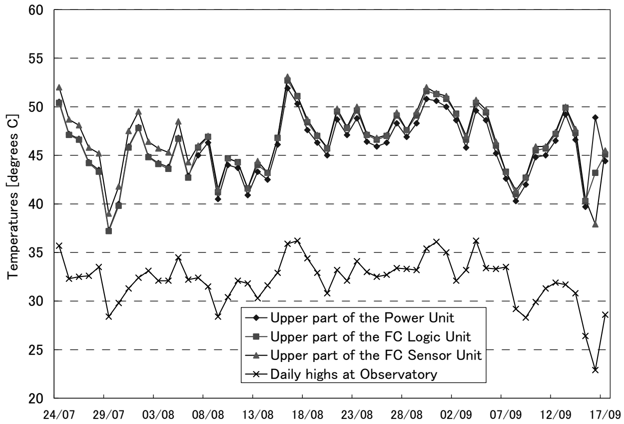

Fig. 7 Result of measured temperatures inside FC-ABS throughout 2010 summer.

(2) Marginal vibration tests of FC embedded in the signal

It has been confirmed in type approval that the field controller embedded in the network signal for station yard meets the vibration conditions prescribed in the Japanese Industrial Standards (JIS-E3014 Type 2 [1G]). However, it was a question if the field controller could sustain the actual severe vibration at elevated tracks, tunnels, and bridges. Therefore, a vibration-overload test and comparison with on-site vibration conditions were carried out to find out if the signals for the network signaling will need to have additional vibration-proof measures and whether there are any weak spots. The test result indicated that the signal itself was damaged even before reaching the point where the field controller stopped control, showing that the physical structure of the signal was the weak spot (Table 2).

Table 2 Result of marginal vibration tests

Type \ Direction	Vibrating direction and acceleration X (right and left)	Y(back and forth)	Z(up and down)
Repeating Signal	Signal corruption 2.0G	Signal corruption 1.0G	Signal corruption 2.0G
	Become nonfunctional Over 2.0G	Become nonfunctional Over 1.0G	Become nonfunctional Over 2.0G
Shanting Signal	Signal corruption 2.0G	Signal corruption 1.0G	Signal corruption 1.5G
	Become nonfunctional Over 2.0G	Become nonfunctional Over 1.0G	Become nonfunctional Over 1.5G
Multiple Route Indicator	Signal corruption 2.0G	Signal corruption 2.0G	Signal corruption 2.0G
	Become nonfunctional Over 2.0G	Become nonfunctional Over 2.0G	Become nonfunctional Over 2.0G
Color Light Signal	Signal corruption 1.5G	Signal corruption 1.0G	Signal corruption 2.5G
	Become nonfunctional 1.5G	Become nonfunctional 1.0G	Become nonfunctional Over 2.5G

1) Observation on the need to enhance vibration resistance

A review was conducted to determine if it would be necessary to enhance the vibration resistance of the signal structure for the network signals used for the elevated track sections. The vibration data measured from a conventional color light signal (elevated track at Kinshicho station: suspension type, no vibration-proof fitting), JIS specification (JIS-E-3014 Type 2), and the marginal vibration test results were compared (Table 3). In the JIS standard, the test uses 1 [Gp-p] for the X (right and left), Y (back and forth), and Z (up and down) directions. Relative to the on-site vibration conditions, the X direction has approximately 9 times, the Y direction 3 times, and the Z direction 1.1 times of resistance to vibration acceleration. In comparison with the marginal vibration results, the X direction has approximately 13.6 times, the Y direction 3 times, and the Z direction 2.9 times of resistance to vibration acceleration. Other signal structures also have resistance to vibration acceleration above the JIS standard. Consequently, it was concluded that no additional vibration-proof measures for the elevated track sections would be required.

Table 3 Comparison of measured data on site and prescribed value in JIS (Japanese Industry Standards) E3014 (Vibration test methods for parts used for railway signals)

	Measured data on site		JIS E 3014 Type 2	Marginal vibration test
	Signal [Gp-p]	Pole [Gp-p]	Pole [Gp-p]	Pole [Gp-p]
X-direction	0.6	0.11	1	1.5
Y-direction	2.6	0.35	1	1
Z-direction	3.6	0.86	1	2.5

2) Countermeasures for weak spots

From the implementation of these tests, it was found that the screws and fittings of the signal were the weak spots, which had limited tolerance to vibration. Although the signal of the network signaling itself has sufficient vibration resistance to the on-site vibration conditions, it is necessary to make improvement to enhance the sturdiness in the manufacture of the signals.

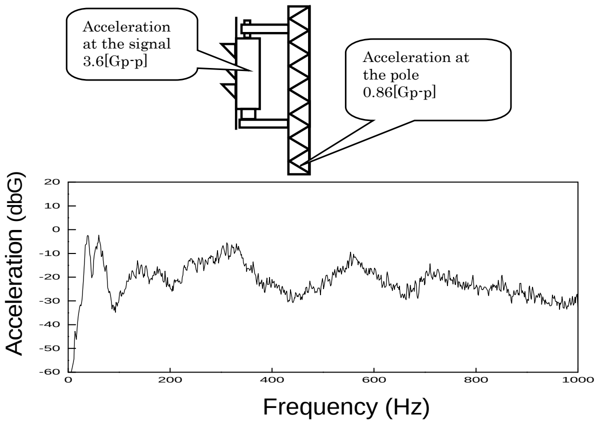

Fig. 8 Vibrational characteristics of a color light signal and its pole on site

6. Conclusion

This article gave an overview of the project to simplify and integrate the signaling facilities of the Keiyo line and explained the development and test results for their application to the Keiyo line. We will continue to pursue safe and reliable transport as the top priority of the project, resolve issues throughout the installation phase, accumulate new technology and know-how, make the tests more efficient, cut cost, and make further improvements to the network signaling system so as to expand its application to other line sections.

Reference

Yoshiyuki HIRANO, Takashi KUNIFUJI, Noboru HIURA "Developing the network signaling system for practical use," JREA, 49, No. 5 (2006)

NEWS

○ **Appeal on Advanced Shinkansen Technology in High Speed Rail Seminar held in India**

High Speed Rail Seminar was held in Delhi, India on 13th January, 2012 in order to promote Japanese railway technologies overseas hosted by Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Council for Global Promotion of Railway, and others. At the seminar, Mr. Satoshi SEINO, President of JR East, Mr. Tsutomu MORIMURA, Senior Executive Director of JR Central, etc. made their presentations and stated strongly of the high technologies and safety of Shinkansen.

Among Japanese participants, there were attended Mr. Takashi KITAMURA Assistant Vice - Minister for MLIT, and Mr. Akitaka SAIKI, Japanese Ambassador to India. On the Indian side, Mr. Trivedi, Minister of Railways and Mr. Mittal, Chairman of Indian Railways were present themselves among many high ranking governmental and national railways officers. With a good discussion in the seminar the attendees well understood the future realization of high speed railways in India.

President SEINO mentioned on the management of JR East, effective operation and economical effect of Shinkansen, upgrading the facilities of Tokyo station as a central terminal, and then on the running features with noise protection mechanism of the newly developed series E5 cars, which have been running on the Tohoku Shinkansen line since its full service started last March.

He also stated the disaster protection measures taken on Shinkansen, and especially, explained the urgent earthquake detection system and supplemental anti-earthquake work for electric poles installed on its elevated infrastructures. Because of these protective measures he strongly commented that Shinkansen has been running in safe condition, resulting in no dead or injured passenger at the Great East Japan Earthquake happened last year.

He reported at the end of his presentation that a new consulting company named "Japan International Consultants for Transportation Co., Ltd." was established in November 2011 with such companies as JR West, Tokyo Metro, JR Kyushu, JR Freight, Tokyo Express Railway and Keihan Electric Railway. He emphasized, "This company will be able to support any of the railway projects covering from railway planning to its actual operation".

Mr. MORIMURA of JR Central showed their experience and implementation of the Tokaido Shinkansen since its inauguration to the present, and introduced the total high speed railway management system, "N 700-1 Bullet", which has been composed based on their experience and expertise, and proposed for oversea use. He added that any of the high speed railways needs to be controlled by the total management system and that the Tokaido Shinkansen has been managed to run safely and keep on time performance by their system. He commented further, "N700-1 Bullet will accommodate to mass transport, and help save energy and cost".

○ **Agreement was reached to establish an official consultative organization for planning Indian high speed railways**

Mr. Takeshi MAEDA, Minister of MLIT, reported on the visit to India from 11th January at the interview held after the Cabinet meeting.

His visit was aimed to promote Japanese high speed railway technology for use in India. Though he could not make him participate in the High Speed Rail Seminar held in Delhi on 13th January, he communicated very energetically on the 12th with the top officials of railways, maritime, and roads administrations of Indian government. He made an agreement to set up a high level consultative organization between India and Japan to talk about the Japanese cooperation in planning high speed railways in India. At the meeting with Mr. Trivedi, Minister of Railways, and Mr. Aggarwal, Vice Chairman of CII Railway Equipment Division, they showed him the Concept of High Speed Railway Construction Project, the investment for which will exceed the double amount of the one presently invested for 12th 5 year railway project, and they requested the Japanese support for the conceptual project. The Indian minister showed interests not only in the Japanese technologies but also in the renovation process of the Japanese National Railways into the newly born JR Groups. He then asked the Japanese support not only for the hardware side, but for such software side as efficient railway management and operation, etc.

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