A New Signaling System Applying Information Technology

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OVERVIEW: The primary role of a signaling system is to ensure the safe and stable running of trains. There is also a great need, however, for improving the efficiency of railway operations and reducing the maintenance cost through the modernization of signaling systems. One approach to meeting these needs is a highly safe and highly functional signaling system using general-purpose computers. Hitachi, Ltd. is at the forefront of the trend toward generalized signaling systems through its development of "electronic interlocking devices for flexible composition." Hitachi is also working to modernize the entire signaling system by applying general-purpose computer technology and latest information technology to electronic terminals, level crossing controllers, and fail-safe transmission equipment. In the years to come, Hitachi will continue its efforts in developing modern signaling systems appropriate for the needs of the 21st century. As a total system integrator, Hitachi aims to achieve a total railway system that can make a contribution to the entire railway industry.

INTRODUCTION

AS a total system integrator for railway systems, Hitachi, Ltd. works to provide signaling systems that can improve the efficiency of railway operations. To promote its business efforts in this regard, Hitachi has adopted the slogan "modern signaling systems for the 21st century." Hitachi's overall goal is to achieve a total railway system that can contribute to the advancement of the entire railway industry (see Fig. 1).

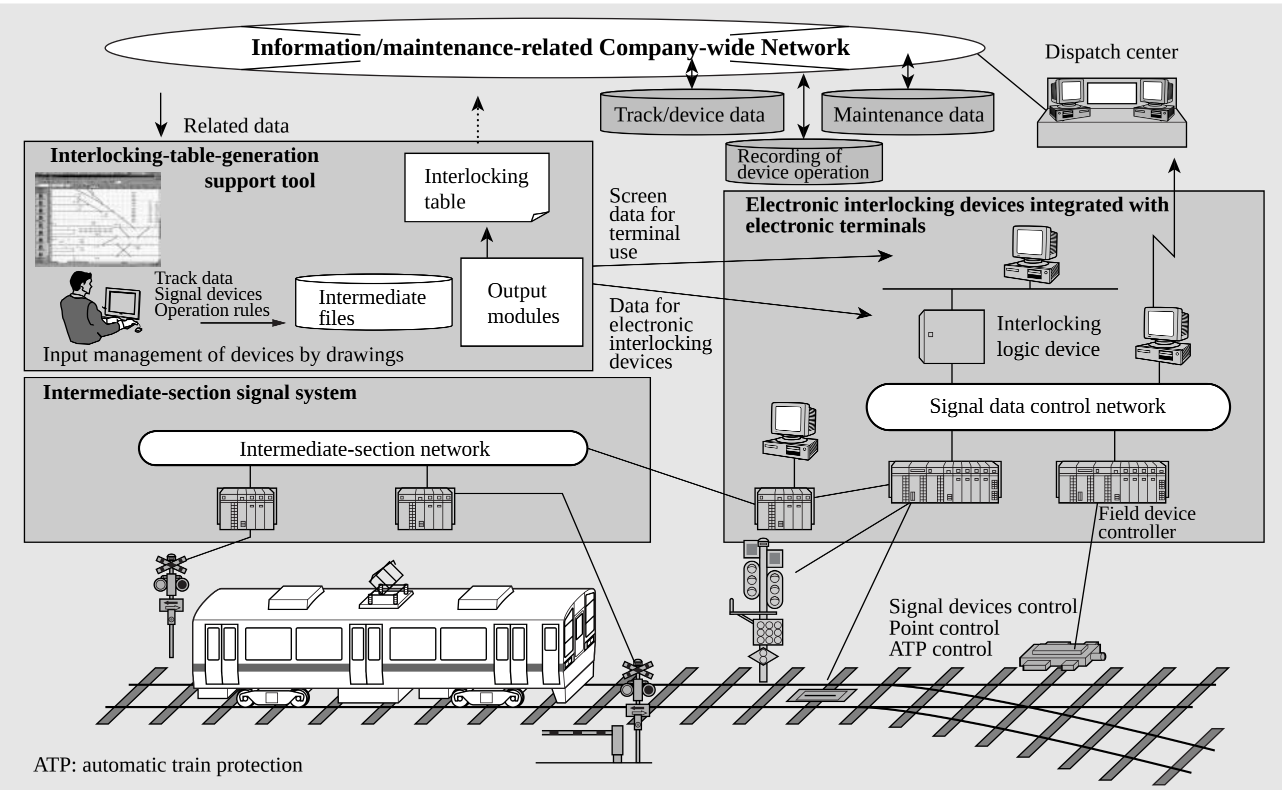

Fig. 1— Concept of a New Signaling System for More Efficient Railway Operations.
Hitachi proposes a new signaling system to solve a variety of problems affecting railway-signaling systems. The new system provides an interlocking-table-generation support tool for rear support, electronic interlocking devices integrated with electronic terminals for station control, and an intermediate-section signal system for the interval between train stations.

It has been ten years since Hitachi began delivering electronic interlocking devices for flexible composition. At present, Hitachi has an extensive lineup of electronic interlocking devices suitable for a wide variety of train stations. All of these devices utilize general-purpose computers and adhere to high levels of safety, maintainability, and functionality.

This paper reports on several key elements of Hitachi's modern signaling systems. These are new electronic interlocking devices integrated with electronic terminals, an intermediate-section signal system that improves maintainability and other characteristics of inter-station signal devices, and a tool to support making out interlocking tables, which were made by experts in the past.

FEATURES OF ELECTRONIC INTERLOCKING DEVICES FOR FLEXIBLE COMPOSITION

Hitachi's electronic interlocking devices for flexible composition have the following features all centered about the use of general-purpose computers.

(1) Interlocking with a built-in interlocking table

This is a new form of control logic in which an interlocking table is input into an interlocking-data-generation system (IDS) and control is performed using converted data. In this approach, standard control logic and station-specific control data are separated, which makes it possible to shorten the time required to develop interlocking devices for new train stations and to perform interlocking rebuilding.

(2) Remote maintenance information gathering

This function gathers maintenance information in a remote manner by connecting with interlocking devices from a control center via a network, telephone lines or other means. This makes it possible to perform fault analysis quickly and to achieve fault restoration in a short period of time.

(3) Powerful functions

A maintenance-management function manages the start and the end of track possessions and performs route setting of maintenance vehicles. There is also a control function for station yard crossings.

ELECTRONIC INTERLOCKING DEVICES INTEGRATED WITH ELECTRONIC TERMINALS

The Need for Electronic Interlocking Devices Integrated with Electronic Terminals

In the past, Hitachi's electronic interlocking devices for flexible composition and electronic terminals were manufactured as separate equipment, and the manufacturers of these two types of equipment were even different. This made it necessary to implement fail-safe measures separately for each type of equipment. In addition, interlocking devices and electronic terminals were connected by serial-transmission methods that necessitated redundant functions and equipment to ensure fail-safe properties. This waste of resources became a hindrance to improving responsiveness and lowering costs. Due to the fact, moreover, that electronic terminals were manufactured on the basis of circuit diagrams, new circuit diagrams had to be created when upgrading such equipment.

In response to these problems, the need arose for electronic terminals to adopt a scheme that allows input of control tables through the use of general-purpose computers, the same as for electronic interlocking devices.

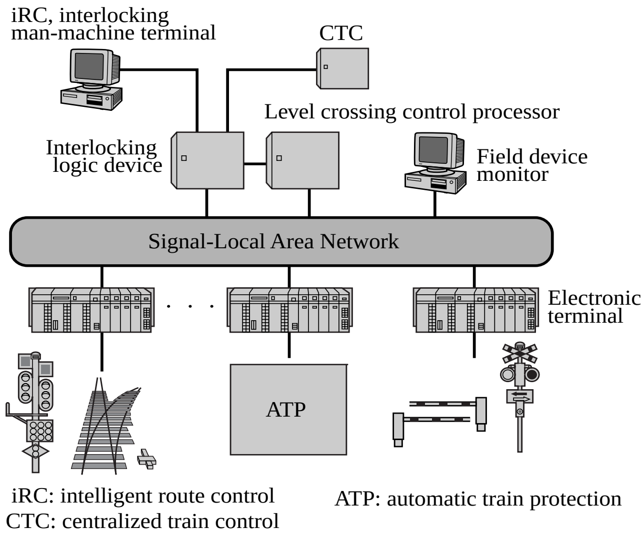

Fig. 2— Configuration of Electronic Interlocking Devices Integrated with Electronic Terminals.
Interlocking logic devices and electronic terminals interconnect over a signal-data control network to directly control field devices like signals and level crossings.

Features of Electronic Interlocking Devices Integrated with Electronic Terminals

In the case of electronic interlocking devices integrated with electronic terminals, there is no interface equipment between interlocking devices and electronic terminals as in the past—interlocking devices directly control electronic terminals. This configuration improves control responsiveness (Fig. 2).

Furthermore, as in the case of electronic interlocking devices for flexible composition, control data is not created from circuit diagrams but rather by direct input of simple description formats like control tables and device lists. This enables the construction and testing of new train stations to be completed in a relatively short time.

Functions of Electronic Interlocking Devices Integrated with Electronic Terminals

These devices include signal controller units that directly control signal lamps, point control units, and fail-safe input/output contact units that enable field devices to be directly controlled.

They also possess logic associated with automatic train protection (ATP). Input of ATP control logic makes it possible to output ATP cut conditions and others.

Station Yard Crossing Control in Electronic Interlocking Integrated with Electronic Terminals

The control of station yard crossing in electronic interlocking integrated with electronic terminals is achieved by a level crossing controller that incorporates control equipment and connects with interlocking devices by serial transmission. In this way, the results of pursuit tracking by interlocking devices can be used to achieve highly secure crossing control.

The level crossing controller connects directly with electronic terminals so that crossing control can continue and unnecessary crossing warnings can be suppressed even when interlocking devices have been shut down due to maintenance or abnormalities.

INTERMEDIATE-SECTION SIGNAL SYSTEM

Environment Surrounding Intermediate-section Signal Devices

Signal devices set up in the intermediate section between train stations cover a broad range of equipment such as signals and level crossings, and the time taken for restoring faults and conducting inspections and maintenance has, as a consequence, been excessive. In addition, a huge amount of cable must be laid in this intermediate section since control devices like signals and level crossings must be controlled and the distance between such devices is long.

Against this background, the need has grown stronger for an intermediate-section signal system that can shorten the time for restoring faults and conducting inspections and maintenance and that can reduce the amount of cable in the field.

Intermediate-section Signaling Network and Remote Monitoring Terminals

The proposed system lays a high-speed network in the intermediate section, deploys transmission equipment having digital-input/digital-output (DI/DO) interfaces, and gathers status information on signal devices via this equipment. Information collected in this way is continuously surveyed on monitoring terminals situated at a dispatch center. These monitors can display the track status of trains and the control status of signals and level crossings. They can also indicate the location of a fault and perform remote device resets and other functions (Fig. 3).

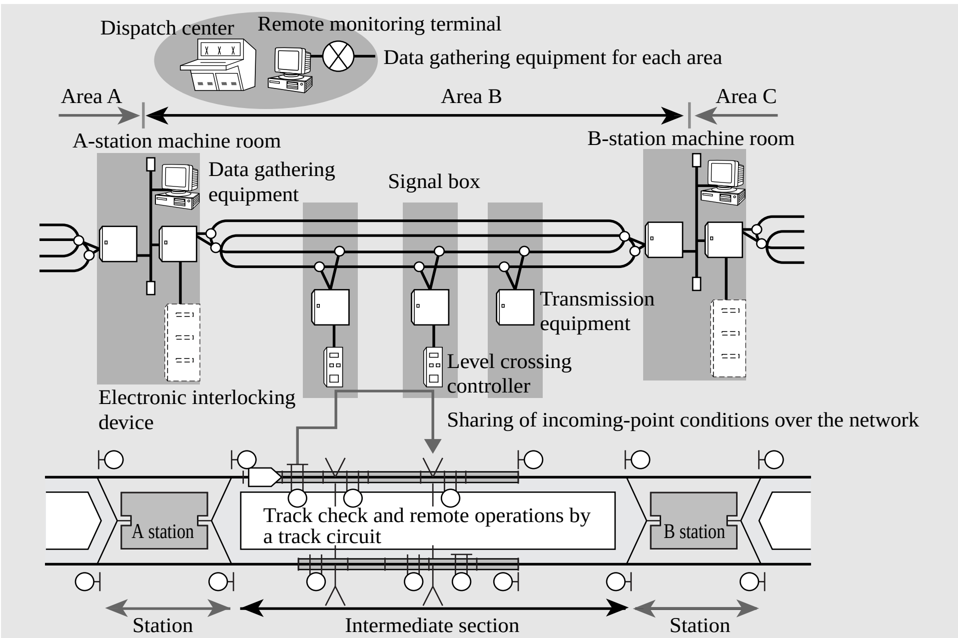

Fig. 3— Overview of Intermediate-section Signal System.
The system features a high-speed optical network in the intermediate section to gather data from signal devices like signals and level crossings. This data is used to reset devices and monitor the entire system from remote monitoring terminals.

Network-compatible, Intermediate-section Level Crossing Controller

A level crossing controller determines the incoming/outgoing status of a train through the use of a short track circuit of train detectors. Because this status can be gathered over the network, the amount of cable from train detectors to level crossing controllers can be reduced. Furthermore, for the case in which multiple level crossing controllers share a train detector, cable to each controller becomes unnecessary and the amount of cable can be drastically reduced. In the case of performing level crossing control by train detectors, the fear in the past was that a crossing gate fault could occur if level crossing controllers were booted up while a train was situated between incoming and outgoing points. Level crossing controllers connected in a network, however, not only process information on train detectors but on the track circuit as well enabling correct track status of a train to be determined within the control interval. This, in turn, makes it possible to boot up control equipment from a remote monitoring terminal. There is consequently no need to go out into the field to conduct a reboot when, for example, transient noise from lightning shuts down the equipment.

INTERLOCKING-TABLE-GENERATION SUPPORT TOOL

The Need for a Support Tool

To create data used by electronic interlocking devices, the present approach is for an expert in signaling to analyze the interlocking table prepared by the railway company and to create an interlocking-device data table that can be converted to final data by IDS. This work, however, requires much labor and time, and is heavily dependent on expert know-how. These factors impose severe limitations in the process of implementing or upgrading electronic interlocking devices. To solve this problem, Hitachi is now developing an interlocking-table-generation support tool (referred to below as simply “support tool”). The configuration and features of this support tool are described below.

Support Tool Configuration

The support tool consists of the following three modules.

(1) Data input interface for track configuration and signal devices
(2) Interlocking-logic data-generation module
(3) Interlocking-table data-output module

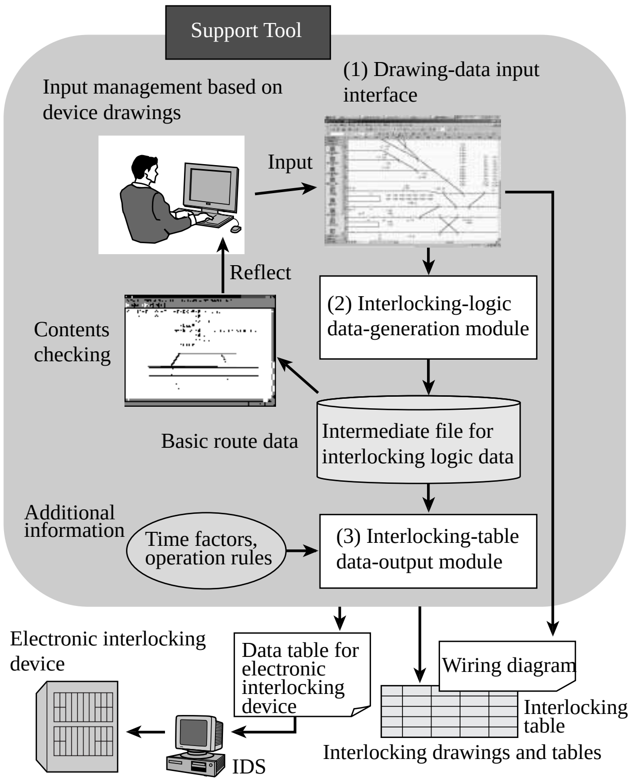

Fig. 4— Interlocking Table Generation and Data Generation Flow Using the Interlocking-table-generation Support Tool.
The support tool provides for centralized management of interlocking-table generation to raise productivity and simplify maintenance and upgrading.

Fig. 4 shows the data generation procedure for electronic interlocking devices which uses the support tool.

To generate a new interlocking table, the first step is to input track configuration and the arrangement of signal devices in drawing form using the input interface shown in step (1) in Fig. 4. Here, the user can easily make a drawing by simply arranging components and track patterns provided by the input interface.

The interlocking-logic data-generation module then extracts route configuration, signal conditions, etc., from drawing data and device-related attributes and automatically generates basic interlocking logic [step (2) in Fig. 4]. Next, to obtain information that could not be ascertained simply on the basis of the drawing, the user is asked to make selections interactively from a set of displayed choices. Interlocking logic data generated in the above way will be saved in an intermediate file that includes general information.

Furthermore, as user-generated interlocking logic can be confirmed interactively, it can be easily reflected simultaneously on the data input interface shown in step (1) of Fig. 4.

The interlocking-table data-output module outputs an interlocking table, a data-table format for device use, etc., from the intermediate file according to the purpose at hand.

Features of Support Tool

The support tool provides the following features for generating interlocking tables.

(1) Automatic processes

The extraction and verification of various kinds of data related to interlocking logic processes are now automated. In conventional way, these processes had relied on manual operation. These include extraction and verification of the relation among routes, track circuits, and switches, verification of interaction among multiple routes, and checking of intervals and fouling-point positions while taking overrunning into account.

(2) Consistent data management

The support tool enables to manage interlocking data derived from drawings as consistent digital data. Data related to interlocking rebuilding can also be easily updated.

(3) Application of data to peripheral equipment

Drawing data can be easily applied to various kinds of screen data for interlocking devices thereby raising the productivity of systems peripheral to interlocking devices.

(4) Improvement of table generation

The support tool can be applied to project planning or prior evaluation when introducing new interlocking devices. It can also be used in interlocking rebuilding from the planning stage to trial-and-error operations, resulting in improved productivity.

Future Issues

In future development work, we plan to enhance functions to work more efficiently with various kinds of data (interlocking table, CAD drawings, track-pattern data, etc.) related to the data generation for interlocking devices and to make the support tool even more convenient to use.

CONCLUSIONS

This paper has described electronic interlocking devices integrated with electronic terminals, intermediate-section transmission equipment, and an interlocking-table-generation support system utilizing advanced technologies in system control.

As a total system integrator for railways, Hitachi will continue to apply advanced technologies in the development of signaling systems for the 21st century to meet the need for safety, reliability, extendibility and reduced recycling costs in railway systems.

REFERENCE

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