Hitachi's Latest Supervisory and Control System for Advanced Combined Cycle Power Plants

Tsuyoshi Iijima
Katsunori Ouchi
Yoshio Maruyama
Satoru Nemoto

OVERVIEW: Hitachi's Integrated Autonomic Control System series of supervisory and control systems make extensive use of digital technology. By applying these systems to power plants, Hitachi has provided numerous systems that address the needs of electric power providers. Its latest model has achieved better controllability, maintainability and reliability by improving the controller processing capabilities and employing RTB (remote terminal block) and intelligent PI/O (process input and output device) with rewritable ROM (read only memory). In addition, the latest model is also able to adapt flexibly to trends toward the rationalization of facilities in Japan, and for the first time, it was applied to the supervisory and control system of an ACC (advanced combined cycle) power plant.

INTRODUCTION

RECENTLY, electric power providers in Japan are subject to strong demands for the supply of electrical power at a reasonable price. The same applies to the supervisory and control systems that perform the role of a power station's human interface. Meanwhile, developments in IT (information technology) have resulted in marked improvements to the software techniques used throughout supervisory and control systems, and to the hardware in which they operate.

Against this background, electric power providers need to respond actively to the rationalization of facilities while maintaining existing levels of performance by introducing new technologies.

Hitachi has proposed a wide variety of facility rationalization measures using the cutting-edge integrated autonomic control system.

The first application of Hitachi's integrated autonomic control system to a new ACC (advanced combined cycle) power plant was supervisory and control system at the Futtsu Thermal Power Station group No. 3 of the Tokyo Electric Power Co., Inc. This paper describes the configuration and characteristics of this system, and describes the rationalizations that were achieved at this facility as a result (see Fig. 1).

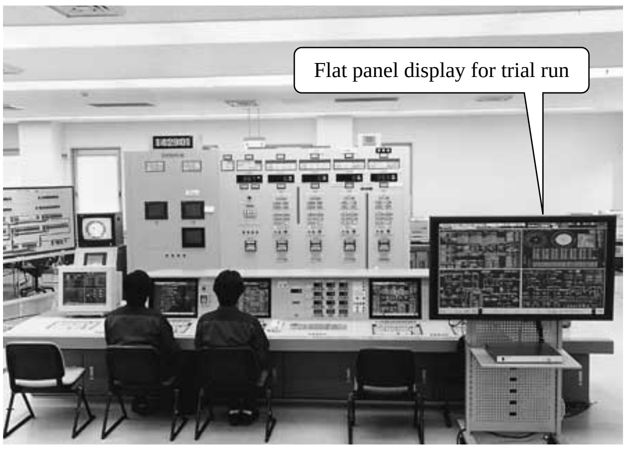

Fig. 1—The Central Control Room for the Futtsu Thermal Power Station Group No. 3 of the Tokyo Electric Power Co., Inc.
A simple and user-friendly interface is implemented through an efficient combination of four CRT consoles and a group supervisory panel.

ISSUES OF THE ADVANCED COMBINED CYCLE POWER PLANT'S SUPERVISORY AND CONTROL SYSTEM

The Futtsu Thermal Power Station group No. 3 of the Tokyo Electric Power Co., Inc. (abbreviated to "Futtsu 3" below) consists of four stages of 380-MW ACC power generation facilities using dry low-NO_x combustors. For construction of Futtsu 3, the supervisory and control system not only succeeded the basic system configuration of a conventional ACC power plant, but also aimed to arrive at a system that is able to exploit the characteristics of Hitachi's integrated autonomic control system for facility rationalization.

To make the system easier to maintain and more efficient without impairing its reliability or controllability, it was based on Hitachi's original

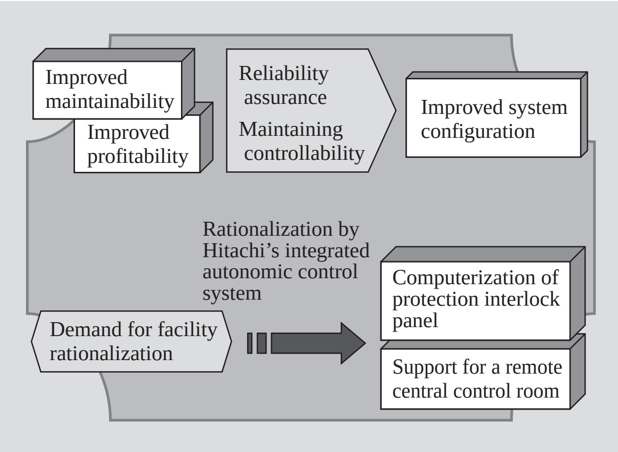

Fig. 2—System Configuration Issues.
New techniques have been introduced to rationalize the facility.

hierarchical autonomous distributed system and built by combining the latest hardware, such as PCM (programmable control module) and RTB, with ACC control techniques that have been already been perfected (see Fig. 2).

CONFIGURATION AND CHARACTERISTICS OF THE SUPERVISORY AND CONTROL SYSTEM

Stage Control Equipment

The stage control equipment of the ACC power plant controls the gas turbines, steam turbines, HRSGs (heat recovery steam generators), and various items of auxiliary equipment.

In Hitachi's integrated autonomic control system, the main controller of the primary control equipment is integrated by using the PCM and RTB, and the conventional hardware circuits are implemented in software. The principal characteristics of this system are as follows:

(1) The main controller that has main computational functions and communications with other equipment is provided with greater speed and capacity. The PCM is also speeded up (its processing speed is about 10 times faster than the main controller), and performs dispersed processing by digital computations. In this way, the number of main controllers has been reduced by about 30% compared with a conventional system.

(2) The RTB with signal conversion functions has been made more efficient and easier to maintain by cutting down to about 400 converters and about 3,000 buffer relays per stage.

Control Computer

The control computer cooperates with the stage control equipment, and is responsible for functions such as plant monitoring, computer automation, and CRT (cathode ray tube) operation. In a conventional system, these functions are shared with the group computer, the stage computer situated in each stage, and exclusive equipment for the CRT consoles accommodated in the group operating panel. In Futtsu 3, the functions hitherto assigned to the stage master computer can instead be performed by using a real-time control server for the control computer and

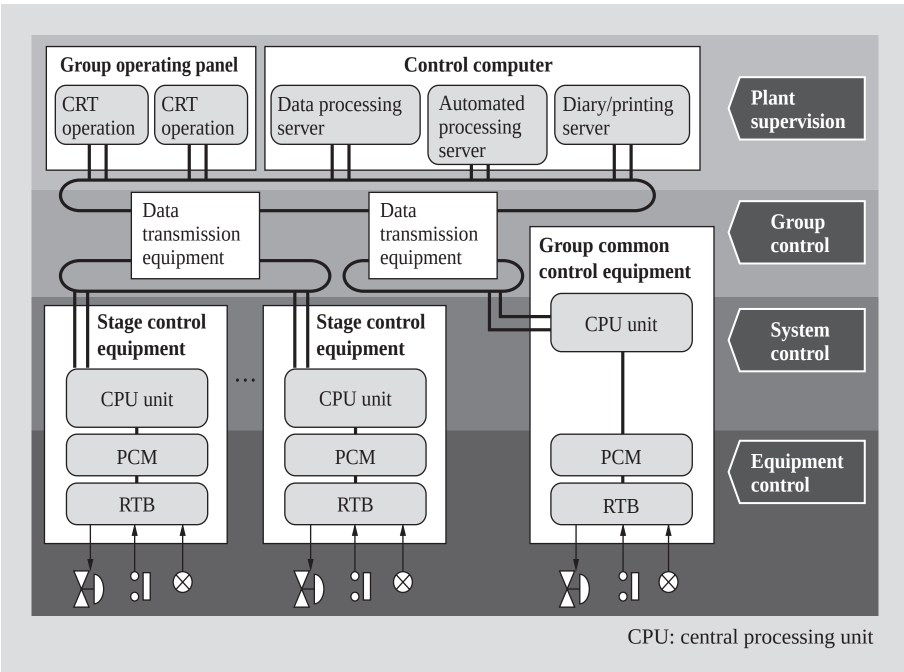

Fig. 3—Configuration of Main Control Equipment and Computers.
A suitable hierarchical configuration and functional distribution are implemented by Hitachi's integrated autonomic control system.

industrial personal computers for the CRT consoles. Also a duplex configuration was used only for the data processing system executing basic supervisory functions in the group computer, while a single configuration was used for the other functions. In this way, the total number of computers was reduced (see Fig. 3).

Network Configuration

The network in the ACC power plant consists of three systems: stage control, group common control, and group control. A conventional group network is divided into two parts: a supervisory network installed specifically to support CRT operations and the human interface, and a control network that connects the stage control equipment with the group common control equipment. In Hitachi's integrated autonomic control system, these networks are integrated into a single network based on fast high-capacity μ-Σ100 network technology. This makes the system easier to maintain by compacting what was previously two sets of data transmission equipment into just one set.

Since conventional networks use electrical signals to transfer data, it has been necessary to employ electro-optic conversion equipment when data needs to be carried over longer distances. Hitachi's latest model uses optical communication throughout, and thus it does not require any additional conversion equipment (see Fig. 4).

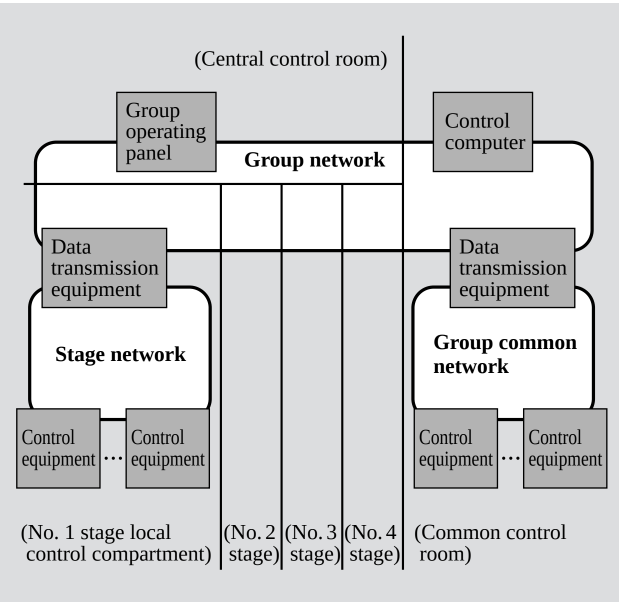

Fig. 4—Network Configuration.
The network configuration corresponding to the stage configuration is implemented by installing data transmission equipment (gateways) between the group network and stage networks.

FACILITY RATIONALIZATION

Computerizing the Protection Interlock Panel

The protection interlock panel — where all the circuits are hard-wired in a conventional system — was computerized by introducing a triple redundant PCM system. This not only reduces the number of components and the amount of wiring, but it also eliminates the analog circuits that had to be adjusted during every routine check, and can therefore be expected to greatly rationalize the maintenance work. The number of control panels is also reduced to 75% based on the conventional case, allowing the equipment to be installed in less space.

A protection interlock panel is essential for carrying out emergency stops when a fault has occurred in the running of the plant, and thus requires a very high level of reliability. To address this need, the interface circuits that detect trip factors are made triple redundant, while alarm circuits and test circuits that are not directly concerned with plant safety are digitally duplexed.

(1) Interface circuits

The interface circuits that process the plant's status input signals are computerized with a combination of PCM and RTB. The RTB is used for buffer processing of contact signals and signal conversion of analog signals, while the PCM is used to run software that makes judgements relating to protection levels and protection operation conditions.

This has the effect of making the system easier to maintain because the computation state inside the PCM can be monitored from the central control room by using maintenance tools for the control equipment.

(2) Alarm circuits and test circuits

Main controllers are used for the alarm circuits that perform fault monitoring and the test circuits that perform tripping valve test operations. In a conventional system, abnormal contacts are amplified by relays in the alarm circuits and transmitted to a computer by multicore cables, and the test circuits are configured with relays to provide interlock functions. In Futtsu 3, these functions are all implemented in software.

The introduction of a main controller makes it possible to use a network. By using communication cables to transmit alarm signals to the computer, the work associated with cable routing is made much easier. As with the interface circuits, this approach makes it possible to monitor the computation state with a maintenance tool (see Fig. 5).

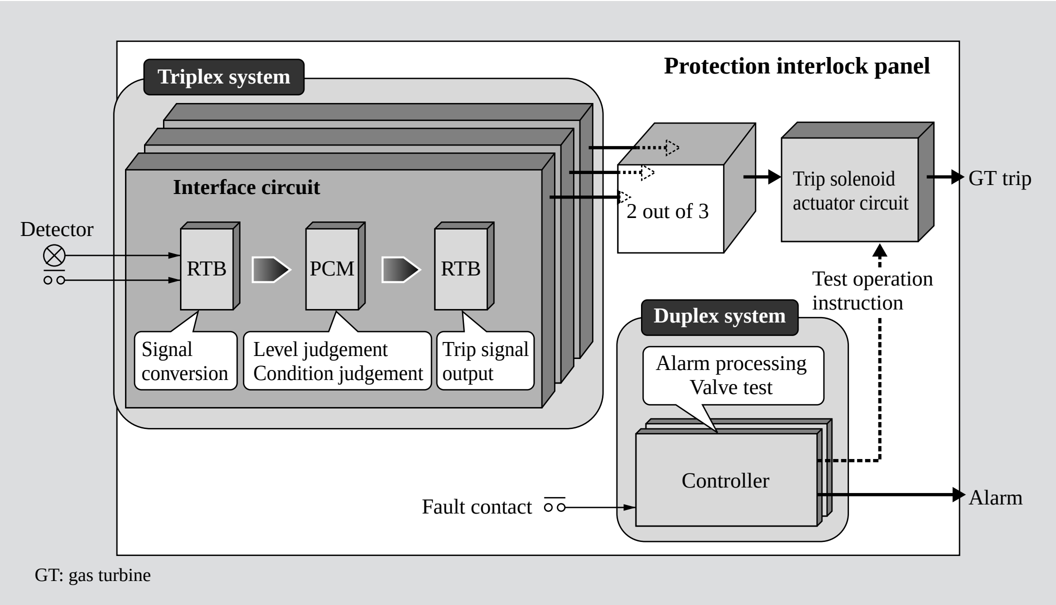

Fig. 5—Summary of the Protection Interlock Panel Computerization.
By using software wherever possible, the amount of wiring inside the panels and the number of panels were greatly reduced. The reliability of this system was also ensured by adding suitable degrees of redundancy where necessary.

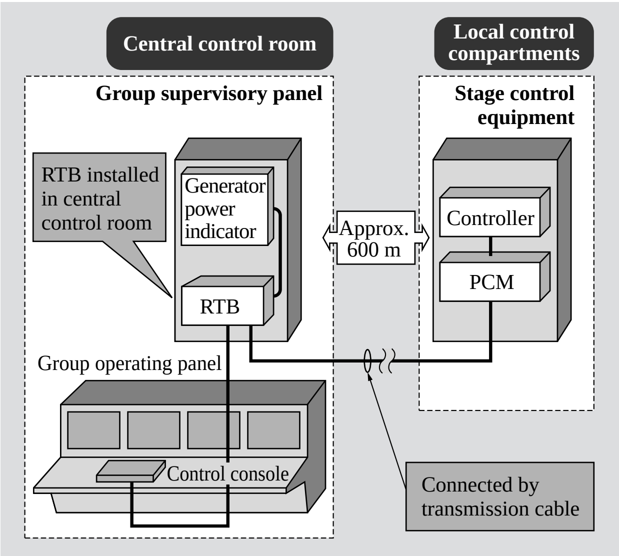

Fig. 6—Support for a Remote Central Control Room.
The number of cables was reduced by using serial communication between the central control room and the control compartments.

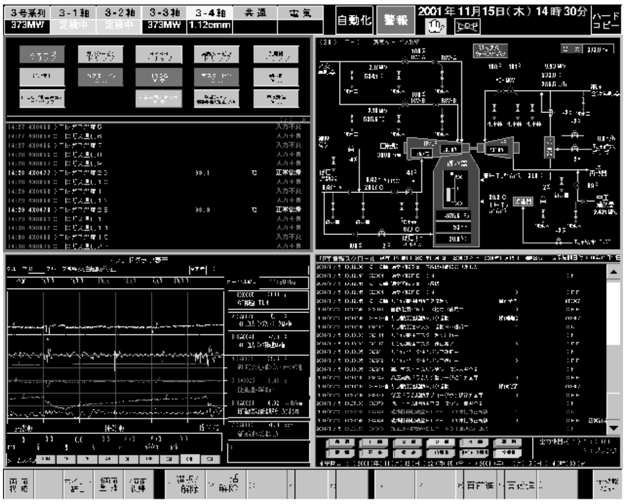

Fig. 7—Examples of Monitoring Screens in the Central Control Room.
Various means including shape, color, and arrangement are used to efficiently convey a huge amount of plant information to operators.

Adapting for Remote Central Control Room

Instruments that are directly connected to the control equipment in the control compartment, such as control consoles for manual startup and shutdown of stages and generator power indicators, are set on the group operating panel in the central control room. Consequently, the central control room is often separated from the turbine building with the control compartment. In such cases, a long signal cable is needed to connect between the central control room and the control compartment, leading to increased requirements for cable materials and a greater cable installation workload. On the other side, the connection between RTB and PCM is a serial communication link that enables RTB to be located at a distance from PCM. To exploit the characteristics of Hitachi's integrated autonomic control system, RTB is installed in the group supervisory panels of the central control room and PCM is installed in the control compartments, and then the connection between each room has been realized by transmission cable. This makes it possible to make do with 18 two-core cables (a conventional scheme would have required 70 multi-core cables) over a distance of approximately 600 m (see Fig. 6).

Furthermore, since Hitachi's latest model uses a high-speed (10 Mbit/s) optical communication network for the exchange of data, it is able to supervise and operate the system in the same way as a conventional set-up (see Fig. 7).

CONCLUSIONS

In this paper we have discussed an example of the application of Hitachi's thermal power station control system to a newly-installed ACC generator plant.

As continuing efforts are made to liberalize the electric power market in Japan, the demand for cost reductions in the construction and maintenance of power plants is becoming increasingly strong. On the other hand, it is also very important to continue supplying electric power that can be used safely. Hitachi will continue to make a concerted effort to address these needs in the planning of supervisory and control systems that assist in the running of power plants.

REFERENCES

(1) A. Ito et al., "A Reliable Next-generation Integrated Supervisory and Control System," *Hitachi Hyoron* **80**, pp. 235-240 (Feb. 1998) in Japanese.

(2) A. Takita et al., "The Latest Supervisory and Control System Technology for Thermal Power Stations," *Hitachi Hyoron* **81**, pp. 167-170 (Feb. 1999) in Japanese.

(3) T. Kimura et al., "Application of a Reliable Next-generation Supervisory and Control System to a Thermal Power Station, *Hitachi Hyoron* **82**, pp.159-164 (Feb. 2000) in Japanese.

ABOUT THE AUTHORS

Tsuyoshi Iijima

Joined Hitachi, Ltd. in 1991, and now works at the Power Plant Control Systems Engineering Department, the Power Control Systems Division, the Information & Control Systems Division of the Solution Systems. He is currently engaged in the development and design of power plant supervisory and control equipment. Mr. Iijima can be reached by e-mail at tsuyoshi_iijima@pis.hitachi.co.jp.

Katsunori Ouchi

Joined Hitachi, Ltd. in 1987, and now works at the Power Plant Control Systems Engineering Department, the Power Control Systems Division, the Information & Control Systems Division of the Solution Systems. He is currently engaged in the development and design of power plant computer systems. Mr. Ouchi is a member of the Institute of Electrical Engineers of Japan (IEEJ), and can be reached by e-mail at katsunori_oouchi@pis.hitachi.co.jp.

Yoshio Maruyama

Joined Hitachi, Ltd. in 1992, and now works at the System Solution Engineering Department, the System Solution Division, the Information & Control Systems Division of the Solution Systems. He is currently engaged in the development and design of power plant supervisory and control equipment. Mr. Maruyama can be reached by e-mail at yoshio_maruyama@pis.hitachi.co.jp.

Satoru Nemoto

Joined Hitachi, Ltd. in 1989, and now works at the Thermal Power Plant Engineering Department of Hitachi Engineering and Production Division in the Thermal & Hydroelectric Systems Division of the Power & Industrial Systems. He is currently engaged in the design of electrical and I&C system engineering for thermal plants. Mr. Nemoto can be reached by e-mail at satoru-a_nemoto@pis.hitachi.co.jp.