ABSTRACT: The recent changes in the environment surrounding the electric power industry following deregulation, a discount of power rates, and other factors have led to demands for substantial rationalization and simplification of power generation facilities. Meanwhile, with demands for greater generation output, high-efficiency operations, and frequent plant start-up/shut-down, it is now more important than ever before to ensure the reliability of facilities and maintain power quality. Consequently, while ensuring the reliability built up through our previous supervisory and control systems for power stations, we have developed a next-generation system called “Hitachi Integrated Autonomic Control System 7000 (HIACS-7000),” which represents advances in maintainability, operation, and cost efficiency. This system has the many characteristics required of power generation systems, including: (1) enhanced performance by adopting high-performance and high-reliability controllers and a large-capacity, high-speed network; (2) greater reliability and maintenance by standardizing the plant interface and the hardware in the interlock circuit; (3) greater reliability and rationalized production by treating software as components and by standardizing software; (4) rationalized cabling by adopting a field LAN; (5) reduced installation space requirements through a compact human interface system; and (6) maintenance tools with enhanced maintenance and visibility.

INTRODUCTION
THROUGHOUT the world, power generation suppliers, whether of thermal, hydroelectric or nuclear power, are finding that cost reduction is their most important task, given free competition and deregulation. Furthermore, advances in computer and communications technologies have been remarkable, and high-speed processing using central processing units (CPUs), greater speed and openness of communications, and downsizing using personal computer technologies are among the shifts that have rapidly been taking place in industry generally, with many excellent outcomes.

For supervisory and control systems for power stations, which have a high public utility, utmost importance has long been attached to reliability and real-time operation. This has brought developments in operating systems and networks for control, configurations for greater redundancy, self-diagnosis technologies, hardware configurations for interlock and protection functions, and other advancements.

While maintaining its tradition for reliability, Hitachi, Ltd. has incorporated the latest technologies and developed a leading-edge supervisory and control system for power stations called “Hitachi Integrated Autonomic Control System 7000 (HIACS-7000).” This system emphasizes cost efficiency, and is suitable for hydroelectric, thermal, and nuclear power generation facilities, reducing costs while maintaining high reliability and delivering excellent processability, functionality, and maintainability.

NEXT-GENERATION SUPERVISORY AND CONTROL SYSTEM FOR POWER STATIONS: “HIACS-7000”

Fig. 1 shows the system configuration of “HIACS-7000.” The system’s characteristics are described below:

1. Realization of a horizontally distributed system, in which controllers are aggregated by the control system, adopting a 32-bit reduced instruction set computer (RISC) CPU, and a 100-Mbit/s optical
duplex network
(2) Enhanced reliability and shorter manufacturing time through the standardization of hardware and software
(3) Significant reduction in the amount of hardware by incorporating interlock and protection functions in the printed circuit boards (reducing the number of relay panels) and by adopting a field LAN
(4) A centralized maintenance tool which rationalizes maintenance through such means as unified management of drawings, expanded and improved monitoring functions, and remote support functions
(5) Economical human interface system enabling improvements in monitoring by using a compact control server that takes advantage of the reliability gains of global standard personal computer technologies (including Pentium processor*1, and Windows NT*2).

CONTROL SYSTEM
Improved Controller and Network Performance
Achieving a horizontally distributed system requires a large-capacity, high-speed network which can transmit massive amounts of information, as well as high-performance controllers having a large-capacity memory.
(1) Large-capacity, high-speed network
An optical duplex loop transmission system has been developed with ten times the transmission rate and four times the transmission capacity of the HIACS-5000 system. This has enabled faster transmission between controllers and improved CRT operation response. Even when a transmission error occurs, the transmission can continue through loop-back control.

*1: Pentium is a registered trademark of Intel Corp. of the United States.
*2: Windows NT is a registered trademark of Microsoft Corp. in the United States and other countries.
(2) High-performance controller
The processing capacity of the CPU has been improved by adopting a 32-bit RISC. And with greater memory capacity, the number of controllers in the system has been substantially reduced. Also, by adopting high-density packaging, and application specific integrated circuit (ASIC) technology, the controllers have become more compact, reducing space requirements for cabinet installation.

Process Input-Output
In the process input-output circuit configuration, the high- and low-voltage circuits are separated to improve noise resistance. The circuit is also configured via a relay panel so that interlock and protection operations can be ensured, even when the controller crashes (Fig. 2). Typically, however, a great deal of labor has been involved in the manufacture or modification. Therefore, an intelligent process input and output (PI/O) and a remote terminal block (RTB) were developed. A read-only memory (ROM) and RISC CPU have been mounted in the intelligent PI/O. An interlock circuit and protective circuit have been built into the ROM, enabling it to execute its functions independently, even when the controller has crashed. In addition, the RTBs are separated from the high-voltage circuit, and have an analog signal conversion function. Fig. 3 shows the programmable control module (PCM), the leading intelligent PI/O. The operating status of the PCM can be monitored in real time using the maintenance tool, providing excellent visualization. Furthermore, the interlock circuit can be modified simply by loading from the tool.

A high-speed field LAN can also be connected to the PCM, enabling the transfer of high-speed analog and digital input-output signals. Many kinds of RTBs can be mixed and connected to this transmission line, and by changing the transmission rate, it is also possible to select the transmission distance. In addition, duplex redundancy has been chosen as the standard for the field LAN, for better reliability.

Applying the PCM and RTB enables:
(1) Reduction of interlock relay panels and ensures

![Fig. 2—Rationalization Adopting PCM and RTB. The conventional interlock function is provided by the PCM, and separation of high- and low-voltage circuits is achieved using the RTB. Connection is then made by the field LAN. This means potential for a dramatic reduction in hardware circuits and rationalization of cabling.](image)

![Fig. 3—PCM Card. The interlock and protection functions realized by the hardware relay panels have been enabled by a single printed circuit board. Modifying the content is simple, and is performed by operating the lock switch on the front panel and using the maintenance tool, enabling substantial reductions in the time required.](image)
interlock and protection functions when the controller crashes,
(2) Improved reliability and shorter manufacturing time through the standardization of hardware,
(3) Effective use of space in the control equipment room and rationalization of cabling with the installation of RTB cabinets in remote locations and on site,
(4) Separation of a noise source by separating controllers, PCM cabinets, and RTB cabinets,
(5) Simpler additions and modifications by enabling RTBs to be added to the field LAN later,
(6) Prior site delivery of RTB cabinets only, helping to shorten plant construction time.

Software
With the introduction of digital control systems, the number of drawings for production and maintenance has grown dramatically. This stems from the addition of drawings for producing software, along with conventional functional drawings.

To facilitate the understanding of control circuits, a methodology for hierarchical design was developed in HIACS-7000 to cope with the increased number of drawings. The hierarchical design expresses functions collectively as a large-scale functional macro (large macro) and a control circuit consisting of combined macros. The control circuit remains as a black box except when requested, and the contents can be obtained by opening the window as necessary. This makes the software one of the components and standardizes it. Human error can therefore be prevented. It also greatly contributes to the understanding of drawings and to a shorter production time. Furthermore, HIACS-7000 has greatly improved software reliability since it permits automatic management of all data necessary for digital control systems, such as addresses, the order of operations, and transmission of controllers within the maintenance tool. The result is a 60% reduction in the number of drawings and easier understanding of their contents. This makes a significant contribution to maintenance rationalization.

Improved Maintenance
HIACS-7000 enables collective management of production drawings and software, thanks to the installation of a CAD maintenance tool as standard.

The maintenance tool allows real-time display as engineering values of the contents of hierarchical design, and PCM circuits. Hierarchical design circuits can also be displayed as two hierarchies on the monitor (Fig. 4). An ISDN connection between the maintenance tool and factories enables the collection of information on failures and remote support of CAD drawing data. Therefore, detailed maintenance can be

![Fig. 4—Online Monitor of Hierarchical Design. Nearly all of the control information can be accessed using the screen at the top. The bottom screen opens to provide additional information only when necessary. These are supported by the maintenance tool. Two hierarchies can be monitored simultaneously.](image-url)
carried out in close cooperation with the manufacturer, while modifications can be accelerated.

MONITORING AND OPERATIONS HUMAN INTERFACE SYSTEM

Compact Control Server ‘HF-W Series’

The compact control server ‘HF-W series’ uses global standard personal computer technology (Pentium processor, Windows NT). This hardware boasts excellent maintenance support services and other features, including: (1) adoption of long-life parts and enhanced reliability through an improved cooling system; (2) secure real-time services realized through a real-time package arrangement; and (3) maintenance service and long time maintenance contract. The control server operates as a human interface device for large-scale monitoring and operating systems, and as a human interface device cum server for small and medium-size systems.

Advanced Human Interface System

With excellent operation and real-time responsiveness, this system offers such standard functions as the display of system charts, historical trends, alarms and, for paperless operation, scrollable displays.

CRT Operation

Today, along with the higher performance of human interface devices, a dedicated server is not required for processing CRT operation functions that control plant operating terminals from CRT screens. Functions provided as standard include the ability to display eight operation terminals at the same time and the ability to call up operations from system drawings displayed on the screen.

Approaches for More Advance Monitoring

The “graphic builder” enables the pasting of multimedia objects such as images, sound, and video. In addition to conventional signal processing, it also enables the display of overlapping drawings and digital images for more advanced monitoring.

CONCLUSIONS

This report has described the characteristics and specifications of “HIACS-7000”, a next-generation total monitoring and control system which offers high reliability and economy as a total monitoring control system.

We are now focusing on producing “HIACS-7000” for advanced thermal power plants and pumped-storage power plants. “HIACS-7000” has applications to nuclear power plants, as well as retrofit renovations of existing systems.

We plan to further improve the performance of the total monitoring control system.

REFERENCE


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