Compact-Type Digital Protection and Control Equipment for Power Systems

Fumio Iwatani
Tomio Chiba
Isao Wachi

OVERVIEW: The introduction of the competitive principle into the power industry has also led to growing demands for more compact and cost-effective devices, while maintaining high levels of reliability and capability in digital products. To meet these requirements, Hitachi has developed compact-type digital protection and control equipment that employs a 32-bit reduced instruction set computer (RISC) processor and is compatible with open networks that support general-purpose communications interfaces, such as IEC 60870-5-103, the transmission control protocol/Internet protocol (TCP/IP), and the distributed network protocol (DNP) 3.0. This equipment provides a superlative ease of use, with features such as the avoidance of human errors by the overall application of an interactive automatic software generating system, and efficiency evaluation at the design stage by the use of logic simulations. In addition, the application of general-purpose communications interfaces and a transportable human interface enabled by ordinary browsers has led to greater flexibility of maintenance and operation capabilities, and has also created a system configuration that will cope with future requirements in information technology (IT).

INTRODUCTION

HIGH levels of reliability and sophistication are required for protection and control devices used in electrical-power systems. At the same time, a firm trend toward the deregulation of power systems and the competitive principle is being introduced into the power industry. Due to this fact, electrical power companies are looking at various ways of implementing cost-effective alternatives and are also developing equipment for power systems that is more compact and less expensive, without compromising high levels of capability and reliability of these systems.

To meet requirements, Hitachi has developed and commercialized compact-type digital protection and control equipment that has improved serviceability, while being compact and highly sophisticated. This equipment features enhanced reliability, and is compatible with open networks in IT integration.

This article discusses the basic concepts and characteristics of this equipment, as well as the techniques used to increase its reliability and serviceability.

BASIC CONCEPTS

The compact-type digital protection and control equipment is compatible with open networks and enables sophisticated applications that can respond to the next generation of communication needs based on the design concepts described below.

(1) All-In-One; A high level of integration and high-density mounting have resulted in an all-in-one configuration in which the power supply, auxiliary voltage transformer (VT) and current transformer (CT), central processing unit (CPU), binary input/output, and network interface are packed together into a single unit.

(2) Network Compatibility; Power companies have recently planned to introduce systems that employ networking to enable functions such as remote monitoring of equipment states, in order to increase the efficiency in the operation and maintenance of facilities. In addition, we have also incorporated communications functions that can adapt flexibly to future IT needs.

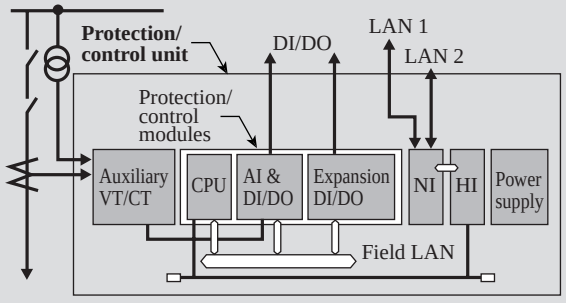
(3) Reliability; Software programming applications for analog input processing, filtering, relay calculations, scheme logics, and trip output make it possible to avoid

human error during software development and also improve software reliability. Since there is a risk that incorrect operation of the power protection and control equipment will result in a system outage, it is necessary to prevent equipment malfunction due to a single failure. For that reason, we have divided the functions of this protection and control equipment into individual modules to ensure that each module can operate independently.

(4) Adoption of Standardized Modules; Our wide range of past experience and accumulated knowhow in protection and control equipment for power systems led us to implement a standardized system of modules for both hardware and software.

BASIC CONFIGURATION AND CHARACTERISTICS

The basic configuration of this protection and control equipment is shown in Fig. 1, together with an external view.



(a) Basic configuration of protection and control equipment

(b) External view of equipment (unit)

AI: analog input NI: network interface HI: human interface
VT/CT: voltage transformer/current transformer
DI: digital (binary) input DO: digital (binary) output

Fig. 1— Basic Configuration and External View of Compact-Type Digital Protection and Control Equipment for Power Systems.
High levels of integration and high-density mounting make it possible to mount the auxiliary VT and CT together with the power supply in a single unit, for an all-in-one configuration. Remote monitoring of the equipment is enabled by the mounting of general-purpose network interfaces as standard.

All-In-One Unit Configuration

The use of a high-performance 32-bit floating-point arithmetic RISC processor enabled us to install all protection sequence software including digital filtering on a single board, which reduces the total number of boards and results in a single unit. System expansion is easily enabled by a building-block method using the same hardware modules. This also means that both of the protection and control functions can be configured in a single unit.

Diversification of Human Interface

We have developed a system that has the following features of the human interface (HI):

(1) Network interface for remote operation

(2) Support (optional) browser software for conventional personal computers

(3) Unit-surface-mounted HI

Improved Self Checking Functions

(1) We have designed and implemented a new LSI with more powerful functions, such as automatic correction of single-bit errors and a detection and monitoring of two-bit errors during program execution.

(2) For the analog input portions, we have employed a monitoring method that uses constant higher harmonics injection to enable self checking.

(3) We have introduced restart function to avoid function halt due to temporary failure or malfunctions.

Other Features

(1) This equipment employs digital filtering at a high-speed sampling rate (at 2.4 kHz/2.88 kHz) and 16-bit A/D conversion. In addition, analog input (gain and phase) can be calibrated by software.

(2) The equipment enables the following interfaces: IEC 60870-5-103, TCP/IP, DNP 3.0, and local operating network (LON).

(3) It minimizes computation errors by floating-point arithmetic regulations (IEEE 754).

(4) The equipment enables reliable control system communications by using a double-redundancy system.

(5) The use of flash memory by this equipment enables on-board update of programs.

(6) This equipment has a password system adopted for security to prevent changing settings.

INCREASED-RELIABILITY TECHNIQUES

We have devised a centralized management system over all stages from design to system testing, to

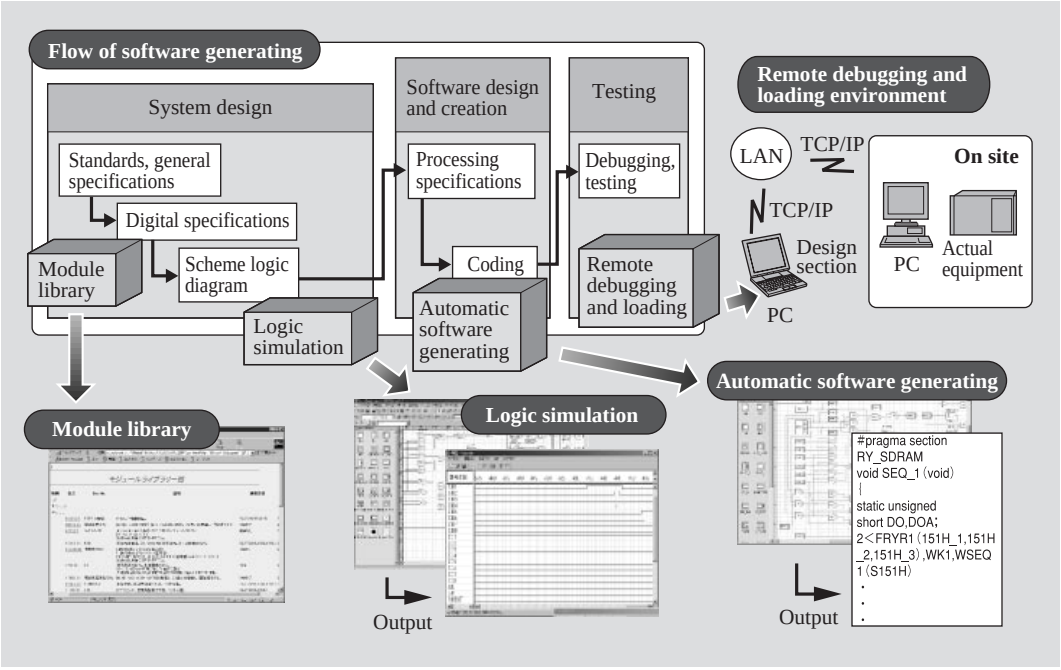


Fig. 2— Outline of Reliability-Increasing Techniques.
The use of an automatic software generating system has devised centralized management over all stages from design to product-testing, enabling improvements in the reliability and quality of products.

improve reliability and quality, by applying an automatic software generating system (see Fig. 2). Our designed system has the following components.
(1) Software Module Library; A standardized software module library was rearranged to enable interactive processing with component images.
(2) Logic Simulation; A schematic logic simulation system has enabled verification by making it clear how given input signals can affect the timing and period of output signals.
(3) Remote Debugging and Loading Environment; It is now possible to perform remote debugging and loading of software on the actual machines, using a plant-wide LAN. This makes it possible to centralize the system management, which means that any problems that may occur during the equipment testing stage can be fed back to an upstream process, and countermeasures can be made to reflect on the actual equipment.

MAINTENANCE IMPROVEMENT TECHNIQUES

There are needs within electrical power companies for reducing labor costs in the maintenance and operation of equipment. These needs, in turn, generate a need for an IT system that can anticipate future developments. To meet these needs, our protection and control equipment is designed to have the features described below (see Fig. 3).
(1) Mobile HI; The general-purpose communications interfaces are standard interfaces, including TCP/IP, DNP 3.0, and field LAN (LON). This system also enables access through a conventional browser, independent of the operating system of the personal computer, and there is no need to install special software.
(2) IT Compatibility; Since general-purpose communications interfaces are provided as standard, the equipment can be connected to the Intranet of the electrical power company. That enables ubiquitous computing. In addition, if the equipment is connected through the Internet to a system of the manufacturer or a service company, it is possible to provide more efficient services by speeding up the response when a fault occurs, or by simplifying the response to a product upgrade.

CONCLUSIONS

This article has discussed the basic concepts, basic configuration, and features of Hitachi's compact-type digital protection and control equipment that we have developed to be compatible with open networks, to meet the needs of electrical power companies, together with the application of techniques to increase reliability and maintainability.

In the future, we will consider introducing a series

VT: voltage transformer
CT: current transformer
CB: circuit breaker

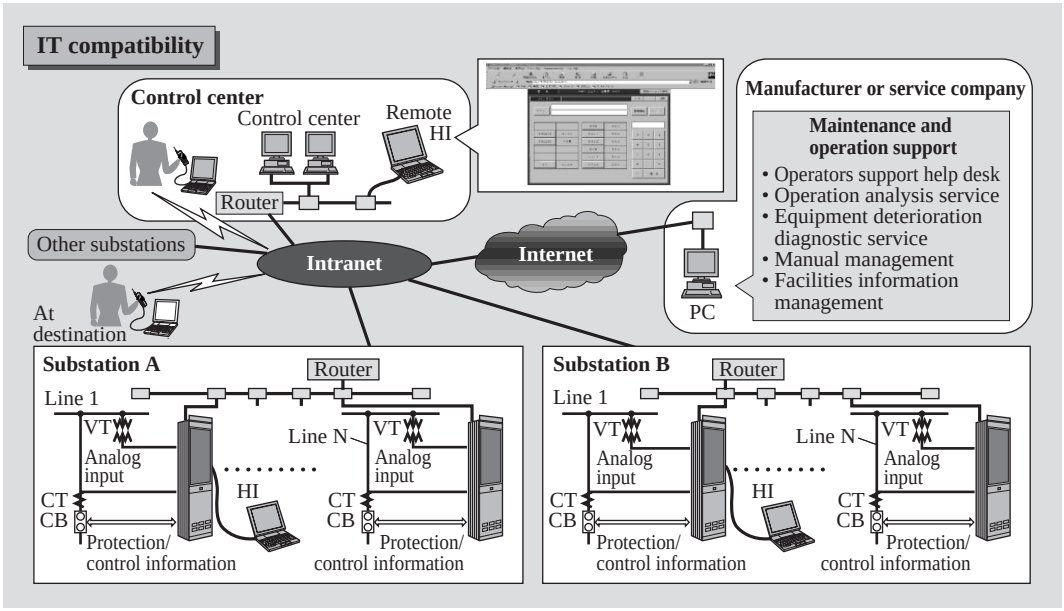


Fig. 3— Outline and Usage Example of Improved Maintainability of Compact-Type Digital Protection and Control Equipment—a System Configuration Looking Forward to Future IT Compatibility.

of products based on our protection and control equipment for low-voltage systems for customers who want a lower price.

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ABOUT THE AUTHORS

Fumio Iwatani
Joined Hitachi, Ltd. in 1969, and now works at the Power & Industrial Systems Division, Power & Industrial Systems. He is currently engaged in the compiling of electrical power distribution systems. Mr. Iwatani is a member of IEEJ, and can be reached by e-mail at fumio_iwatani@pis.hitachi.co.jp.

Tomio Chiba
Joined Hitachi, Ltd. in 1969, and now works at the Power & Industrial Systems Division, Power & Industrial Systems. He is currently engaged in the development of key components of the protection and control equipment for power systems. Mr. Chiba is a member of IEEJ, and can be reached by e-mail at tomio_chiba@pis.hitachi.co.jp.

Isao Wachi
Joined Hitachi, Ltd. in 1985, and now works at the Power & Industrial Systems Division, Power & Industrial Systems. He is currently engaged in the design of protection and control equipment for power systems. Mr. Wachi is a member of IEEJ, and can be reached by e-mail at isao_wachi@pis.hitachi.co.jp.