Present Status and Fuji Electric's Involvement with Instrumentation and Control Systems

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1. Introduction

The investment environment surrounding the industrial system sector is continuing to grow due to increased public demand for capital investment. According to medium-range forecasts, the market for electric measurement equipment will continue to experience mild growth overall during the period from 2006 to 2009; government-based demand will continue to be limited and will level off; exports will be centered on China and other Asian countries and will continue to increase slightly, and public demand for investment to reduce the high cost of crude oil and to add value to products is expected.

Instrumentation and control systems are anticipated to become capable of considering carefully the comfort and safety of society and the global environment while contributing to the stable manufacture of high quality products with the desired productivity. Moreover, at plants where the manufacturing equipment is approaching the time for renewal, it is desired to utilize existing assets while migrating to a system capable of supporting future technological innovations.

Meanwhile, owing to the latest advances in IT (information technology) and personal computers, there are plans to combine instrumentation and control systems with MES (manufacturing execution system), ERP (enterprise resource planning), SCM (supply chain management) and other such core systems, or combine them with intelligent field devices, and there is demand for a comprehensive optimized system structure, from the field level to the level of production management and operation, based on a vertically and horizontally integrated solution that seamlessly integrates the various components and applications required at the production site.

On the other hand, the so-called "year 2007 problem" is one that Fuji Electric cannot avoid, and in establishing and executing a countermeasure policy, as a part of an effort to strengthen the rationale for an instrumentation and control system that provides vertical and horizontal integration solutions, and cognizant of the transmission of technology and of measures to prevent the hollowing out of this industry, Fuji Electric again improved and enhanced the element technologies of the instrumentation and control system, i.e., the main constituent elements of control technology, engineering technology and device manufacturing technology, and constituent components such as measuring instruments.

This paper presents Fuji Electric's vertical and horizontal integration solution, and described the present status of and Fuji Electric's involvement with the abovementioned constituent elements.

2. Market Trends and Challenges for Instrumentation and Control Systems

2.1 Market trends and challenges for distributed control systems (DCSes)

In the 1990s, DCSes underwent a dramatic change from specialized systems for DCS manufacturers to open-standard systems used with UNIX*1 and Windows*2, which are the de facto standards for operating systems. SCADA (supervisory control and data acquisition), a monitoring and control package that uses Windows as its operating system, emerged first, and PC-based DCSes that use SCADA as middleware were introduced into monitoring and control systems. Then Internet technology and OPC*3, the de facto standard interface of Windows, and field bus technology revolutionized the DCS market.

In the years since 2000, programmable logic controller (PLC) instrumentation systems have been introduced to the market, and the segregation of the instrumentation control domain among DCS manufacturers, PLC manufacturers and SCADA manufacturers has become even more complex.

On the other hand, the focus on DCSes has changed, from mere monitoring and control systems to systems that are being reconsidered by users as an effective means for reducing the TCO (total cost of

∗1: UNIX is a registered trademark in the U.S. and other countries, licensed through X/Open Company, Ltd.
∗2: Windows is a registered trademark of U.S.-based Microsoft Corporation.
∗3: OPC is a standard interface specification of Microsoft.

ownership) for the total lifecycle duration, from DCS adoption until renewal, and with the introduction of IT, as a way to optimize the operation of manufacturing systems.

In this context, a DCS does not exist by itself, but must be linked to an ERP, SCM or MES core business system to form a system that operates effectively. Seamless integration and the provision of MES products are huge challenges.

With longer service lives of equipment, DCSes are being required to provide long-term maintenance and protection. The extent to resolve the conflict between longer service life and higher versatility of general-purpose products based on open standards remains a huge challenge.

In the domestic Japanese DCS market, new plant demand is small, but the majority of demand arises from the need to renew equipment in order to maintain a plant. The challenge facing DCS manufacturers is achieve long-term operation while continuing to utilize a user's assets and providing a revolutionary system.

2.2 Market trends and challenges of measuring instruments

The market for measuring instruments has continued to diminish due to a reduction in capital investment over the long-term and lower prices, but in the past few years, the market has recovered as a result of increased in capital investment in Asian markets and especially China, and the enhancement of facilities in the basic materials industry, which is the main customer of measuring instruments.

Measuring instruments can be broadly categorized as field instruments such as transmitters and flow meters, receivers such as recorders and controllers, and analyzers. A noticeable recent trend among measuring instruments is the provision of functions that support networking. The first example of a field bus used in the field was announced in 1998, and the necessity of a field bus has become a frequent topic in recent business discussions. Communication functions such as Ethernet*4 support are now required in receivers as well. Moreover, the trend toward globalization of measuring instruments is remarkable, and for transmitters, de facto standards are increasingly being used in the specifications, and the resulting low cost is often the key to receiving orders. On the other hand, however, there is a growing demand for specialized devices for particular customers.

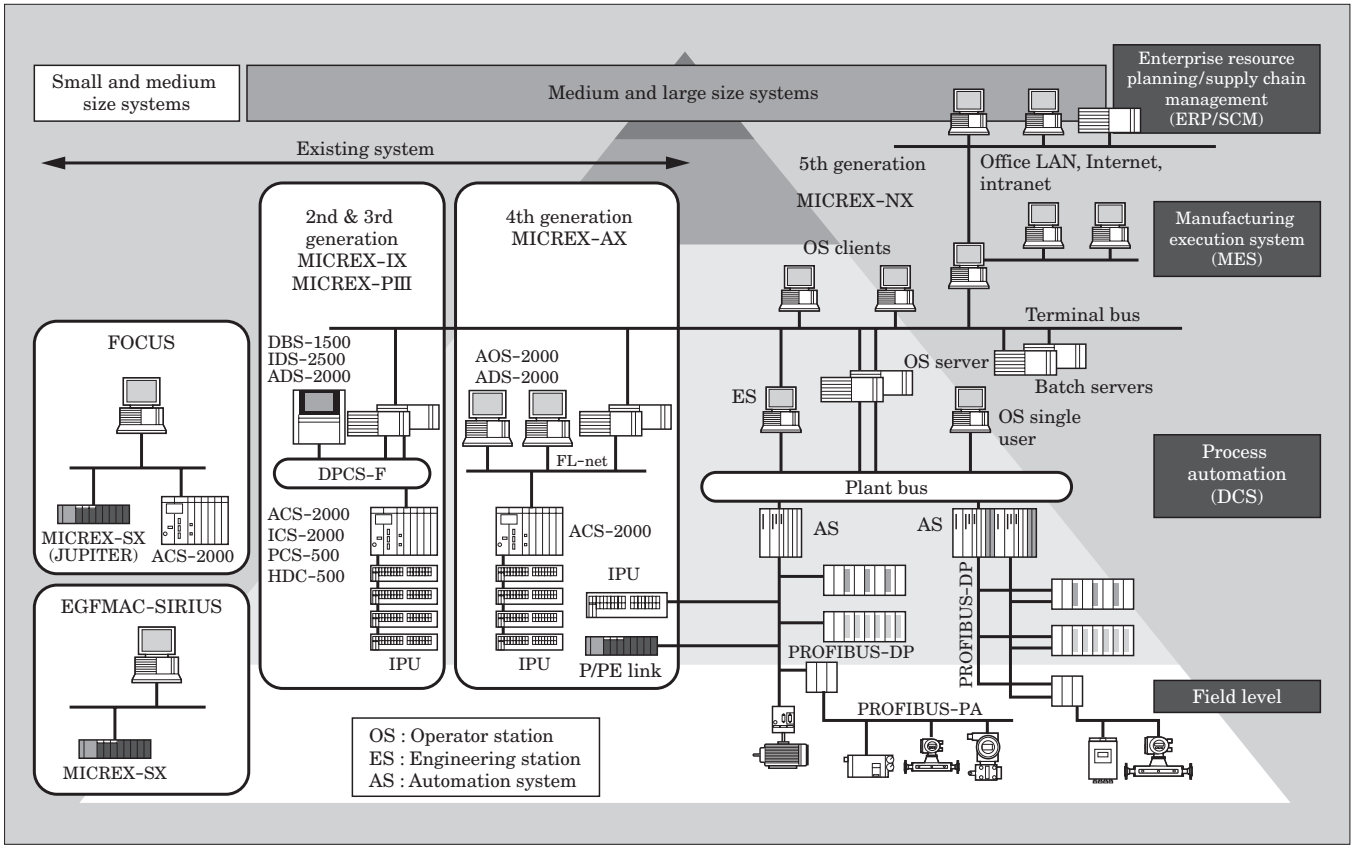
3. Fuji Electric's Involvement with Instrumentation and Control Systems

3.1 Involvement with DCS

Fuji Electric possesses excellent core technology

*4: Ethernet is a registered trademark of U.S.-based Xerox Corporation.

Fig.1 MICREX system configuration



in the distinct fields of electric (E), instrumentation (I) and computer (C) control, and Fuji's DCS has been developed as a system capable of realizing an EIC integrated system.

In the latter half of the 1990s, Fuji Electric announced the MICREX-AX as a 4th generation DCS based on the concepts of open standards, evolution and inheritance.

Then in 2004, the MICREX-NX was introduced to the market as a 5th generation DCS. The MICREX-NX enables the realization of a vertically integrated system that seamlessly connects systems from the shop floor to the operating level, flexibly connects devices such as sensors, inverters and UPSes (uninterruptible power supplies) located on the shop floor, and also enables the realization of a horizontally integrated system capable of supporting all processes from the receipt of raw materials to shipping.

For medium and small size systems, there are also FOCUS and EGFMAC-SIRIUS systems, which can be constructed from a SCADA system and a general-purpose PLC, and which can support a wide variety of needs.

Figure 1 shows the system configuration of Fuji Electric's information control systems and their hierarchy.

(1) Vertical and horizontal integrated system

(a) Vertically integrated system

An MES is positioned between an instrumentation and control system and core business system, like an ERP or SCM, at manufacturing site. MES part is optimizing business resources (people and equipment). MES functions include schedule management, product inventory, progress management, production results management, production equipment management, quality management, and so on. Fuji Electric provides the MainGATE-Process plant production management system as an MES for the manufacturing industry. In response to user requests, optimal MES systems are being provided as solutions, and by seamlessly integrating the MES with a MICREX system, a system vertically integrated from the field level to the manufacturing control level can be realized.

(b) Horizontally integrated system

The MICREX-NX is a system that covers the range from process control to discrete control, and realizes consistent integration, from upstream raw materials equipment to downstream distribution and utility equipment. Furthermore, as shown in Fig. 2, these systems are used in various industries and enable the consolidation and integration of plants.

(2) Lifecycle solution

The MICREX-NX, as shown in Fig. 3, reduces the TCO in all phases of the lifecycle, from plant system construction to management (operation and maintenance), and renewal, and is capable of providing various solutions to run the plant optimally. This special edition introduces solutions in each sector.

Fig.2 MICREX-NX application areas

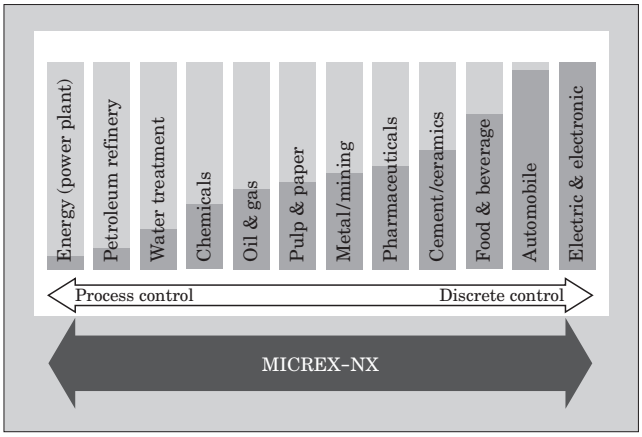
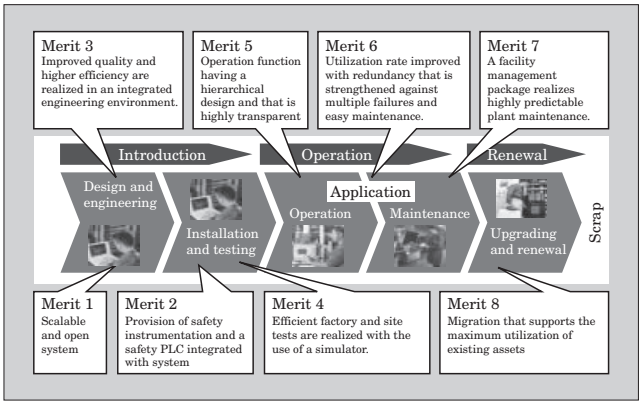


Fig.3 Merits provided throughout the lifecycle



(a) Merits of use

① Supports scalability from small and medium-scale to large-scale plants

② Supports international standards at every level

③ Safety instrumentation and safety PLC system can be constructed with automation system (AS) standard components (CPU, I/O and modules)

(b) Engineering merits

An engineering station (ES) has an abundance of functions, as listed below, and these enable the engineering work time to be shortened and input errors to be reduced, thus improving quality and efficiency.

① Function blocks that are registered in a library are used to realize the AS control functions and to generate automatically the faceplate displayed at an operator station (OS). The AS and OS engineering work becomes integrated.

② An abundant library is provided for single control functions and for field control.

③ Software simulations of application software and of inputs and outputs can be performed. A dynamic plant simulator is also provided.

④ During the design phase for AS application software, the system can be designed without the need to be aware of redundancy.

⑤ With the automatic addressing function, the

system can be designed without the need to be aware of memory allocation.

(c) Management merits

① With a hierarchical design, constructed control functions are reflected in the operation, and operation is simplified.

② Sensors and control elements are easily connected to the PROFIBUS, thus enabling the provision of a highly transparent operation function.

③ Each DCS component can separately be made redundant, and linking these components will enable the system to be resistant to multiple failures.

④ DCS constituent elements can separately be made redundant according to the degree of importance of a process, thereby enabling the construction of a redundant system that has weighed the risk and return on investment.

⑤ A version cross checker function strengthens the management of the change history.

⑥ Automatic startup after the replacement of hardware improves the utilization rate.

(d) Renewal merits

When renewing an existing system, migration to the MICREX-NX can be implemented step-by-step.

① The multi-server function enables the MIC REX-NX to be connected to an older generation network (DPCS-F or FL-net) and the older generation controller to be monitored from the OS.

② The MICREX-NX can be connected via link devices to P/PE-link or T-link devices, and may coexist with new and old PIOs.

③ A converter function enables the efficient utilization of application software assets.

(3) Solution packages

The MICREX-NX is capable of providing the following solution packages.

(a) Facility management package

The facility management package PDM (process device manager) comprehensively acquires device diagnostic information and device-specific information for field devices, facilities or the like, and provides diagnostic technology capable of detecting tendencies for failure in a plant or machinery, thus vastly improving the efficiency of such maintenance work as preventive maintenance, fixed cycle diagnostics, overhauls, etc.

(b) Batch system

The MICREX-NX's batch system is built on a software package base that complies with the IEC 61512 standard (ISA S88) and with FDA21 CFR Part 11 that concerns electronic recording and electronic signatures and was established by the U.S. Food and Drug Administration (FDA).

(c) Route control

This package performs the monitoring, control and diagnosis of systems that transfer fluids by pipe or pipeline. Product brands change daily, and changes in the transfer route can easily be implemented without the need to create special programs.

(d) Operating support system

This package automatically captures operating information, and can automatically deploy that data in the operating flow, so that the operational know-how of a skilled operator may be inherited easily. This package is provided as a solution package for the year 2007 challenge.

(e) Field-specific packages

Field-specific package groups are prepared in a library for each manufacturing industry.

(4) Medium and small-size systems

In addition to the previous FOCUS system for small and medium-size control systems, in 2004, Fuji Electric began selling the EGFMAC-SIRIUS system capable of supporting small-scale control systems. Both systems are configured with a general-purpose SCADA and the MICREX-SX, which is a general-purpose PLC. By mounting Fuji Electric's instrumentation control-related know-how onto a general-purpose SCADA, the system is able to provide the same engineering environment and operating environment as with a conventional DCS.

(5) New involvement with engineering support systems

In addition to the engineering merits enumerated in section 3.1, paragraph (2), item (b), as in the HEART series, Fuji Electric has commercialized a specification and description language to increase the quality of specifications. Furthermore, by supporting all phases of engineering work with a common platform, continuity of the control system engineering can be established from price quotations and specification verification to onsite startup. This enhances the production technology capability, facilitates the inheritance of technology, and of course, improves productivity and quality.

(6) Advanced online optimization technology and control platform

Online optimization is the optimal online operation of a system, having been vertically integrated from the above-described field to production control and operation, for a certain objective, which is one of the vertical integration objectives. Fuji Electric is expanding the functionality of its FeTOP (Fuji Electric total optimization) system that was developed as an online optimization system for power plants. FeTOP has the basic functions of a load predicting function, non-linear optimization calculation function, non-interactive control function (multivariable model predicting function), and an interface for the user and DCSes of various companies, a database of actual data and the like, and aims to provide technology capable of realizing online optimization in various fields.

3.2 Present status of measuring devices and Fuji Electric's involvement

Measuring devices (sensors) are the original source

of process instrumentation, and play an important role in improving productivity, quality and preventative maintenance. Table 1 lists Fuji Electric's involvement in the improvement of measuring devices.

Fuji Electric's involvement in each type of measuring device is described below.

(1) Field devices

Representative examples of field devices include pressure and differential pressure transmitters, flow meters and temperature transmitters.

The specifications and performance of transmitters have been standardized, and competition in the global market is fierce. Even under these circumstances, there are demands for long-term stability, functions that support a field network, and a safety level (SIL: safety integrity level) that complies with IEC 61508. Also, for particular customers, Fuji Electric has developed transmitters that fully utilize Fuji's distinctive technologies, such as low power and network technologies.

Types of flow meters include the electromagnetic type, ultrasonic type and the like. The ultrasonic type is expected to generate increased demand due to its advantages of non-contact measurement and convenient installation. Fuji Electric is focusing on ultrasonic flow meters as a key device, and in 2005 brought to market a high-precision hybrid ultrasonic flow meter (composite method using transit time difference and Doppler effect; models: FSH and FSW) that is targeting use in identifying business transactions, and Fuji is moving ahead to develop a product line. Additionally, ultrasonic type meters are the main flow meters used with ultra pure water in semiconductor manufacturing, and in application to smaller aperture sizes, and the number of units sold is steadily increasing.

(2) Receivers

Receivers are broadly categorized as either recorders or controllers. Recorders are transitioning to paperless recording. There is backing for regulations and guidelines to prevent falsification of data from paper-based recorders (ink jet type), and that demand is being supported. Paperless recorders are required to support Web servers and provide data acquisition functions, and in 2005, Fuji Electric introduced a paperless recorder product (model number: PHR/L) fully equipped with a communication function.

Demand for single loop controllers used in the first process instruments was driven mainly by replacement demand, but that use is coming to an end. In medium and large-scale systems, controllers were replaced by DCSes and PLCs, and in small-scale systems, were replaced by upgraded temperature controllers and other general-purpose controllers. Temperature controllers feature improved communication functions, control operations, calculation functions and the like, and as a highly functional and high-precision general-purpose controller, their range of suitable applications is expanding. Fuji Electric introduced high functionality temperature controllers (models: PXH and PXG) to the market in 2005, and example applications of these temperature controllers are presented in this special issue. Also, it is strongly requested that temperature controllers for mechanical equipment be built-into the interior of that equipment, and the module type and board

Table 1 Fuji Electric's involvement to improve measuring devices

Model	Key technology	Fuji's involvement for improvement	Main fields of application					
			Materials production	Water treatment	Food, pharmaceuticals	Mechanical instrumentation	Semiconductors	Environmental measurements
Pressure, differential pressure transmitter	Micro silicon sensor, low power consumption, network	Compatibility with general-purpose (global standard) transmitter	○	○	○			
Ultrasonic flow meter	Pulse Doppler, composite method using transit time difference and doppler effect (world's first)	Increase accuracy, expand aperture range	○	○	○	○	○	
Temperature controller	High-speed control, advanced high resolution, network	Increase functionality, increase accuracy, modularization, integrate to a single board	○		○	○	○	
Recorder	High-speed sampling, network	Web server, improve data acquisition function (paperless recording)	○		○	○	○	
Gas analyzer	NDIR sensor, solid electrolyte sensor	Simultaneous measure of multiple components, direct insertion to measure flue gas	○			○		○

type, without a display control panel, are becoming the most common type of temperature controllers. There are needs for better control precision, for communication functions to be expanded and for PLC functions to be incorporated, and Fuji Electric will strive to support these needs.

(3) Analyzers

Gas analyzers are classified according to their use, whether for environmental monitoring, such as for monitoring air pollution, or for use in processes that measure the atmosphere in an industrial furnace or the like. The NDIR type, zirconium type, and magnetic type analyzers are based on traditional measurement principles, but are also equipped with multi-component measurement functions, and calculation functions such as auto calibration. Recently, a laser-based direct insertion type (type that directly attaches a sensor to a flue or chimney) was introduced. Fuji Electric has introduced an NDIR type analyzer equipped with various calculation functions (installation model: ZSU; compact model: ZSV) which can measure five different components (NO_x, SO_2, CO, CO_2, O_2) with a single analyzer, for air pollution monitoring and for process monitoring. Fuji is also working to bring this technology to the direct insertion type of analyzers.

Regulations are creating demand for analyzers for environmental monitoring-use. Timed to the start of VOC (volatile organic compound) emissions regulations that began in April 2006, NDIR VOC meters were introduced to the market in December 2005.

In response to demand for safe and delicious tasting water, Fuji Electric is introducing unique water quality meters (a trihalomethane meter, an acute toxicant monitor, an oil-on-water analyzer, etc.) to the market.

(4) Basic technology for manufacturing sensors

The sensor elements built-into the various measuring devices are based on so-called MEMS (micro electro mechanical systems) technology. Fuji Electric has cultivated this technology in the manufacture of sensors for pressure transmitters, inkjet elements for paper recorders, and the like, and in recent years, is actively working to expand its application range in various fields.

Fuji Electric is also involved in a so-called MEMS foundry service to combine wireless and sensor technology with MEMS, or to develop a sensor that incorporates biotechnology, and then to leverage the features of this technology and accept contracts from clients for micro-machining.

4. Conclusion

An overview of the trends and Fuji Electric's involvement with instrumentation and control systems has been presented.

By responding to demands for improved operating efficiency and higher quality of manufacturing systems, and by supporting future requirements for fewer human operators and for equipment replacement with succeeding generations, the role of instrumentation and control systems will become even more important.

Fuji Electric intends to continue to strive to provide customers with optimal solutions.