Automation System Trends and Overview of Fuji Electric's Solutions

Ken Kakizakai
Shigemi Wakasugi
Kazuyuki Kisa

1. Introduction

The increase of capital investment since 2006 in the field of industrial systems has invigorated for improvement and innovation at production plants. In the field of automation systems, various initiatives are underway, including efforts to provide field intelligence according to the replacement interval, to construct seamless production information management systems by merging such core business systems as MES (manufacturing execution system), ERP (enterprise resource planning) and SCM (supply chain management), and to construct wireless LAN-based IT networks.

Product quality in the manufacturing industry implies not only the quality of the product, but also the organizational and technical capability to realize such quality, and encompasses the entirety of a company's performance (quality of management). "Quality" reflects the essence of a company and is an important factor that directly influences management.

Meanwhile, the approach to manufacturing quality has recently changed from a "product inspection centered approach" to one that emphasizes "quality assurance at the manufacturing process level," and is progressing toward a higher level of quality control. As a representative example of "visualization," efforts are underway to share (vertically integrate) manufacturing information about onsite and managerial staff and operations, and to provide an environment that supports traceability.

On the other hand, in order to reduce the risk from major accidents and disasters, and to ensure a high level of safety for human life, environment and equipment, plant safety is also being closely watched, and alarm management systems based on process hazard analyses are being introduced. Moreover, when a JIS (Japanese Industrial Standard) was created based on the international safety standards IEC 61508 and IEC 61511, compatibility with international standards was requested. As a result of this request, the application range of safety instrumentation systems, which has been limited to specific fields such as overseas petrochemical plants, is expected to expand in the future.

Furthermore, large-scale plants are operating with fewer personnel as a result of requests for lower running costs and advances in automation technology, and the skilled operators, who have been involved in running a plant since it was built, are retiring in large numbers. On the other hand, the realized high reliability and stable operation of devices are linked to a significant decrease in the BM (breakdown maintenance) index*1 and fewer incidences of trouble. The passing down of know-how from skilled operators to plant operators and maintenance personnel has became a critical issue. This so-called year 2007 problem is predicted to become increasingly severe in the future, and requests are growing for a more sophisticated operation support system that can provide a mechanism enabling the passing-down of operational know-how relating to the stable operation of equipment and response to equipment failure.

Environmental problems and the increase in raw materials prices as typified by the recent sudden rise in crude oil prices are spurring requests for energy savings, and the optimization of individual plant operation and trials of optimization through energy sharing among factories and regions are accelerating. Moreover, as represented by multivariable model predictive control, process improvements based on control technology are being applied, and innovation at control sites is steadily progressing.

This paper describes Fuji Electric's efforts in providing "vertically and horizontally integrated solutions" based on the requests of automation systems which have undergone the abovementioned transformations in recent years.

2. Market Trends and Challenges of Automation Systems

2.1 DCS market trends and challenges

In the 1990s, DCS (distributed control systems) evolved from dedicated system for each DCS manufacturer, to open systems based on general-purpose OSes such as UNIX*2 and Windows*3. Also, with the development of Windows as the de facto standard,

*1: BM index is BM incidence/number of instruments.

the SCADA (supervisory control and data acquisition) monitoring and control package that runs on Windows has emerged, and a personal computer DCS that uses SCADA for middleware has been introduced. Additionally, with advances in Internet technology, OPC*4, the de facto interface for Windows, has also penetrated the DCS world, field buses that conform to international standards are being used, and the trend towards open standards for DCS has further accelerated.

In the early 2000s, PLC (programmable logic controller) instrumentation systems began to be sold, and the automation domains of DCS manufacturers, PLC manufacturers and SCADA manufacturers became increasingly complex to separate.

Meanwhile, DCS came to be reconsidered as an effective means for lowering the user's TCO (total cost of ownership) over the total lifecycle, from DCS installation to renewal. Also, with the recent development of IT-related technology, the positioning of DCS as a means for realizing monitoring and control, to achieve automation and labor savings in manufacturing equipment, has shifted to focus on how to increase management effectiveness and company value by directly linking management to the onsite operation of a manufacturing system.

From this perspective, DCS does not exist by itself and must operate effectively with ERP, SCM and MES core business systems, and seamless integration and the filling out of a solution product line commencing with MES is a challenge for the vendor.

In terms of service, long-term DCS maintenance is needed due to the longer service life of equipment and a resolution to the conflicting proposals for greater general-use through the adoption of open standards and for longer service life is a significant challenge. Moreover, demand for DCS in the Japanese domestic market comes not only from new plants, but the majority demand is for equipment renewal in order to maintain existing plants. Because of this reason, the provision of migration technology for transitioning to new innovative systems while inheriting user assets is an important challenge for DCS manufacturers.

2.2 Market trends and challenges of industrial measurement devices

Industrial measurement devices are global products, and in recent years this market has been recovering as a result of increased capital investment by the Asian markets centered on China, and in particularly, as a result of capital investment by the materials industry which is the largest customer of measurement devices. Moreover, as concern heightens for protecting the global environment to prevent global warming and so on, demand mainly from China corresponding to strengthened emissions regulations is increased.

Industrial measurement devices are roughly categorized as field devices for transmitters and flowmeters, receivers for recorders and controllers, and analyzers. Support of field networking, wireless transmission and safety instrumentation are example of recent product trends of measurement devices. At Japan's largest exhibit of measurement and control technology (sponsored by the Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA)) in November 2007, many of these devices were displayed. Moreover, the increase in number of foreign exhibitors and the size of their exhibits hints at the expectations for the Asian measurement device market.

The majority of industrial measurement devices are built-into automation systems, and as a result of progress toward a de facto standard, the demand structure for these industrial measurement devices is treated as a group of measurement devices for which global competition is intensifying. In support of the above, it is becoming increasingly important to reliably assess market requests, bring timely products to market, provide the capability for a wide range of measurements with a single device, reduce the number of models and incorporate added value.

3. Fuji Electric's Approach to Automation Systems

3.1 DCS approach

From the 1970s, when DCS first emerged, until the present day, the sophistication and performance levels of automation systems have continued to increase. As shown in Fig. 1, Fuji Electric realized total automation in a 2nd generation automation system by merging PA (process automation) and FA (factory automation), and realized EIC integration of electricity (E), instrumentation (I) and computer (C) functions in a 3rd generation. As a 4th generation automation system, Fuji Electric announced the MICREX-AX which is based on the concepts of open standards, evolution and inheritance.

The MICREX-MX information and control system released in 2004 corresponds to a 5th generation DCS. As part of collaboration on process automation between Fuji Electric and Siemens of Germany, the MICREX-NX was jointly developed based on Siemens' PCS7 DCS, and is a next-generation information and control system that features vertical and horizontal integrated solutions and integration engineering. The MICREX-NX/V7.0 released in June 2008 further expands the MICREX-NX functionality.

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

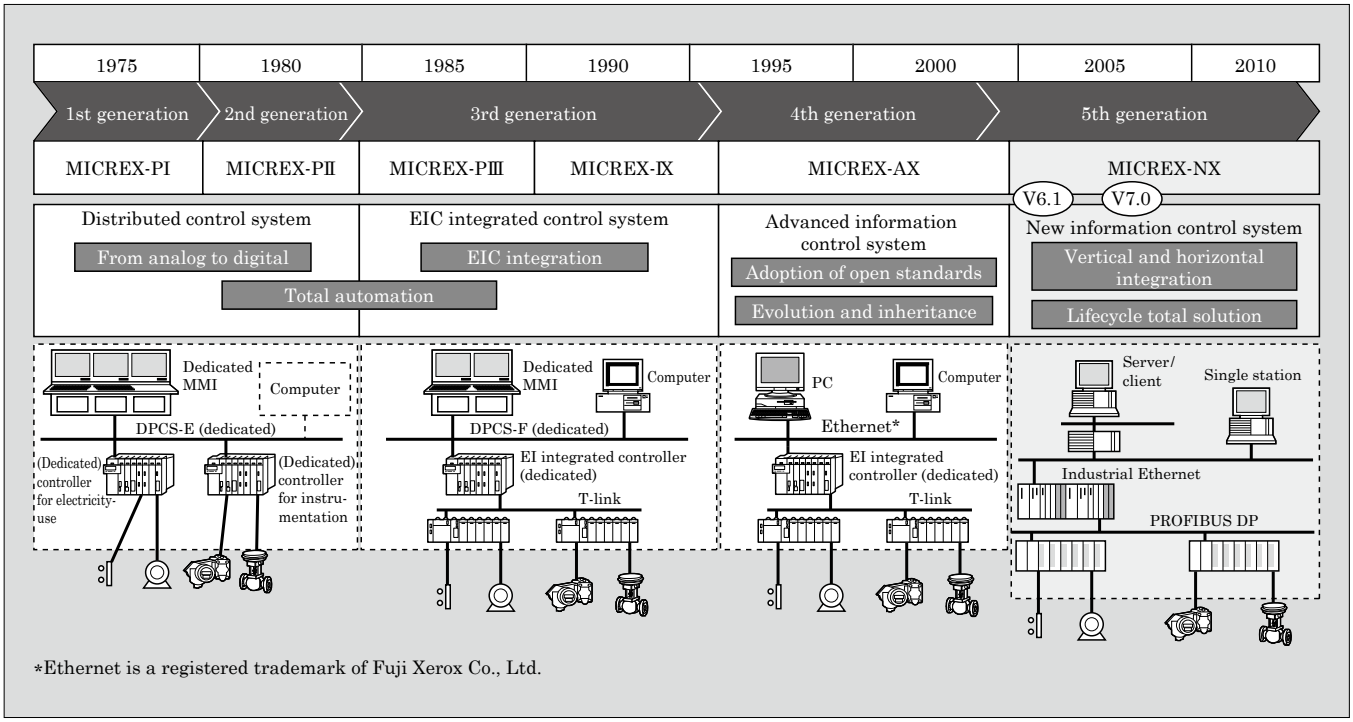
---

*2: UNIX is a registered trademark licensed by X/Open Co., Ltd. in the US and other countries.

*3: Windows is a registered trademark of Microsoft Corporation in the United States and other countries.

*4: OPC is a standard interface specification of Microsoft Corporation.

Fig.1 Development of Fuji Electric's automation systems



*Ethernet is a registered trademark of Fuji Xerox Co., Ltd.

Fig.2 MICREX-NX system configuration

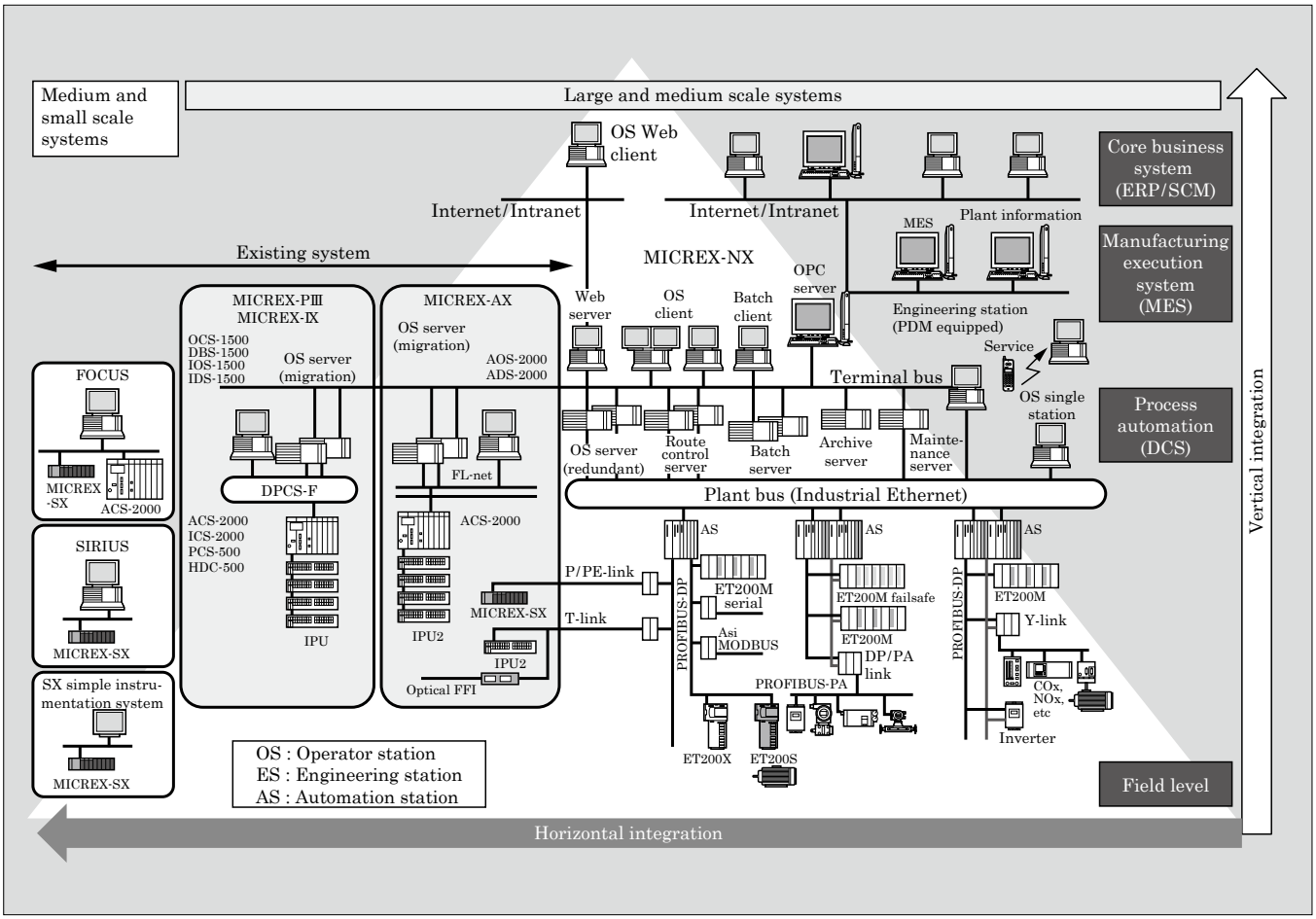


Figure 2 shows the system configuration of Fuji Electric's MICREX-NX system.

(1) Lifecycle total solution

Fuji Electric has proposed the concept of a "lifecycle total solution" for these control systems. The MICREX-NX provides various solutions to reduce the TCO and run the plant optimally in all phases of the lifecycle, from plant system construction to management (operation and maintenance) and renewal. Features of the MICREX-NX are listed below.

(a) Scalable and open core system
(b) Extendable and innovative system configuration featuring a core system integrated with safety instrumentation, safety PLC, etc.
(c) Improved quality and high efficiency realized with integrated engineering environment
(d) Efficient factory testing and onsite testing realized through use of simulator
(e) Operation functions having hierarchical design and high degree of transparency
(f) Improved availability with high redundancy against multiple failures and easy maintenance
(g) Highly proactive plant maintenance with equipment management package
(h) Migration that supports maximum use of existing assets

(2) Vertically and horizontally integrated system

(a) Vertically integrated system

MES is positioned between an instrumentation control system and a core business system, such as ERP or SCM, at a manufacturing site and serves to optimize manufacturing assets such as personnel, work, products, equipment, and so on. MES functions include schedule management, product inventory, progress management, production results management, production equipment management, quality management, etc. 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 that is vertically integrated from the field level to the manufacturing control level can be realized.

(b) Horizontally integrated system

The MICREX-NX system is suitable for applications from process control to discrete control, and can centrally manage information needed for decision making by integrating field level systems over a wide range, from production equipment at a factory to distribution and utility equipment. Furthermore, these systems are suitable for various types of work and enable plant consolidation and integration.

(3) Safety instrumentation system

The MICREX-NX's safety instrumentation system has been certified for both hardware and software by the German technical safety organization TÜV, comply with safety standards IEC 61508 and IEC 61511, and conform to safety integrity level (SIL) 3 which is required for a qualitative risk assessment of safety.

(a) Integration of control system and safety instrumentation system

In order to support the high-level and specific requests of safety instrumentation systems, safety instrumentation systems are often commercialized separately from control systems. On the other hand, however, progress is being made in the sharing of the controller, operation environment and engineering environment between the MICREX-NX's safety instrumentation system and other control systems, so that the safety instrumentation system may exist in combination with the control system. Figure 3 shows the features of the safety instrumentation system in the MICREX-NX.

(b) Safety matrix

The safety matrix is a tool that facilitates engineering of a safety instrumentation system. By using the safety matrix and a CFC (continuous function chart), software for a safety instrumentation system can be generated easily. When safety conditions have been input with the safety matrix, a CFC deployed with the required safety function blocks is generated automatically. The safety matrix also provides several other functions in addition to engineering.

① Upon activation of the safety instrumentation system, the operating conditions can be displayed graphically on a HMI (human machine interface).
② The safety matrix also has an auto report function for verification, maintenance-use and system improvement.

By using the safety matrix, a safety instrumentation system can be designed relatively easily, and at the same time, the required condition display and analysis data can be provided to the HMI.

(4) Functional extension with MICREX-NX/V7.0

In June 2008, the MICREX-NX V7.0 was released,

Fig.3 MICREX-NX's safety instrumentation system

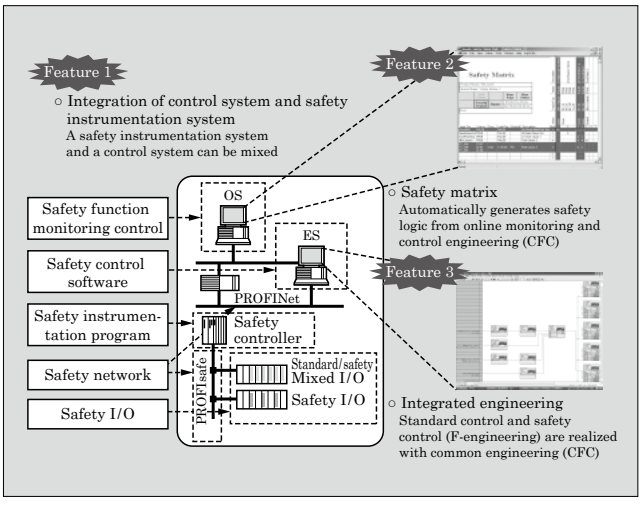


Table 1 Main functional improvements of MICREX-NX/V7.0

Category	Functional improvement	
Hardware	Industrial PC 547B (dual core processor, gigabit Ethernet)	
	Controller-use CPU (memory : 30Mbyte, instruction execution speed : 18ns)	
Operation	Alarm management	Alarm filtering for each process status
		Operator-based message limiting
	Expanded trend functions (online/archive trend mixed display, storage of trend data)	
Engineering	Version control	
	Multi-user engineering (via a network)	
	Batch control and route control system linkage	
Package/library	Advanced control	Model predictive control (MPC)
		Control performance monitor (CPM)
	Operation support system	
	Asset management (stroke counter, operation time)	
	Web display of trend alarm long-term storage data	
Safety instrumentation	Safety matrix	
	Linkage with safety integrity level (SIL) computation and evaluation tool	
Security	Security communication module SCALANCE S (VPN compatible)	
	Windows user management and integrated logon service	
Migration	FL-net gateway	
	IPU-Ⅱ connection	
Miscellaneous (external interface, etc.)	External system connection station SPOSA (single point of system access, OPC/OLE DB IF)	
	PROFIBUS DP/FF link	
	PROFIBUS PA duplex	

replacing the previous V6.1. As shown in Table 1, the improved functionality of V7.0 includes increased performance of the control unit, stronger alarm management, including alarm filtering, enhanced multi-user engineering, and additions of model predictive control and the like to the package library. These improvements are described in detail in related articles of this special edition.

(5) Solution package

The MICREX-NX provides packages for each field in the various manufacturing industries and also provides many information management packages.

(a) Equipment management package
(b) Batch system package
(c) Root control package
(d) Operation support package

(6) Measurement system package for medium and small control systems

In addition to FOCUS which has been sold as a medium and small control system, and SIRIUS which is capable of supporting medium size control systems, in 2007 Fuji Electric released an SX instrumentation package for use with the "SX Simple Instrumentation System." All systems are configured with MICREX-SX, which is SCADA and a general-purpose PLC, but by applying Fuji Electric's expertise in measurement control to SCADA, an engineering environment and operation environment unchanged from those of the conventional DCS are provided.

3.2 Approach to industrial measurement instruments

Industrial measurement instruments form the basis for process equipment, and provide a critical function for productivity and quality improvements, preventive maintenance, and so on. Industrial measurement instruments are often separated from measurement and control systems in a business situation, and their features and differences are an important point for expanding sales. Fuji Electric's approach for various measurement instruments is described below and is listed in Table 2.

(1) Field devices

Representative field devices include gauge and differential pressure transmitters, flowmeters and temperature transmitters.

Transmitters have adopted de facto standards for their specifications and performance, and are fiercely competing in the global market. Additionally, there is progress being made in complying with requests for improved long-term stability, field network support functions, wireless transmission and SIL. This special edition introduces the "FCX-AⅢ Series of New Type Differential Pressure/Gauge Pressure Transmitters" that achieve improved long-term stability and small size.

Types of flowmeters include the differential pressure, electromagnetic and ultrasonic types and so on, and demand for the ultrasonic flowmeter is expected to increase due to its advantages of non-contact measurement and convenient installation. Fuji Electric is fo-

Table 2 Approach for main measurement devices

Function	Key technology	Approach	Main application fields					
			Oil, petrochemical	Electric, electronic	Steel	Food, medical	Environment	Water treatment
Absolute and differential pressure transmitter	Micro-silicon sensor; low power consumption; network	Support general-use (global standard) transmitter; safe; wireless	○		○	○		○
Ultrasonic flowmeter	Anti-bubble; pulse Doppler/transit time difference model	High accuracy, expanded diameter	○	○	○	○		○
Controller	High-speed control; high resolution; multi-zone optimal control	High level functionality; high accuracy; modular type		○		○		
Recorder	High-speed sampling; network	Expanded data accumulating function; multi-channel		○		○		
Gas analyzer	Infrared sensor; cross stack laser/solid electrolyte	Stack direct measurement; Multi-component simultaneous measurement	○		○		○	

cusing on ultrasonic flowmeters for measuring liquids, and has brought to market a high-precision hybrid ultrasonic flowmeter (combined method using transit time difference and Doppler effect) for certified measurements and an installed type that realizes a 0.2 s high-speed response and has a reduced size and that targets the semiconductor field (water purifying apparatus), the PA field and the management of the supply and discharge of water from factories and offices.

(2) Recorders and controllers

Recorders are transitioning from paper-based recording to paperless recording. A diversity of communications, logging and data accumulation functions, multi-channel and high-speed switching performance and functionality are requested and development is progressing to support those requests.

Demand for the single loop controllers used in the first stage process instruments was driven mainly by replacement demand. In medium and large-scale systems, controllers are being replaced by DCSes and PLCs, and in small-scale systems, are being replaced by functionally upgraded temperature controllers and other general-purpose controllers. Temperature controllers to be incorporated into machinery equipment are transitioning from a box type (panel embedding type) to board and modular types (without a display control panel), which are becoming the most common types of temperature controllers. Temperature controllers to be incorporated into machinery equipment are requested to provide improved control accuracy, expanded communication functions, and to incorporate multi-channel control, PLC functionality and the like, and development is progressing to support those requests. This special edition introduces Fuji Electric's PUM multi-loop modular controller.

(3) Gas 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 infrared absorption type, zirconia type, and paramagnetic type analyzers are based on traditional measurement principles, but are also equipped with multi-component measurement functions, and expanded calculation functions such as auto calibration. A cross stack type (that directly attaches a sensor to the stack) using a laser has recently been introduced.

The market for environmental monitoring is growing rapidly with the increasing protection of the global environment and strengthening of regulations in China and elsewhere, and in May 2007 Fuji Electric released the ZRE single beam infrared gas analyzer for monitoring emission gases from a stationary source. This analyzer has a simple construction and is capable of measuring five components (NO_x, SO_2, CO, CO_2 and O_2) simultaneously. The ZSS cross stack laser gas analyzer introduce in this special edition has also been released on the market.

3.3 Approach to infrastructure development for measurement and control technology

Measurement and control technology is fundamental technology in all manufacturing industries, and is a core technology that consolidates the technologies of such diverse fields as steel, petrochemical and water treatment.

Fuji Electric has positioned measurement and control technology as a core competence and, to improve that technology, is basing its approaching to the infrastructure development on the following types of keywords.

(a) Safety instrumentation technology
(b) Control technology
(c) Systemization technology
(d) Embedded software technology
(e) Network and wireless technology
(f) Sensing technology

With these technologies, solutions can be provided for all industries and society, not only for process automation.

4. Postscript

Automation systems are becoming increasingly important in order to comply with requests for improved safety and security of manufacturing systems, higher operating efficiency and improved quality, to support a decreasing birthrate and aging population in the future, and to implement generational changes.

This special edition introduces Fuji Electric's approach to the safety and security of an automation system, provides examples of solutions, and discusses the control technology and measurement devices forming that foundation. Fuji Electric intends to continue to focus on the latest technology, extend it to system development, and to release distinguished systems in a timely manner.