

Instrumentation and Control Technologies Supporting Solutions: Current Status and Future Outlook

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Outlook

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1. Introduction

The industrial infrastructure business of Fuji Electric targets factories, facilities and industrial parks to provide our customers with a “smarter operation” through three pillars: “a stable energy supply,” “the realization of energy savings” and “the provision of safety and security.” By focusing on the entire production activities of customers, we are able to provide solutions for all of the life cycles of equipment and facilities. Fuji Electric has positioned its instrumentation and control technologies as fundamental technologies of industrial infrastructure businesses, and by organically connecting equipment and facilities through control technology, sensor technology and network technology, we achieve visualization and supply solutions.

In this special issue, we will introduce some applicable solutions of instrumentation and control technologies, as well as the latest technologies and components that support them. In this paper, we will describe the current status and future outlook of solution supporting instrumentation and control technologies.

2. Market and Technology Trends

2.1 Customer challenges and needs

(1) Meeting the needs of globalization

Manufacturers are being desired to meet overseas need to supply their products to the market in a timely manner. In addition to placing manufacturing bases near promising markets, they are being integrated in countries and regions that provide low cost manufacturing through reduced labor costs, etc. To meet these needs, integrated management of distributed sites, global supply chain management, security and intellectual property protection are all very important.

By mixing in human resources of different cultures, it is required that there be work standardization, work history management and a safety design

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for conventional on-site equipment. As a result, various efforts are made at establishing international standards to meet these needs.

(2) Meeting the needs of an environmental society

It is strongly desired that measures be taken to suppress global warming and achieve zero-emission operations. Besides, Japan has been aiming at a sustainable environmental society, giving consideration to recovery from the Great East Japan Earthquake in March 2011. In order to achieve this, we have been making efforts to achieve a sustainable social framework that provides efficient in-house power generation including natural energy sources such as solar power, as well as realizing the miniaturization of facilities and equipment, and steady monitoring and enhancement of operation efficiency. One effective measure is in the proliferation of electric vehicles and plug-in hybrid vehicles (PHVs) and the development of infrastructure such as quick charging stations has also been making progress. From the environmental aspect, in order to respond to toxic substances control measures including the “Air Pollution Control Act” and “Water Pollution Control Act,” we need to measure in real time the release of discharged gases and drainage from plants under adverse conditions (low concentration, very small quantities and with high dust) and to optimize drainage control using the measurement result.

(3) Ensuring high reliability and safety

Regardless of the age of facilities, higher operating rates are demanded in those of production sites, and there needs to be minimization of shutdowns and opportunity losses that accompany accidents and damage to equipment. On one hand, developed nations such as Japan have to deal with the increasing number of retirements of skilled personnel engaged in on-site work, which also leads to concern over response to emergency situations. In addition to a high level of reliability and safety being required of facilities, operation support technologies are being anticipated that can predict the lifespan of facilities and equipment, as well as detect early abnormal signs so as to induce maintenance measures before accidents occur.

In order to achieve these goals, facilities need to be equipped with intelligence functions for self-diagnosis and functional safety so that even if an accident were to occur, operations could continue through redundancy of equipment and other measures. Furthermore, systems themselves are being required to provide appropriate operating guidance and assistance to workers to respond to non-steady states such as abnormalities, start-ups and shut-downs.

2.2 Technological trends⁽¹⁾

We will now introduce some of the trends related to the major technologies for meeting the challenges and needs of customers.

(1) International standardization

Standardization in the instrumentation control field of industrial processes is making active progress through alliances to create standards such as TC65 (industrial process instrumentation control) of IEC (International Electrotechnical Commission), TC8 (system aspects related to the electrical power supply), TC59 (performance of household electrical appliances) and TC95 (measuring relays and protective devices). Among these efforts, action is being taken toward the establishment of interoperability standards such as field networks and wireless for industrial uses, as well as environmental and safety standards including control system security (IEC 62443) and functional safety (IEC 61508), while also taking action to standardize activities related to management planning, etc. Machine and equipment safety is also making progress in various fields and equipment standards, especially with respect to the higher level standards of ISO 12100 (machine safety). This, in turn, has led to the introduction of safety instrumented systems in Japan.

(2) Field networks

With regard to field networks*¹, various networks are standardized and utilized according to the characteristics of the field in which the networks are intended to be used.

In the field of factory automation (FA), PROFIBUS/PROFINET, EtherNet/IP and CC-Link have been becoming mainstream as network protocols. Among these, EtherCAT, MECHATROLINK

and PROFINET IRT have become the mainstream for drive systems that require high precision and high speed.

In the process automation field (PA), 4 to 20 mA analog communication is still the standard, but digital communication via protocols such as HART and FOUNDATION Fieldbus are gradually gaining acceptance.

For wireless applications for industrial uses, utilization has begun for instrumentation applications via wireless protocols such as the WirelessHART and ISA100.11a standards, even as the protocols continue to be developed to overcome reliability issues. Furthermore, with regard to wireless technologies for industrial uses, standards among TC65 of IEC are being discussed in order to establish a framework that supports the coexistence of various wireless systems (wireless coexistence).

(3) Field equipment technologies

In order to facilitate sensor installation and maintenance, there has been a greater need for wireless sensors, as well as long-term drive and maintenance-free sensors supported by batteries and self-powered technology. To achieve this, MEMS*² technology has been utilized, aiming at miniaturization and power savings.

From the aspect of plant asset management, demand has been increasing for field equipment that have intelligent functions for storing and transmitting various information such as their model type, life expectancy based on operation time and usage frequency, etc.

In general, instrumentation sensors expand the range of conventional temperature, pressure, flow rate and level sensors. From the viewpoint of safety and security and environmental measures based on past earthquakes and accidents, radiation dosimeters, vibration sensors and exhaust gas analyzers have been attracting attention.

3. Fuji Electric's Efforts in the Field of Instrumentation and Control Technologies

3.1 "Connection" concept

Fuji Electric's industrial infrastructure business has developed the following menu of five solu-

*1: Field Networks

These are industrial use networks which mainly aim at control communication between controllers and field equipment. They make notification to controllers with regard to values such as temperatures, pressures, speeds and positions that were measured in the field equipment related to process automation (PA) for petrochemical plants and factory automation (FA) for

automobile manufacturers, etc. Optimized control is carried out by notifying I/O and actuators of the results calculated by the controller based on the various measurements.

*2: MEMS

This is an acronym for "Micro Electro Mechanical Systems." It can also refer to micro machines. This is the generic name

for devices that integrate components such as sensors, actuators and electronic circuits in silicon substrates featured in semiconductor process technologies. As application examples, this technology is seen in the small nozzles at the heads of inkjet printers and in pressure, acceleration, flow and vibration sensors.

tions for helping our customers achieve a stable and enhanced production capacity and lower production costs.

(1) Stable supply of energy solution

This is a solution for supplying the stable amount of energy required by factories and plants.

(2) Energy savings solution

This solution achieves total energy savings ranging from the energy savings of individual equipment and facilities at manufacturing sites to advanced energy management of an entire factory.

(3) Safety, security and environmental solution

This solution realizes an environment devoted to secure “manufacturing.”

(4) Automation and efficiency solution

The solution achieves automation and efficiency results from the viewpoint of entire optimization.

(5) Stable operation of equipment solution

This solution supports the stable operation of various facilities and equipment.

As shown in Fig. 1, the instrumentation and control technologies conceived by Fuji Electric “connect” the elemental technologies of control systems, measuring equipment and sensors, radiation equipment, power electronics and advanced control technologies, as well as become a core fundamental technology bearing the control scene of the solutions. (Refer to “Instrumentation and Control System Solutions to Support Stable Operation, Energy Efficiency and Environmental Conservation” on page 10 and “Drive Control System Solutions Utilizing High-Speed Controller and Large-Capacity Network” on page 16.)

Fuji Electric has constructed control systems suited to the scale of operations through a control system platform, and in addition to this, is working to solve the diverse challenges of its customers through various technologies represented by its advanced control technologies, environmental mea-

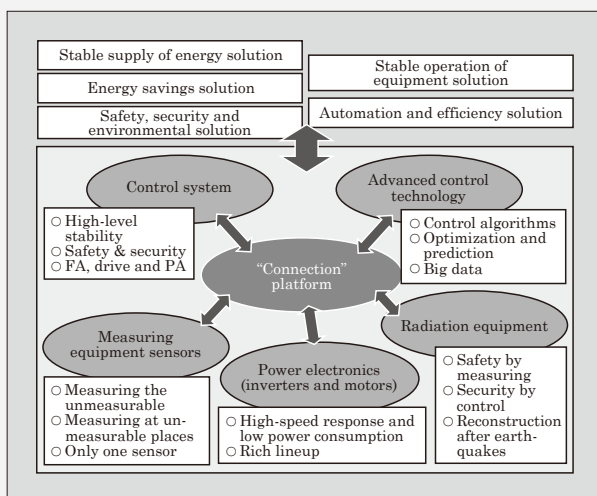


Fig.1 Fuji Electric's instrumentation and control technologies

surement technologies, and service technologies.

3.2 Control system platform

In order to achieve our “connection” concept, we developed a control system platform (see Fig. 2). This platform consists of a control system layer, software library layer and engineering environment.

The control system layer is composed of a controller, network, HMI, database, etc. We have a rich lineup of various components to obtain an optimal cost performance that corresponds to the system scale and facility importance ranging from simple constructions consisting of only a controller and I/O to highly-reliable redundant systems.

The software library layer is an extremely important component of the control system platform. There was a time when the evaluation of the control system was determined mainly by the performance and functionality of hardware, which was represented by the controller and network. However, in today's world, with the remarkable evolution of hardware technology, engineering (quality, lead time, cost reduction, etc.) has become much more significant. The software library layer is the component that corresponds to this change, and it consists of a group of software that has made common the advanced control technology developed by Fuji Electric over many years, which is used in each industry, organization and product. Fuji Electric is dedicated to accumulating its control technologies and is making efforts to ensure that the latest technologies have commonality in the future. This software library layer can be used freely

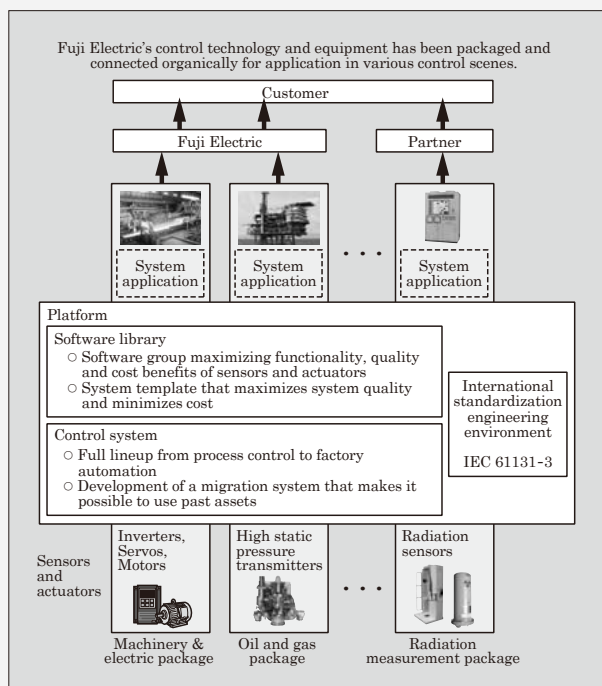


Fig.2 Control system platform

from the application constructed on the control system platform.

The engineering environment has been integrated to comply with the international standards IEC 61131-3, and the control software that functions on the platform can be handled in a manner that is globally integrated regardless of the software library or application, thus maintaining compatibility not dependent on the application system.

Separate industry packages (industry dedicated functions) such as a continuous process control system, batch process control system, drive control system and power generation system have been built on the control system platform, allowing for solutions that meet the needs of each industry.

3.3 Control system

Figure 3 shows Fuji Electric's monitoring control system position map. The "MICREX-NX" is a control system for large and medium scale operations, and it conforms to several international standards such as IEC 61508 (functional safety), IEC 61511 (safety), ISA S88 (batch control), FDA 21 CFR Part11 (electronic records and signatures of food and drug products). It has been mostly used in iron and steel energy centers, as well as in the chemical, pharmaceutical, and water treatment fields. Since commencing sales in 2004, over 250 systems have been sold and delivered. (Refer to "Information and Process Control System to Support Stabilization and Safety, 'MICREX-NX'" on page 27).

The "MICREX-View" is a control system for medium and small scale operations, and this series provides a lineup of systems that meet various scale and cost requirements.

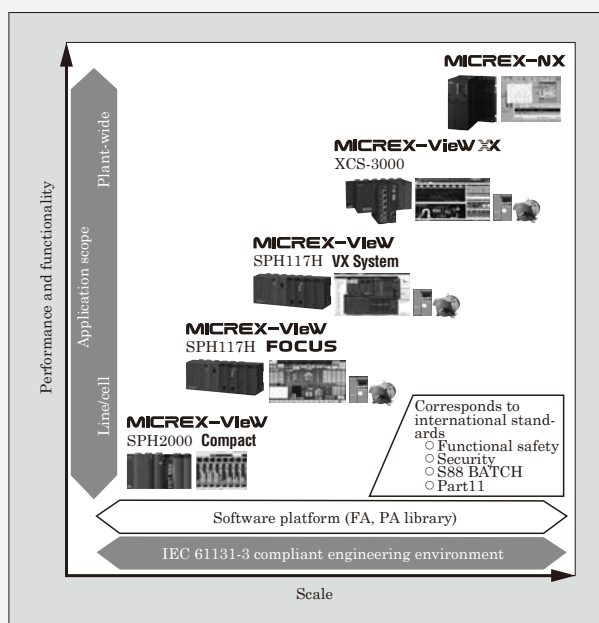


Fig.3 Fuji Electric's monitoring control system position map

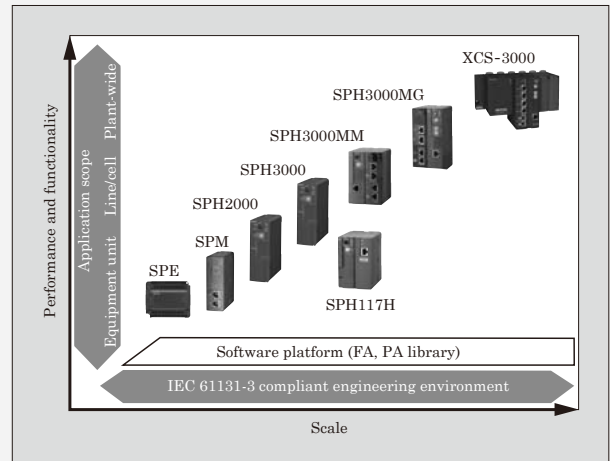


Fig.4 Fuji Electric's controller position map

In addition, we have developed the "MICREX-View XX (Double X)" and added it to our lineup. This product has been built on a control system platform that maintains compatibility with existing systems, while also providing the latest operation and engineering functions. This is a highly reliable system capable of making the controller, network, I/O, HMI, database and other individual devices redundant in duplicate as necessary. (Refer to "Small- and Medium-Scale Monitoring and Control System to Realize Inheritance and Evolution of Customer Assets, 'MICREX-View XX'" on page 33, and "Latest Operation and Engineering Functions of Small- and Medium-Scale Monitoring and Control System, 'MICREX-View XX'" on page 38.)

Figure 4 shows the controller position map that makes up the control system layer. We have a lineup that meets the application scope, scale, and cost of our customers ranging from components to systems capable of advanced redundancy. Our lineup can be applied to a wide variety of applications such as single machine control, line control that performs high-speed and high-precision synchronous operation of inverters and motors, turbine control, continuous process control and batch process control. All controller engineering environments are compliant with IEC 61131-3 international standards, and software has been created to be compatible with other products. (Refer to "Integrated Controller Realizing Machine Control and Advanced Motion Control, 'MICREX-SX Series'" on page 43.)

3.4 Advanced control technologies

For safe and optimized control of factory facilities and plants, various control technologies have been developed.

Fuji Electric has developed various technologies while focusing on the following core technologies in order to make advanced automatic control possible. As prediction and diagnosis technologies,

we have developed our own original neural network technology, as well as the multivariate statistical process control technology; as optimization technologies, we utilize mathematical programming and meta-heuristics^{*3}; as control technologies for stably operating plants, we have developed technology for multi-variable model predictive control, as well as a control performance monitoring technology that diagnoses the structural deterioration of plant control functions. However, there are many cases in which skilled personnel are required to respond to non-steady states such as abnormalities and plant start-ups and shutdowns. Therefore, the matter of inheriting technologies is becoming an issue for many of our customers. There is a trend of increased interest in data analysis technologies in which large amounts of historical data measured at plants are analyzed and the analysis results are used to respond to non-steady states. Fuji Electric has been developing solutions to these types of problems through our multivariate statistical process control abnormality diagnosis technology, quality estimation technology that utilizes the partial least-square method and skilled personnel operation pattern analysis technology via pattern mining. (Refer to “Data Analysis Technology in Plant Control” on page 21.)

3.5 Environmental measurement technologies

Fuji Electric has a lineup of industrial gauges that include pressure and differential pressure transmitters, flowmeters, water level gauges, recorders, and controllers. In addition to these products, we continue to work to develop other environmental measurement technologies and products.

In order to carry out recovery and reconstruction after the Fukushima Daiichi Nuclear Power Station accident, there has been increasing need for a wide variety of radiation equipment and systems. Fuji Electric has been developing radiation monitoring technologies for over 40 years and has been able to quickly respond to this need. We have developed technologies for a wide range of applications including lightweight, compact and easy-to-use personal dosimeters and portable body surface radiation monitors, and environmental radiation measurement technologies such as transportable monitoring posts and a wide range of dose monitoring devices, as well as the miniature and portable devices for depth direction soil radiation concentration distribution monitoring. We have also developed food radiation measurement systems for which expertise and pre-processing are not re-

quired. These types of developments have helped us contribute to safe and secure radiation monitoring activities.

Efficient fossil fuel burning is one of effective measures to reduce CO₂ emissions. Furthermore, the reuse of the discharged gas is also an effective measure. In order to achieve these types of goals, Fuji Electric is working to develop laser gas analyzer technology. Since the analysis time is extremely fast at 1 to 5 seconds, we are able to remarkably improve the precision of combustion and exhaust gas recovery control, allowing us to contribute greatly to reducing CO₂ emissions. (Refer to “Cross Stack Laser Gas Analyzer Contributing to Energy Conservation, ‘ZSS’” on page 49.)

In addition, we have developed a MEMS applicable vibration sensor, and by using this, we have been able to develop and offer a structural health monitoring system (SHM) for diagnosing the structural safety of aging buildings and buildings subject to earthquakes. (Refer to “Structure Health Monitoring System Using MEMS-Applied Vibration Sensor” on page 54.)

3.6 Service technology

For our customers, it is a very important matter to be able to continue the long-term use, to the greatest extent possible, of production facilities that have been fully amortized. Fuji Electric has expanded its life cycle service to support stable and efficient operations in order to help solving the various issues related to aging facilities. In order to do this, it is essential to have diagnosis technology for each facility. We have developed a diverse range of diagnosis technologies including diagnosis technology of high-voltage circuit breakers and oil-immersed and molded transformers, as well as on-line diagnosis technology for rotating machines. At the same time, we are also working on an on-line monitoring technology that carries out diagnosis via a wireless network so that customer facilities can be diagnosed without having to suspend operations.

4. Future Outlook

Instrumentation and control technology has been conventionally applied mostly to process control systems. It was used for the partial optimization of “manufacturing” and its performance indicators included control functions, performance, reliability and initial investment cost. However, the application range of the instrumentation and control technology has greatly expanded and the

*3: Meta-heuristics

This refers to a basic framework of algorithms designed to accommodate both

specific problems in optimization problems as well as generic purposes. When modifying values from the initial values of solu-

tions, the behavior of organisms are mimicked as well as physical phenomena in order to obtain optimal values.

technology is now required to deal with vertical solutions ranging from manufacturing execution systems (MES) to supply-chain management systems (SCM). As a result, its performance indicators have also changed to place emphasis on overall optimization (TCO reduction) and facility and equipment life cycle costs. We are now being asked to go to the limits in offering new proposals and services based on our customer needs.

In order to meet these needs, we need to further accelerate integration between instrumentation and control technology and IT. By utilizing virtualization and big data analysis technology, we have been able to progress in developing solution technologies such as simulations, operation support, maintenance, and safe and secure proposals, as well as technology for control system security.

5. Postscript

Based on global market and technological trends, we have introduced the current status and future outlook of Fuji Electric's instrumentation and control technologies.

In the future, we will continue to enhance and expand our instrumentation and control technologies so that they become the basis of Fuji Electric's industrial solutions for providing a stable energy supply, energy savings, safety and security and environmental measures.

Reference

- (1) Kurotani, K., Todaka, Y. Current Status and Prospects of Measurement and Control Technologies. FUJI ELECTRIC REVIEW. 2012, vol.58, no.1, p.2-8.





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