The New Information and Control System MICREX-NX

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1. Introduction

Over the past two decades or so, distributed control systems (DCSs) have been widely used as plant monitoring and control systems, and have become a key component for supporting plant businesses centered on the fields of water treatment and measurement systems.

Until now, the most common type of DCS was a high performance, highly reliable "heavy DCS" constructed using mainly specialized hardware and software for widest application across all fields.

However, with the long-term stagnating economy, demand has increased in recent years for more efficient plant operation by sharing shop floor information throughout an entire company and by applying that information to production planning. Additionally, demand has also increased for a reduction in the costs associated with maintenance and engineering, and a "light DCS," which is a highly flexible DCS that can be applied selectively according to the application, and that uses open technology and advanced software to achieve vertical integration from the field level to the manufacturing execution system (MES) level is requested. This light DCS can also be applied to fields such as factory automation (FA) to develop horizontal integrated business solutions.

In response to these requests, Fuji Electric has developed a new information and control system, which we call the MICREX-NX. This paper describes the system configuration and presents an overview of the MICREX-NX.

2. MICREX-NX System Architecture

The MICREX-NX system is a highly reliable, high-performance system that is supported by the principles and concepts of Siemens Corporation's PCS7, based on joint development by Fuji Electric and Siemens. The concept of vertical and horizontal integration was conceived so that a single system can use a unified platform of hardware and software to process a wide range of control objects. In addition, Fuji Electric also plants to develop components capable of connecting to existing systems.

2.1 System configuration

The MICREX-NX system is configured from an operator station (OS) that is an operating and monitoring component, an engineering station (ES) used for setting various parameters, an automation system (AS) that is a control component, and an ET200 series that oversees process I/O. The OS uses an industrial PC and realizes a Windows*1-based open interface. The ES enables control programs and picture parts to be converted easily into libraries in order to increase manufacturability. The AS and the ET200 use a highly reliable programmable controller (PLC) and I/O. General versatility and high reliability are ensured by connecting these components to an Ethernet*2-based plant bus (industrial Ethernet) and a PROFIBUS as the field network. Moreover, with a batch system conforming to IEC61512 (ISA S88), compliance with the regulations concerning electronic records and electronic signatures as established by the US Food and Drug Administration (FDA) (FDA 21 CFR Part 11), the realization of a safety instrumentation system (IEC61508), and so on, the MICREX-NX complies with the latest international regulations and industry standards. (See Fig. 1.)

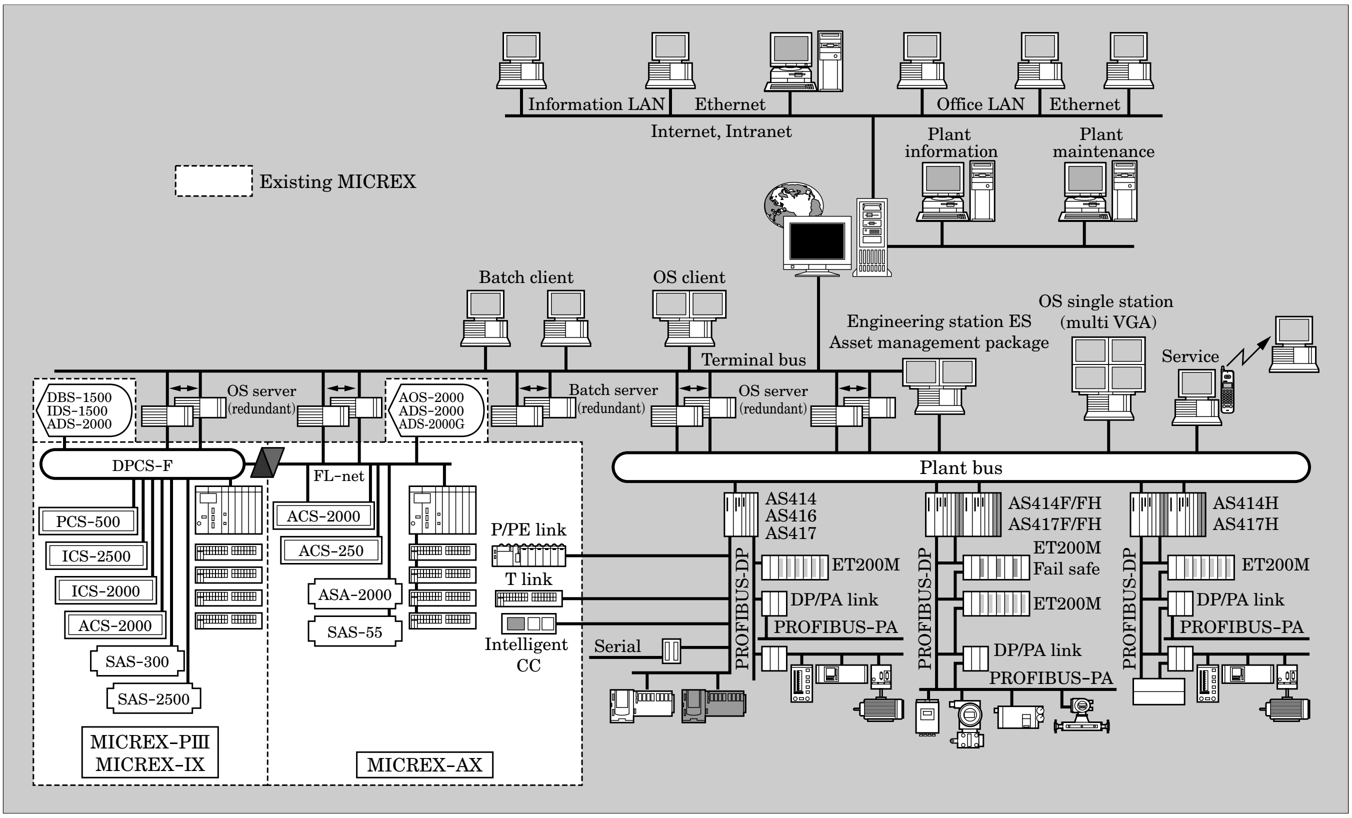
2.2 Vertical integration and horizontal integration

The MICREX-NX system is provided with standardized data management and communication features. The MICREX-NX component is installed in the main process, and many various specialized software packages are used in auxiliary process and for managing warehouse loading/unloading so that the shop floor is uniform with the same product architecture from upstream to downstream. This feature contributes to simplification of the work and to reduced cost in each phase, including engineering, operation, training and maintenance. Similarly, with this wide variety of

∗1: Windows is a registered trademark of Microsoft Corporation of the USA.

∗2: Ethernet is a registered trademark of Xerox Corporation of the USA.

Fig.1 Overview of MICREX-NX system



uniform components, products all having the same architecture can be supplied to the fields of industrial processing, machining, and the hybrid processing (field in which continuous, batch and discrete processes are mixed).

Moreover, integration of this data management enables information from the enterprise resource planning (ERP) and MES levels to be shared as far downstream as the field level.

2.3 High reliability

The MICREX-NX system is capable of complete redundancy. All components from the operating and monitoring component to the network, control system and I/O can be made redundant to protect against multiple errors in the system. Moreover, an event management function, advanced time synchronization and time stamp appending function, and an enhanced self-diagnosis function enable a rapid response to errors.

3. Engineering Station (ES)

3.1 Integrated engineering system

In conventional systems, the control and monitoring systems were engineered separately, and a considerable amount of time was required to define an interface between these systems. With the MICREX-NX, however, all engineering work – from field devices, network, and control applications to the operator station – is performed within an integrated environment. Control applications can be created using a sequential function chart (SFC) or a continuance function chart (CFC). A CFC block contains messages and all data related to monitoring and operation, and a block icon and faceplate for monitoring and operation-use can be generated automatically from a CFC-based control application. Accordingly, the engineering work in an operator station can be performed more efficiently, and because standardized picture parts can be used, the work involved in unit testing is reduced.

Figure 2 shows the automatic generation of parts for monitoring and operation.

3.2 More efficient engineering

(1) Extensive library

Standard components such as motors, valves and PID controllers are provided in advance as software objects in a library.

Because it is easy to create a user library, control applications may be reused, thereby improving efficiency.

(2) Enhanced simulation environment

Using simulation software, a control application generated from CFC or SFC can be tested on an engineering system without the use of an actual machine. As a result, errors can be detected and eliminated at an early stage, thereby enabling early shop floor commissioning and low-cost, high-quality program production.

Fig.2 Automatic generation of parts for monitoring operation

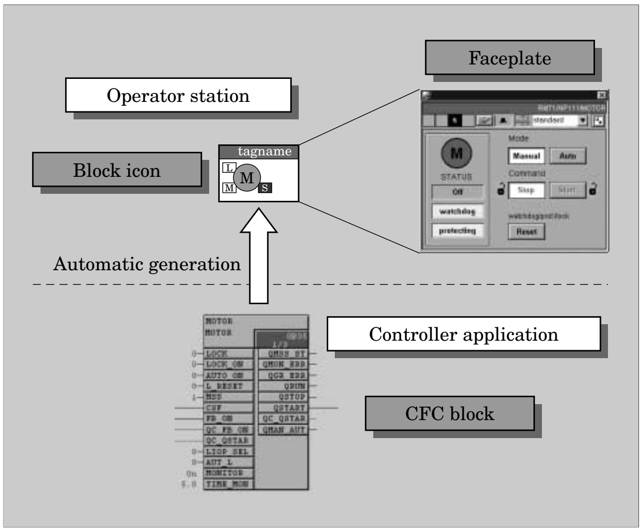
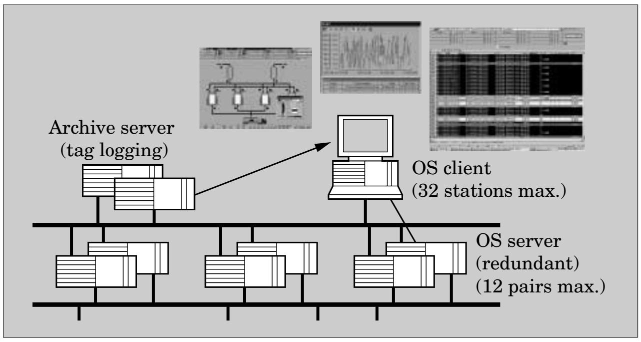


Fig.3 Overview of operator station



3.3 Multi-project engineering

So that a project can be constructed by several teams working in parallel, the project can be divided into sub-projects and engineering tasks can be performed individually. The individual sub-projects can be inserted or deleted from the project at any time.

4. Operator Station (OS)

4.1 System configuration

In contrast to the predetermined combinations of component elements and the number of component stations in the monitoring and operating component of a conventional system, the configuration of the MICREX-NX is scalable according to the size and extension of the object to be monitored.

(1) Single user system

A single user system is configured with a single operator station.

(2) Multi-user system with client server configuration

A multi-user system can be configured with a maximum of 12 OS servers and a maximum of 32 OS clients. Also, an optional archive server may be installed to provide server redundancy and to store large amounts of time-series data.

4.2 Features of the operator station

With a conventional system, the operation screen for each asset was controlled from a menu, and much engineering work was required to realize “intuitive operation” adapted for the actual object. In contrast, the MICREX-NX has the following characteristics.

(1) A standard function divides the entire plant into asset units that can be controlled as “areas.”
(2) Intuitive monitoring and operation of the targeted asset is achieved with a display capable of showing a maximum of five hierarchical structures within an area.
(3) Authorization settings for operator of monitoring and operation in each area enable security to be strengthened.
(4) With a loop-in alarm function, the plant screen for a generated alarm can be displayed simply with the press of a single button.

Also, two additional features are listed below.

(1) An SFC visualization function enables sequence control described by the SFC to be displayed and operated while the plant screen is being monitored.
(2) The display language can be switched online between Japanese and English.

Figure 3 shows the configuration of the operator station.

4.3 Plant monitoring screen creation function

A special screen creation tool having the features described below facilitates the creation of a plant monitoring screen.

(1) A customized object function can create parts (objects) for display.
(2) Operational settings can be specified easily with a dynamic wizard and a configuration dialog.
(3) OLE components can be embedded easily.
(4) A parts library for various drawings is included as a standard feature.
(5) An extensive standard library and a data processing function based on the two script languages of VB script and C script are provided.

5. MICREX-NX BOX

The MICREX-NX BOX is a system in which a PC card equipped with a control function is installed in an industrial PC. Functions of the engineering station, operator station and automation station are realized with this single component. The control function PC card is connectable to remote I/O via the PROFIBUS, and because the power supply system and control signal system (reset signal and the like) are separate from the PC body, control can continue unaffected by errors generated due to such PC-side events as a crash of the Windows operating system, interruption of the power supply, or the like. Potential applications

Fig.4 Configuration of MICREX-NX BOX system

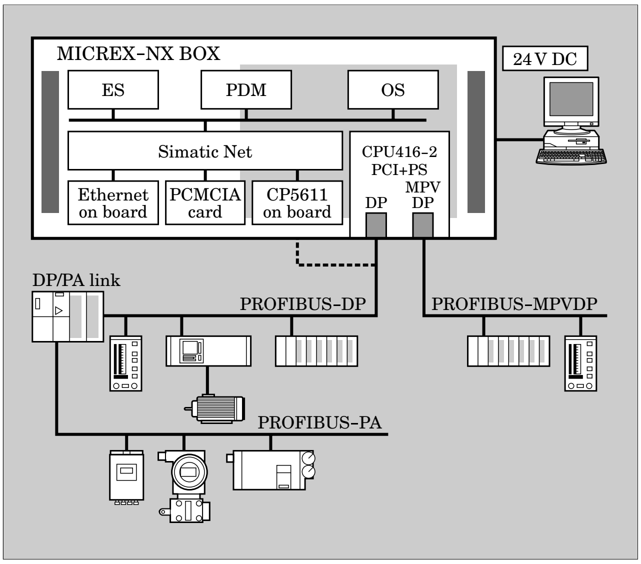
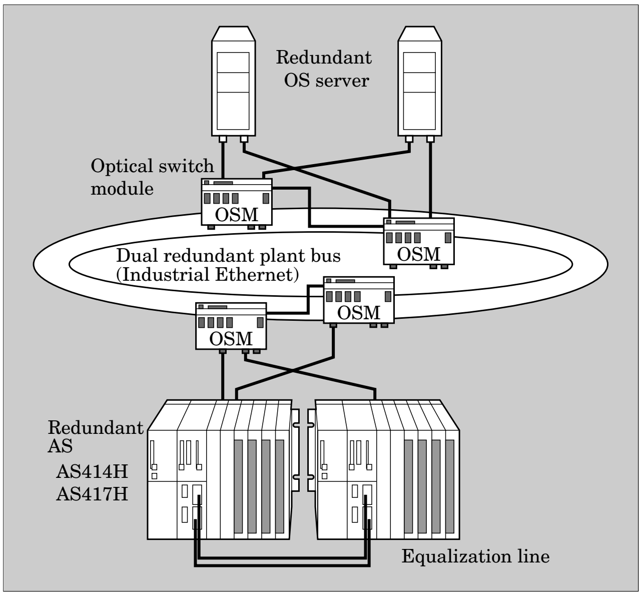


Fig.5 Redundant ring configuration



include small-scale plants, utility plants and systems for testing, instruction, training and research. The software and engineering data are shared with the OS client server system, and the design facilitates linkage to these systems and the expansion of their functions.

Figure 4 shows the configuration of the MICREX-NX BOX system.

6. Network

6.1 Features

The plant bus is a powerful cell network based on the IEEE 802.3 standard. An ISO protocol is used instead of the usual TCP/IP protocol.

Advantages of the plant bus are listed below.

(1) Capable of 100 Mbps transmission
(2) The plant bus is specially designed for industrial use and has excellent ability to withstand adverse environmental conditions.
(3) Redundancy can be achieved with an optical or electronic ring configuration. When an error occurs, changeover is implemented at a high speed of 0.3 seconds.
(4) Total length: 5 km (electrical), 150 km (optical)

6.2 Component hardware

The following hardware components are provided for the plant bus.

(1) Optical switch module (OSM)

An OSM is used in the case of a ring configuration formed from optical fiber cables. With a ring configuration, switching from error detection to loop-back can be implemented within 0.3 seconds. Up to 50 OSMs may be connected per ring.

(2) Electronic switch module (ESM)

An ESM is used in the case of a ring configuration formed from electronic cables. Other specifications are the same as those of the OSM.

(3) Communication module

The communication processor module (CP443-1) is a card for connecting an automation system to the plant bus. By installing a communication processor card (CP1613) in an operator station, that operator station may be connected similarly to the plant bus.

(4) Cables

The following types of cables may be used: multi-mode and single-mode optical fiber cable, and twisted-pair cable and electronically enhanced industrial-use twisted-pair cable.

Figure 5 shows the redundant ring configuration.

7. Automation System (AS)

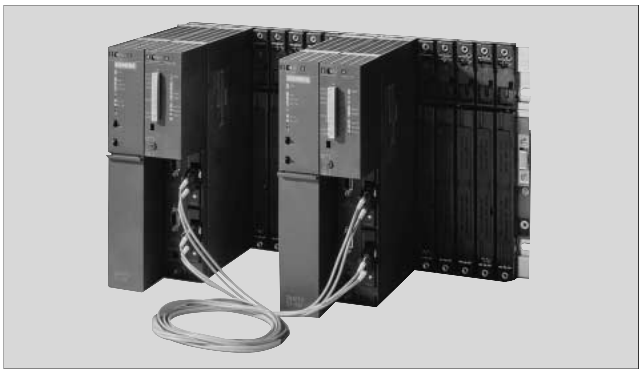
7.1 CPU duplex redundancy

Conventionally, controller redundancy has been implemented with a warm standby redundancy method based on the equalization of partial data and the like. With the MICREX-NX, however, controller redundancy is event-synchronous and is synchronized to the access of a memory area resulting from an external I/O data access or interrupt processing, or to the timing at which processing is performed, thereby enabling a changeover to the standby-side in less than 100 ms, instead of the approximate 1 s that had been required in the past, and is applicable to plants in which even a short interruption of operation not permitted. Also, this mechanism eliminates the need to consider system redundancy when creating an application.

This redundant system is configured from two redundant CPUs and sync cables connected between the CPUs, two PROFIBUS systems, and a remote I/O (ET200M) that is connected to both PROFIBUS systems.

The CPUs are synchronized with two sync cables

Fig.6 Appearance of the automation system



(optical fiber cables) and four synchronization modules.

Two PROFIBUS slave interface modules (IM153-2) are used in the remote I/O so that the interface is also made redundant.

Figure 6 shows the appearance of the automation system.

7.2 Control language

Various languages have been developed to promote the standardization and modularization of programs.

(1) Continuance function chart (CFC)

A CFC is an image of a process flowchart, and is created by connecting the various function blocks with lines on an editor.

(2) Sequential function chart (SFC)

Conforming to the SFC of IEC61131-3, this language aims for control that can easily divide a process into phases.

(3) Standard control language (SCL)

This language conforms to the structured text (ST) of IEC61131-3. This is an advanced language suitable for sophisticated data processing.

8. Process I/O (PIO)

The MICREX-NX PIO is provided with remote I/O and direct I/O functions. The remote I/O is capable of realizing distributed control via the PROFIBUS. The PROFIBUS is an excellent network for remote I/O and is standardized in Europe, but is also becoming a worldwide standard. With the production of many varieties of components from Siemens Corporation or third party manufacturers, the PROFIBUS can readily be used in various types of plants. The transmission speed of this PROFIBUS is selectable up to 12 Mbps according to the intended use, and the cable length per segment may be extended up to 100 m.

The ET200M remote I/O consists of a power supply module, a PROFIBUS module, and up to eight mountable I/O module panels. Many types of I/O are available for the ET200M, and this I/O module enables the basic I/O range to be set according to the measurement range software setting. Moreover, CPU rack redundancy and PROFIBUS I/O transmission line redundancy can also be supported. I/O capable of being made redundant is also available. Each type of I/O has a self-diagnostic function, and therefore, detailed I/O diagnostic information can be displayed at an OS or ES. Of course, I/O modules may also be added and parameters may be changed during operation.

9. Plant Control Package

A wide variety of plant control packages such as batch control and pipe route control are provided for the MICREX-NX. The batch system is described below as a representative example of a batch control package.

9.1 Overview of the batch system

The batch system is a package suitable for today's market needs and complies with IEC61512 (ISA S88), the international standard for batch control, and with FDA 21 CFR Part 11, for which there is strong demand for compliance in the pharmaceutical industry.

9.2 Features of the batch system

(1) Plant hierarchy

The batch system enables a hierarchical structural design that complies with ISA S88.01. A hierarchical structural expression enables the clear identification of which device is being used in which process, and the flexible use of devices according to the product line.

(2) FDA 21 CFR Part 11 compliance

The batch system package satisfies the requirements for access management, electronic signature, data storage, audit records and the like, as specified by FDA 21 CFR Part 11. An access authorization setting enables the plant to be protected from operation by an unauthorized operator. The batch system can also perform such tasks as recording the operating history of an operator, and storing historical data of executed production processes.

(3) Creation and modification of recipes

By using the batch system control center from which monitoring and operation is usually performed, the operator is able to create and modify recipes. The operator can customize the production volume, devices used, and all items used in batch processes up until the production process.

10. Conclusion

The trend toward vertical and horizontal integration will continue in the future, and flexible system configurations (open or multi-vendor configurations) according to the individual plant will be required.

Under these circumstances, in order to continue to satisfy user needs, Fuji Electric will continue to manufacture DCS products that facilitate higher reliability, greater flexibility and long-term maintenance, in order to realize optimal solutions.