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FUJI ELECTRIC REVIEW

1

1999 VOL.45

Integrated Controller MICREX-SX Series

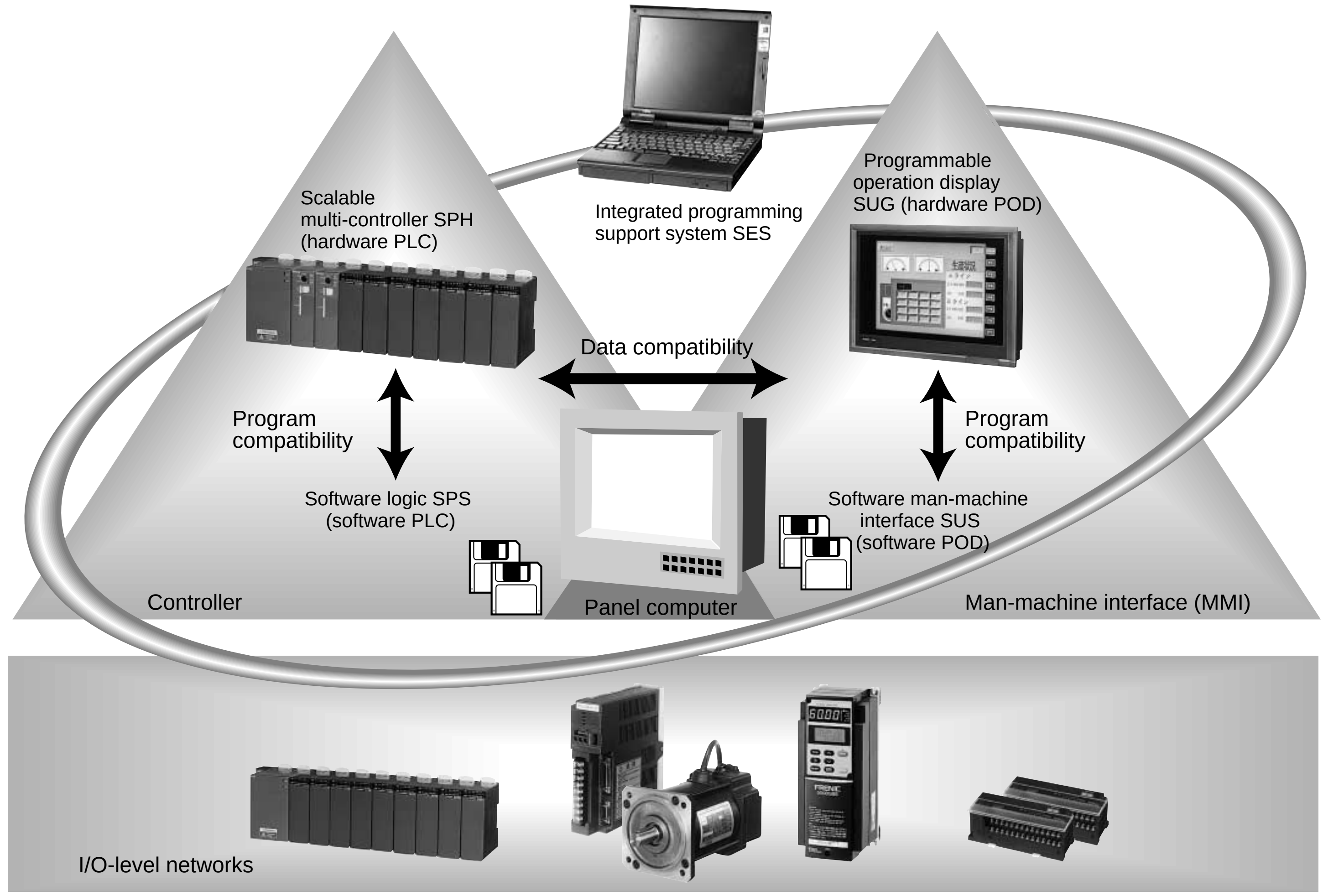
FUJI ELECTRIC

Creating a Better Tomorrow with Trustworthy Technology

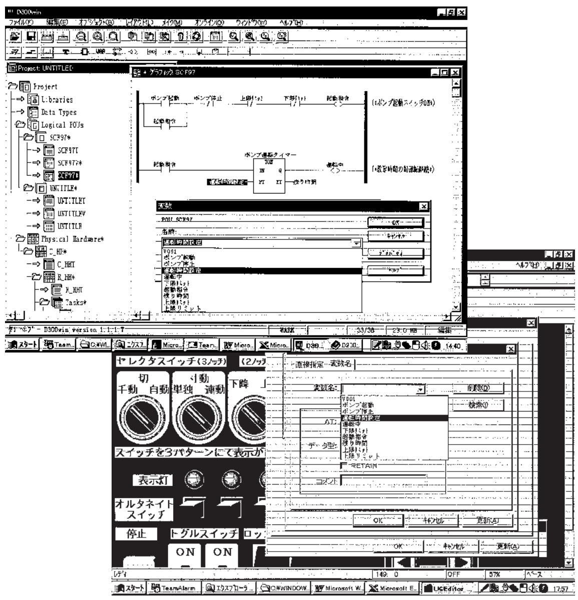
Integrated Controller

MICREX-SX Series

meets Open Systems and unifies Control, Operation, and Monitoring.



A programming display by the scalable and multiple controller



A programming display by the man-machine interface

The integrated controller MICREX-SX series realizes program compatibility, common use of data, and a unified operation environment.

● Scalable multi-controller SPH (hardware PLC)
Realizes a 1-ms control by load distribution with multi-CPU structure and high-speed processing with execution time of 20ns per instruction. This controller realizes the optimum system construction in every case of control and is the next generation controller far beyond the concept of existing programmable controllers.

● Software logic SPS (software PLC)
Uses IEC standard language common to the SPH. Can connect to the SX bus and various I/O-level networks.

● Programmable operation display SUG/software man-machine interface SUS (hardware POD/software POD)
The two lines of exclusive-use hardware SUG and personal computer-use man-machine interface SUS are available. Graphic Display data is compatible between both types.

● Integrated programming support system SES
Supports the controller and the man-machine interface in the unified operation environment.

Fuji Electric's Integrated Controller
MICREX-SX Series

FUJI ELECTRIC
REVIEW

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Cover Photo:

In the recent Factory Automation industry, there has been a great demand for efficiency to make a system utilizing "the International Standards" and "the Openness".

Especially in the field of control devices, it is desired to achieve high efficiency in a total system with high performance programmable controllers and programmable operation displays.

The integrated controller MICREX-SX series make it possible to make efficient systems with open network interfaces, compliance with international standard IEC61131 and high speed and high performance control by multi CPU structure.

The cover photo is a collage of a scalable controller SPH of a multi-CPU system of MICREX-SX series, and displays of IEC61131 programming using D300win.

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Present Status and Prospects for Controllers

Ken'ichiro Ide
Haruki Tanaka
Takanori Takei

1. Introduction

Now we are just at the entrance of the 21st century, remarkable progress in data communication is dramatically changing our social and economic structures.

Similarly, in the fields of factory automation (FA) and process automation (PA), progress in information processing, field such as open technology, multi-vendor supply, network technology, and multimedia technology, typically represented by personal computer systems, is advancing the fields of machine control and production line control. As the result, the appropriate state of so-called controllers is also greatly changing.

This paper examines changes in production systems caused by the flow of this information revolution or digital revolution and describes conditions of future controllers.

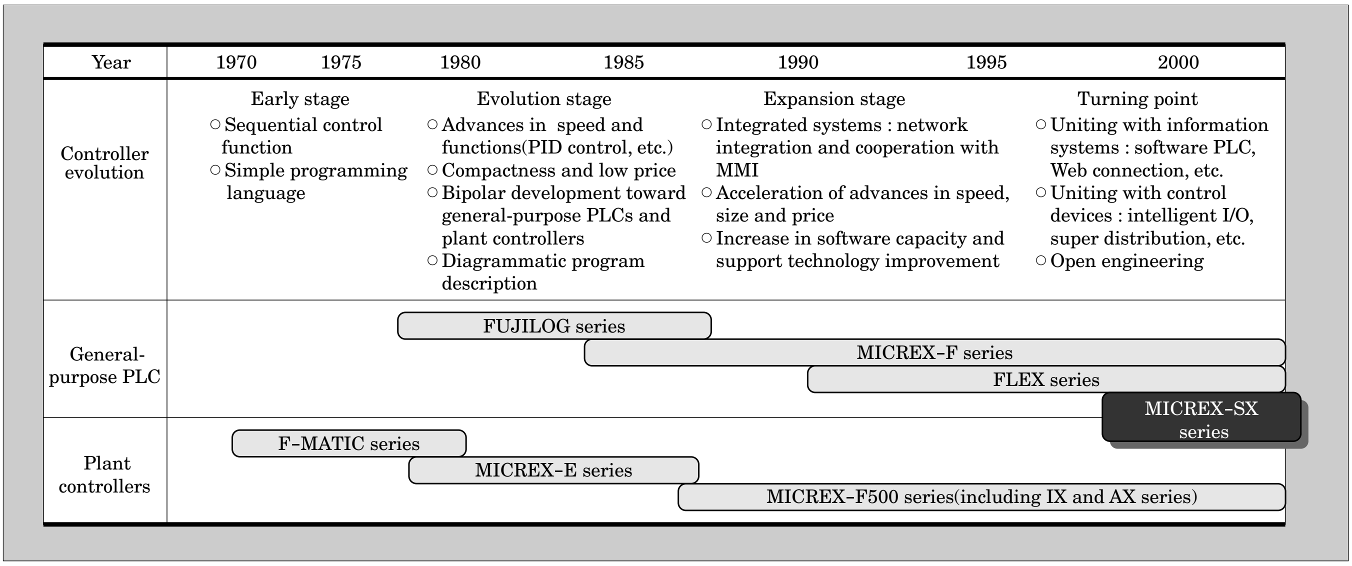
2. Developments and Present Status of Controllers

In 1968, General Motors in the USA presented requirements for industrial control equipment, and in response, several US companies announced products the following year, introducing the programmable controller (PLC). Since then, the PLC has rapidly grown with advances in semiconductor device technology and microprocessors, and has established its position as an indispensable component for control systems.

The relation between controller evolution and Fuji Electric's products is shown in Fig. 1. In its early stage, the controller aimed to replace the wired logic of relay control panels with software and had basic functions for sequential control (logic operation, timer, and counter) with several hundred I/O points. In Japan, controllers with 500 I/O points and a program capacity of 4k words were commercialized and were mainly and selectively used to replace relay panels in large plants.

Late in the 1970s, controller function and performance was rapidly advanced due to the advent of microprocessors, entering an era of full-scale development. Functions such as arithmetic operations, data processing, and proportional, integral and derivative (PID) control were realized in the upper-class controllers, as was high-speed processing. Because of these advances in high-speed processing and data processing

Fig.1 Controller evolution and Fuji Electric's products



function, the controllers were used for the online positioning and tension control of precision steel rolling mills and process instrumentation PID control. In addition to use as relay panel replacements, they were also widely used as plant controllers.

On the other hand, the downsizing and price reduction of small-scale controllers were accelerated, and demands for controllers with only a sequential control function rapidly increased, mainly for use in the machine control systems of the assembly and machining industry. Fuji Electric's small-size controllers, including the FUJILOG series, were widely marketed to users who would purchase the controller and develop programs by themselves. Thus a category of general-purpose PLCs, different from plant controllers, was created.

In the middle of the 1980s, when application specific ICs (ASICs) were put to practical use, the advance in functions and downsizing of controllers accelerated even more. It was the most active expansion period up to 1995. The application of plant controllers spread to various fields. This resulted in systems whose characteristics were developed for specific applications such as instrumentation distributed control systems (DCSs) and high-speed, high-reliability power generator control. At the same time, with the trend toward total systemization such as network integration and man-machine interface (MMI) cooperation, software increased in quantity, and software engineering support technology appeared as an important factor.

Advancing the general-purpose PLC to smaller size and lower price, while the installed functions became similar to the plant controller. While the general-purpose PLC evolved to offer remote I/O, to link drive control such as servos and inverters, and to connect with personal computers, its small size, low price, and advanced functions were the impetus behind a transition in controllers for the 21st century.

3. Changes in Production Systems

To consider appropriate conditions for controllers at this transition point, we will examine changes of the production systems in which controllers are utilized.

3.1 Changes in enterprise production activities

The manufacturing industry has recently shown various changes and seems to be at a major turning point. As a backdrop, changes have been observed in enterprise environments. Enterprises, whether willingly or not, have been fighting off tough international competition and are powerfully promoting various innovations to maintain and strengthen their competitiveness and ability to survive.

3.1.1 Measures for globalization

The rapid development of information and communication has completely eliminated national boundaries. Enterprises in the midst of tough international competition desperately push for globalization as an essential strategy. Such measures aim to expand sales in foreign markets and to aggressively promote overseas production while keeping an eye on production cost reduction, component procurement, and commodity logistics. Organic connections between overseas production bases and existing domestic production systems, that is, measures to increase the competitive advantage through so-called global scale production and logistic systems, are promoted irrespective of the enterprise scale.

3.1.2 Reduction in the total cost of ownership (TCO)

Cost competitiveness, the first requirement to beat the competition, is essential for survival. Reducing total costs, including all phases of production, is always a high priority. Consequently, enterprises are constantly promoting innovation in production systems.

(1) Construction of non-redundant production systems

In a period of high economic growth, manufacturing facilities were permitted to include some degree of redundancy, and in fact, redundancy intended for future modification was required. Today, however, for the purpose of thorough rationalization and improved efficiency, a system with a higher degree of freedom is under study. In this system, "a production system with neither excess nor deficiency, and well suited for the purpose of production is introduced and put into operation." "If there is any change in the production goal, the system can be quickly reconstructed at minimum cost and put into operation."

(2) Reduction in system construction cost

To effectively utilize the increased degree of freedom to reduce cost, systems and components that do not depend on the specifications of specific equipment manufacturers are under development. Under such circumstances, systems could be constructed by freely selecting and combining components, irrespective of the vendor, to minimize costs.

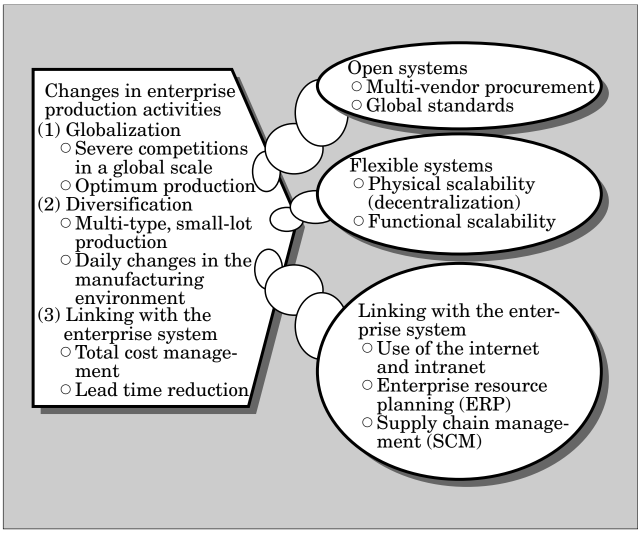
(3) Reduction in engineering cost

The cost of software production and maintenance after operation starts as a percentage of the total cost of a production system rises each year due to increasingly sophisticated systems. There is fear that this trend will result in a crisis. Enterprises continue to innovate software production methods and investigate outsourcing, including the outsourcing of maintenance.

3.1.3 Pursuit of total efficiency improvement

Needless to say, the recent market environment has greatly changed. The former method to efficiently mass-produce a few types of products has passed. The current method has changed to the production of many types of products in small lots. Daily changes in the production environment, such as order size, specifications, and the date of delivery, are normal. Such market environments exert a bad influence on enter-

Fig.2 Changes in production systems



prises, increasing the lead-time as well as increasing the total stock. As a countermeasure, enterprises are working to improve total efficiency by linking the enterprise information system to the production system online, and integrating the management of order entry, component procurement, and commodity shipment.

3.2 Desired production systems

What type of production systems will meet these demands for production innovation? Figure 2 shows required changes in production systems.

3.2.1 Open systems

The various components and networks of a production systems are all required to have open specifications. Open specifications means that "specifications for basic functions and operation procedures are open to the public and standardized, and this standardization is maintained among vendors such that users can freely select devices to construct systems." The current personal computer is a typical example.

Open specifications will release users from the monopoly of vendors and allow them to procure necessary functions and performance from arbitrary vendors anywhere in the world.

3.2.2 Unified engineering

As described above, the sophistication of production systems increases engineering cost. Improved software production efficiency is the main countermeasure to this problem. It is important that the software design method be universal, irrespective of equipment type and geographic region, and must comply with international standards.

From this point of view, the IEC standard for controller programming language [IEC61131-3 (formerly standard IEC1131-3 1993)] is worth special mention for a core component of production systems. This standard was established to unify program description methods and further standardize programming procedures based on software technology. Adopting this standard, we can expect the natural componentization and reuse of software, and a rapid improvement in software productivity.

3.2.3 Flexible systems

Flexible architecture systems that can satisfy requirements for constructing efficient systems suitable for production purposes and quickly reconstructing them to meet production modification are desired. A system with flexible architecture "has physical and functional scalability as well as high-speed processing and sufficient processing capacity." This phrase is important for the configuration of controllers as they prepare to change for the next generation.

3.2.4 Information technology (IT) connection

Previously, production systems were isolated from the enterprise information systems directly connected to enterprise management. However, when facing the tough competition mentioned above, to meet suddenly changing market needs, production systems linked in real-time to the management activities, or in other words production systems that can be connected to IT, are desired.

By linking production systems in real-time with enterprise resource planning (ERP) and supply chain management (SCM) systems through the intranet or other IT, a sufficient output can be maintained and it is possible to flexibly meet production schedule changes such as the date of delivery and quantity. Based on production system information, systems will gradually develop toward management strategic planning.

4. Controller Requirements

As production changes, controllers, the major components of production systems, are facing a turning point toward the 21st century. The keywords of object technology, decentralization, and open systems are required elements for this transition. These requirements, including those already actualized, are examined below.

4.1 Adequate control performance

There are high expectations for control performance, a basic controller requirement, with respect to both processing speed and software capacity. One goal is to achieve a processing speed with a 1ms control cycle. In a program with several ten thousand steps, the execution cycle for an instruction should be less than 50ns, and therefore, 10ns can be expected as a tentative goal.

With regard to software capacity (program step quantity), the transition from hardware processing to software processing has been advanced by progress in application technology such as software componentization. A software capacity of 100k steps will be required.

4.2 Degree of freedom in system construction

With conventional controllers, the selection of controller type determined the scale of the system and performance, and the system was constructed only by supplying the required number of I/O points. However, components must be supplied so that users can freely construct their own systems. Future trends are described below, key points of which will be physical and functional decentralization.

(1) Open I/O

There is already a trend for the I/O to be decentralized and connected by networks. A de facto standard for I/O connecting networks accelerates the flow of diffusion, and I/O modules will soon be available from multi-vendors.

(2) Multi-CPU

The CPU for controllers has become smaller and less expensive due to progress in semiconductor and control technologies. Multi-CPU systems that meet the needs of different applications by increasing or reducing the number of CPUs are gradually becoming more popular and will be the mainstream someday. Multi-CPU distributed control capable of localizing appropriate sections of application functions can rapidly improve the system robustness.

(3) Intelligent I/O

Intelligent I/O is another form of the multi-CPU system, the so-called functional distribution of CPUs. Intelligent I/O uses I/O and simple software to process functionally complete blocks at their process ends and will become an important element in the future. A future topic for intelligent I/O is the modeling of flexible communication between distributed applications, such as servomotor control.

4.3 Open engineering

Although controller programming had the common basic technique of ladder diagram description, manufacturers continued their own vendor-specific guidelines. Recently, however, the international standard IEC61131-3 has gradually come into general use. This can standardize not only program descriptions but also design methods. In particular, the method of software componentization is expected to promote object-oriented technology.

In any case, it will be necessary to provide an open engineering environment in compliance with this standard.

In addition, it is desired to coordinate controllers with the "C" and "Java"* general-purpose languages to apply the increasing capability of information processing engineers to control, and to practically apply technology-oriented programming (auto-programming) as a tool to maximally utilize the control know-how of shop-floor engineers.

4.4 Personal computer controllers

Due to advances in personal computer performance, there is a new trend toward utilizing personal computers formerly used for production management in lower-level control such as sequential control. This trend was accelerated by the open module architecture controller (OMAC) proposed by US automobile manufacturers. The idea is to install control, monitoring, and engineering functions on a single personal computer. The control part consists of software logic (software PLC) and is attracting attention as a new genre.

Many vendors have introduced software PLCs. Detailed service such as coordination with hardware PLCs and ease in connecting I/O units will become necessary conditions. Since a personal computer is the operating environment, the development of a "Java PLC", for example, is expected.

4.5 Information network controllers

The trend of production systems toward real-time connection to ERP and SCM systems through the intranet, an IT, so as to be incorporated into an enterprise information system is described above. It is necessary for controllers at this transition point to have a "flexible architecture", typically represented by open and distributed systems, as well as be connected to an upper-level information system through the IT. The first step will be the installation of network adapters in controllers, which provide Web server and remote message transmission by electronic mail to display the control status through internet or intranet. In the near future, control servers with the same distributed object capability as the information system will be installed in controllers, and the enterprise information system will freely download execution orders to controllers. Therefore, an ideal enterprise manufacturing system will be realized in which the operation of information and control systems is seamlessly linked.

5. Fuji Electric's Activities

Ever since the first controllers were developed, Fuji Electric has supplied control systems to the fields of FA and PA. These control systems have had good results with many users. The controllers facing the transition to the next generation of production systems, particularly those controllers oriented to open systems, could not be realized without partially modifying the characteristics of our own controllers, which posed a difficult problem to Fuji Electric. To continue to be a reliable system vendor in the 21st century, Fuji Electric decided to introduce the new-generation integrated controller MICREX-SX series as shown in Fig.1. The MICREX-SX control systems are oriented to open systems, distributed system and object technologies.

*Java: A registered trademark of Sun Microsystems, Inc. USA

The goal of this series is to realize, as much as possible, the following future controller requirements.

(1) Integration of peripheral modules such as controllers and MMI
(2) Distributed placement of small modules by means of the serial bus
(3) Adoption of the IEC standard language and integrated support system with personal computers
(4) Realization of super high-speed processing (20ns) and multi-CPU
(5) Aggressive utilization of software modules
(6) Systematization inclusive of the software PLC
(7) Compatibility with de facto standard networks

The above list is also the goals for Fuji Electric's controllers 10 years from now. In the future, Fuji Electric will develop "flexible architecture", decentralization, and linking with IT.

6. Conclusion

Revolutions in production systems and controller requirements to meet them have been described.

In the future, controllers will unite with the upper-level information system through linking personal computers and IT, while super distributed systems toward integration with the control object will be developed. Fuji Electric will make efforts to go ahead of the times to continue to be a reliable control system vendor. We would appreciate it if users and parties concerned would give us guidance and support.

The MICREX-SX Integrated Controller Series

Yoh Kikuchi
Keiichi Tomizawa
Hiroshi Ishii

1. Introduction

Control systems in factory automation (FA) and part of process automation (PA) consist primarily of main programmable logic controllers (PLC) with personal computers (PC) for upper side data processing and programmable operation displays (POD) as man-machine interfaces (MMI) and include some networks with which these components are connected. Such control components are progressing towards higher speed, larger capacity and higher reliability. These advances seem never-ending.

In addition to original sequence control, functions required for PLCs are also expanding to include increased capability such as “networking and communication,” “data processing,” “operation and display,” and “motion control.”

Open networks, which have been common in the office automation field, are rapidly expanding in the control field as well. In the West, the de facto standard of networks, led by manufacturer initiative, include the popular PROFIBUS and Device Net. And in Japan, network standardization has been promoted by the Japan Electrical Manufacturers’ Association (JEMA) or the Manufacturing Science and Technology Center (MSTC).

Another trend toward open systems include a software logic (software PLC) or an open NC based on the hardware of PCs. In the past, PCs were used mostly for date processing or operation and display functions. But now they have the advanced capability of mounting PLC functions.

Moreover, standardization of a programming language is also progressing and as international standard [IEC 61131-3, or IEC 1131-3$_{1993}$ in the old number system] has been already established and widely adopted in the West. In Japan, exactly the exact same items have been standardized (JIS B 3503) and its application will be extended.

Reflecting the above-mentioned trends, Fuji Electric has developed the “MICREX-SX series” integrated controller beyond the usual PLC concept. The basic concept will be introduced below.

2. Basic Concept of the MICREX-SX Series

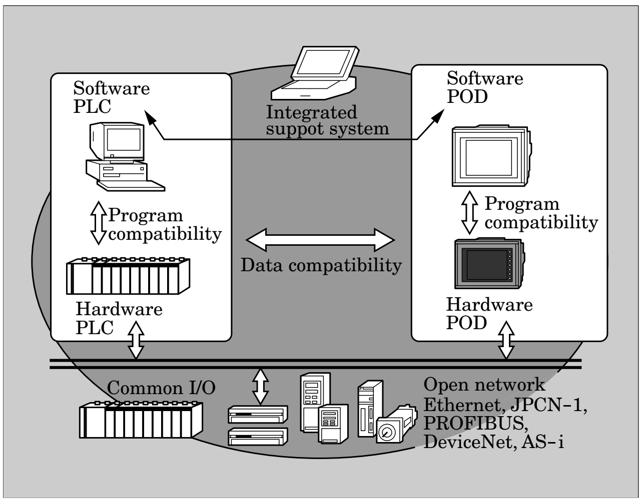
2.1 Integration of control, operation and monitoring

The MICREX-SX series consists of PLCs and PODs, as integrated controllers for control, operation and monitoring, and of the integrated support system (SES) which supports the programming for them. There are two types of PLCs and PODs. One is a hardware type which is realized by dedicated hardware, and the other is a software type which implements the functions on a PC. Figure 1 shows the concept of integrated control, operation and monitoring.

Between the hardware PLC (SPH) and software PLC (SPS), and between the hardware POD (SUG) and software POD (SUS), the programs have respective compatibility. This allows effective development of the programs without the need for recognizing the difference between execution systems.

SES is a software package which runs on a PC and completely supports the PLCs, including their peripheral modules and PODs. By having data managed with labels, easily structured programming is achieved, and the usual memory address management becomes needless.

Fig.1 Integration of control, operation, and monitoring



2.2 Preparation for international standardization and the open system

Measures for international standardization and the open system were reflected in development. A standard programming method which does not depend on model types has been achieved by adopting the international standard (IEC 61131-3) as the programming language. In addition, the hardware is based on IEC and JIS, and the acquisition of CE marking and the UL standard is achieved through standardization. The needs of the overseas markets are easily met.

Moreover, free configuration of the system has been made possible in order to meet a variety of open networks in Japan and the West. In addition, to meet the trend toward open systems with PCs as platforms, the software PLC and the software POD have been provided.

2.3 Scalable system configuration

The system, which was usually configured with several series according to performance and functions, has now been concentrated into one series in the MICREX-SX. For realizing this, several types of CPU modules are provided according to performance. Moreover, multi-CPU configuration with up to 8 CPUs has been attained.

Based on this, only one kind of process input output (PIO) and other types of function modules, except CPU modules, are provided for configuring scalable systems. The usual parallel type internal bus has been changed to a high-speed serial type bus (SX bus). This enables the extension of the internal bus, and, as a result, dispersed system installation for meeting high-speed control may be more freely realized.

3. Scalable Multi-Controller “SPH” (Hardware PLC)

3.1 High-speed control

For high-speed control like motion control, processing must be completed within a scan time of 1 ms. In the past, several milliseconds to about 10 ms was required. Recently the capacity of application programs is remarkably increasing and to meet this trend, instruction execution time speed is shifting from microseconds to nanoseconds.

For the SPH scalable multi-controller of the MICR EX-SX series, dedicated LSIs have been newly developed. The basic instruction execution speed has improved about 6 times, from 125 ns for Fuji Electric’s MICREX-F70/120S to 20 ns (the value for the highest performance model SPH300 of the series, and 70 ns for the standard model SPH200). As a result, calculation processing at a remarkably higher speed was attained and a scan time of 1 ms has been achieved.

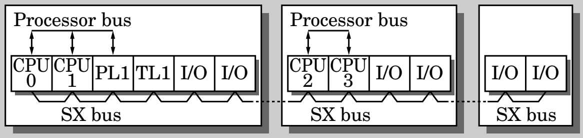
Scanning at 0.5 ms is available if the number of inputs and outputs (I/O) and the program capacity are limited and sufficient response is reserved for high-speed processing such as positioning in the control field.

For achieving the above-mentioned shortening of scan time, the I/O must be refreshed more frequently. The bus must be extended to reduce wiring in control cubicles through dispersion of the I/Os. For these requirements, the SX bus has achieved a transmission

Fig.2 High-speed control

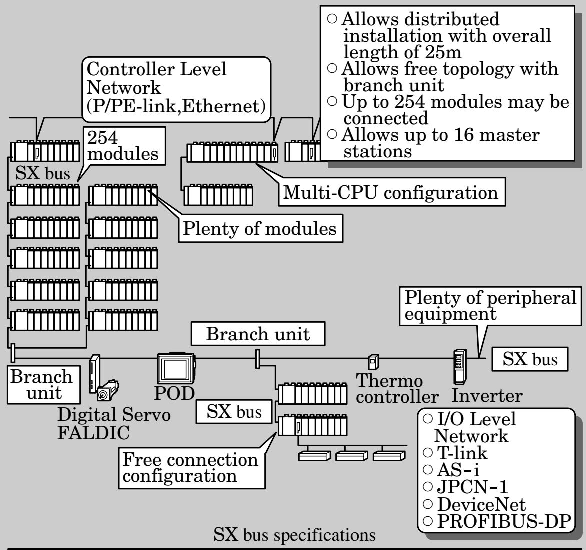
◎World’s fastest processing speed of 20ns using dedicated LSIs
- ○ Equivalent to ladder 15k step/1ms
- ○ 20ns per sequence and 80ns per floating point instruction

◎1-ms I/O signal refresh using SX bus
- ○ Increased I/O refresh rate by using a 25Mbps I/O bus
- ○ Secures regularity of the I/O refresh cycle using tact control
- ○ With an I/O refresh cycle which can be set in 1-ms units to as low as 0.5ms,this system is excellent for processing that strictly requires tact time



◎Achieves high-speed distributed load processing
- ○ With a multi-CPU configuration of up to 8 CPUs,this system offers advanced performance and functions

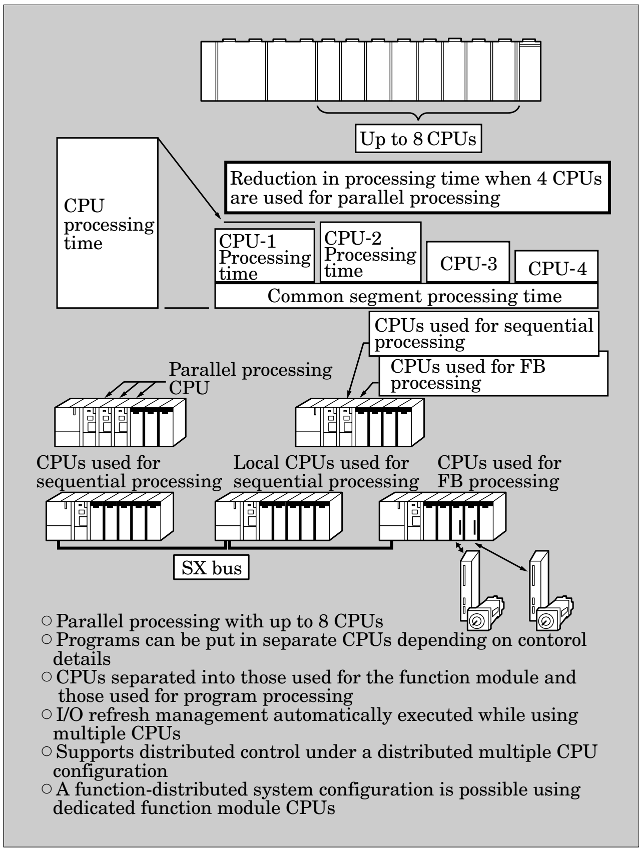
Fig.3 SX bus



SX bus specifications

Item	Specification	Remarks
Communication speed	25 Mbps	1,024 digital I/O terminals can be refreshed at 1ms.
Total length	25 m	
Connection topology	Bus-type	Three configurations allowable using branch unit
Max.number of connected modules	254	Includes power modules. Excludes branch units.
Max.number of master stations	16	CPUs and network masters such as P/PE link are master stations
Max.number of CPU modules	8	

Fig.4 Multi-CPU system



speed of 25 Mbit/sec and a total bus length of 25 m.

Figure 2 illustrates the high-speed control of the SPH, and Fig. 3 shows a summary of the SX bus.

3.2 Multi-CPU system

Free and scalable expansion of target functions, performance and scale has been realized, through a combination of standard modules. Parallel processing with a maximum of multi-configured CPUs has allowed dispersal of the programs to different CPUs according to content, thereby reducing the load per CPU and shortening process time. Figure 4 outlines the multi-CPU system.

Moreover, some redundant CPUs are available, and if the main CPU should fail by any chance, backup operation of the reserved CPU occurs, resulting in improved system reliability.

3.3 Preparation for an open network

The SPH fits various open networks such as Ethernet[*1], JPCN-1 and AS-i, as well as the usually adopted Fuji Electric's original networks P/PE-link and T-link. It ensures compatibility of connection with the usual models and allows users to freely configure their systems.

In addition, considerations are being made for the popular PROFIBUS and Device Net in the West or the FA control network promoted by the MSTC.

Figure 5 shows a network configuration of the MICREX-SX series.

*1 Ethernet: A registered trademark of Xerox Corp., USA

Fig.5 Network

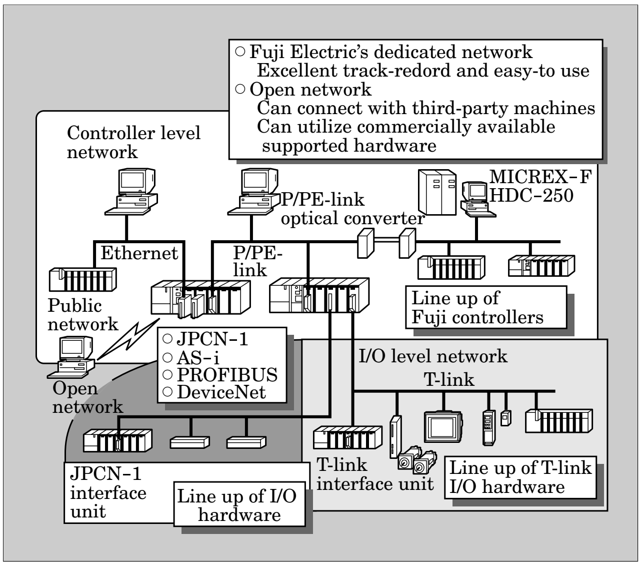
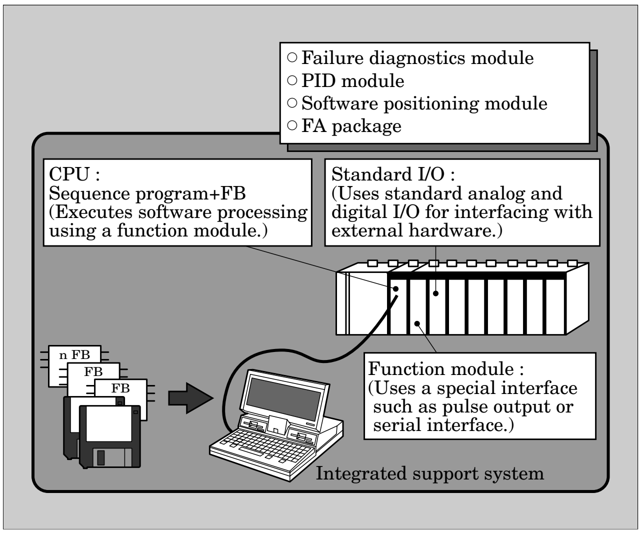


Fig.6 Software function module



3.4 Software function module

For the function modules for communication or position control, a dedicated module has been provided for each communication protocol and position control function in the past. In the SPH a high-speed processing CPU and SX bus realize such functions with software on the CPU. These functions, which up to now were provided with hardware, are now provided with extended function blocks (FB).

Figure 6 shows the concept. Figures 7 and 8 show examples of the function modules.

3.5 Miniaturization

Miniaturization of the PLCs is proceeding as the need for reduced installation space is increasing.

Fig.7 General-purpose communication module

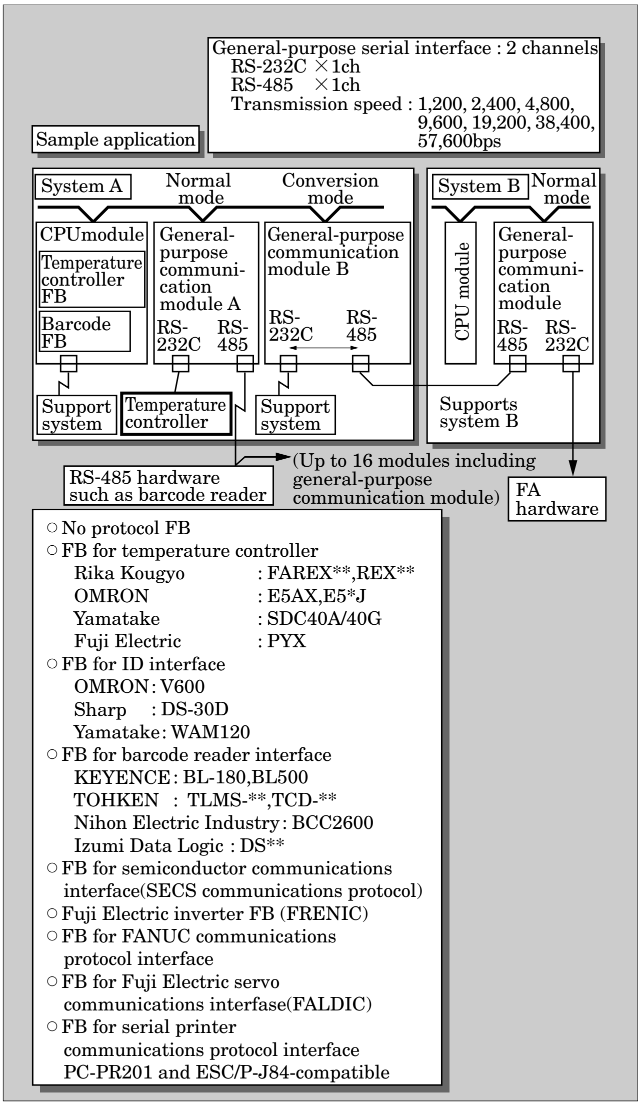


Fig.8 Position control

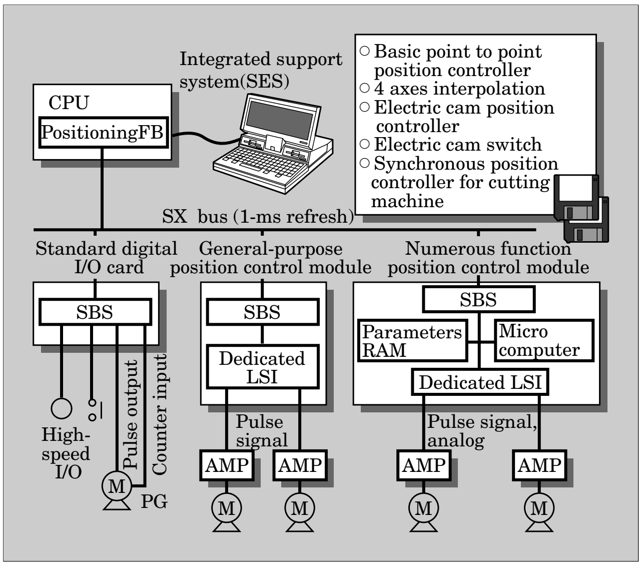
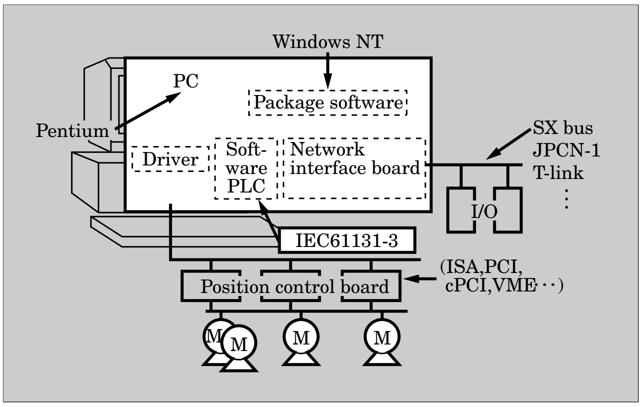


Fig.9 Software PLC



There are many restrictions on space for external wiring terminals or I/O status indicators. But through technical review of construction, mounting and heat radiation, the cubic volume of the I/O module has been miniaturized by about 35% as compared with the conventional MICREX-F70.

4. Software Logic “SPS” (Software PLC)

The trend toward open systems within the information processing field is steadily penetrating into the control field. A typical example is application of PCs to the control field. Application of PCs to monitoring is now in the forefront, but remarkable advances in performance of PC hardware and increasing application examples of software PLCs in the West seem to expand future application to control systems in Japan as well. The software PLC (SPS) is included in the lineup of the MICREX-SX series for meeting these needs.

The software PLC is compatible with the application program of the hardware PLC (SPH). The SPH series is loaded with many convenient application instructions which Fuji Electric has provided thus far, and the software PLC also has them built-in. Making use of Windows NT[*2] as a real time OS has realized control functions in an open environment.

As for system configuration, Fuji Electric’s original I/O interface system with the SX bus and the open system with open networks like JPCN-1 can both be configured. Thus, the most suitable system may be provided for the user.

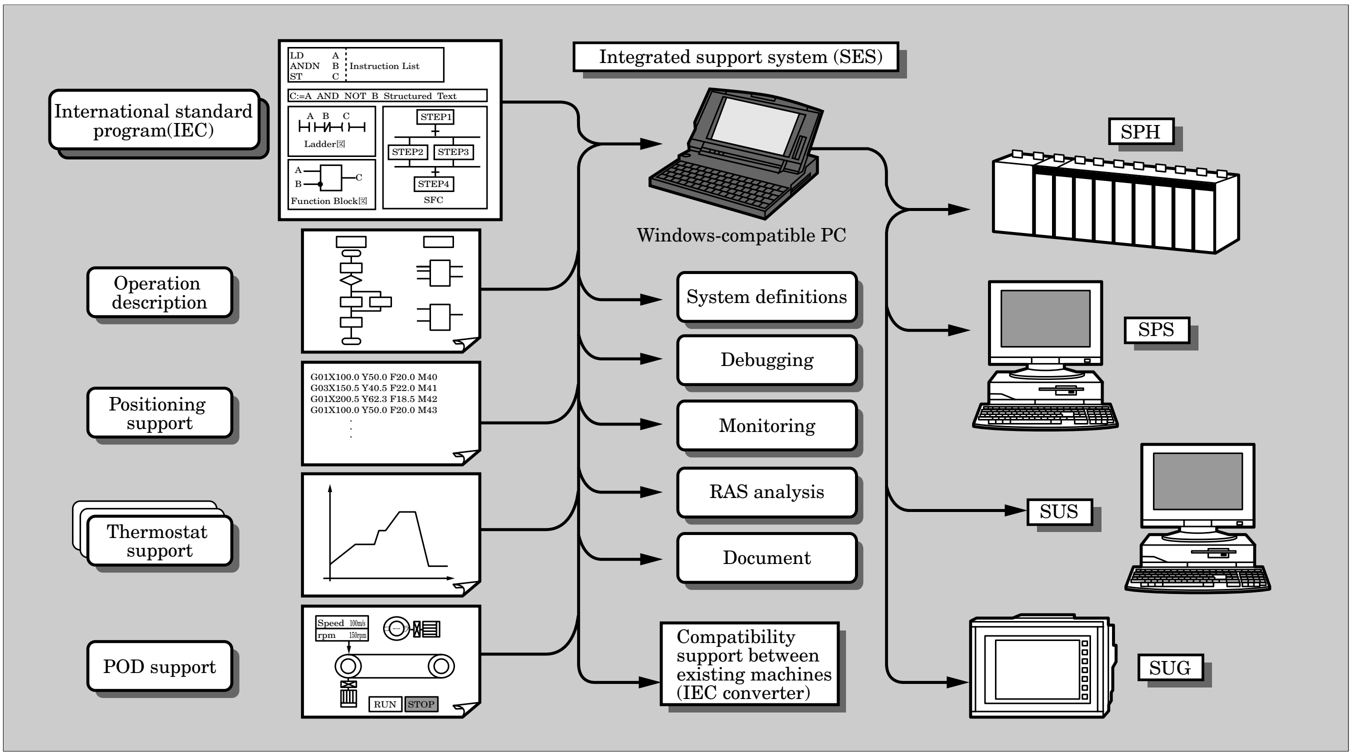
Figure 9 shows the concept of the SPS.

5. Programmable Operation Display “SUG” / Software MMI System “SUS” (Hardware POD / Software POD)

The POD as MMI has the closest relationship to the PLC. In particular, their programs are closely related to each other because they access identical

*2 Windows NT: A registered trademark of Microsoft Corp., USA

Fig.10 Integrated support system



data. Their tight coupling has achieved user friendly usage and improved programming efficiency.

Connecting the POD with the scalable multi-controller SPH through the SX bus allows high-speed and large scale data transfer. This realizes high-speed response of the POD and large capacity of the display data. Connection with PLCs through the usual T-links or open networks is also provided, and the users can select them freely.

6. Integrated Support System "SES"

6.1 Integrated support of PLC and POD

In the field of PLCs and controllers, the need for reducing man hours for software development is increasing in accordance with the advance of the control functions including peripherals. SES has completely realized improved programming efficiency through supporting mainly the PLCs with the international standard language; supporting the PLC function modules for position control, failure diagnosis, and communication; supporting the PODs; and supporting the software debugging function under an integrated environment.

Figure 10 illustrates the functional configuration of the SES.

SES is a software package which runs on a compatible PC with Windows[*3] 95 (98) or Windows NT. The basic operation method, which influences the usage as a programming tool, has followed the Windows style. Therefore, the programming of the MICREX-SX series can be carried out as if using Windows compatible software for word processing and table calculation. It has become very easy to learn how to use the support system.

6.2 Introduction of the International standard language

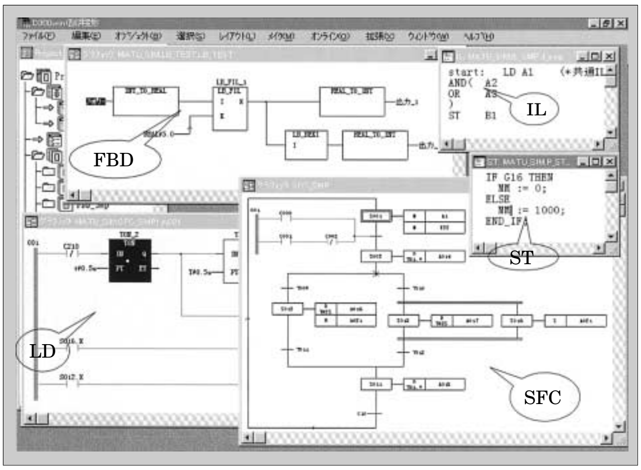
The ladder diagram method is established in Japan but was limited to large scale and complicated programming and has required improvements. Most of the usual programming languages differ from each other depending on the manufacturer or the model. Therefore, practical experience with the model was required and utilization of software resources has been difficult. Introduction of a standard language is now an essential condition in order to improved software development efficiency.

The MICREX-SX series has adopted such a program expression and instruction system that completely conform to the international standard language (IEC 61131-3) which has already been widely adopted in Europe and also in North America. This language allows creation of a program so that anyone in the world can understand, and experience with the model and its language becomes unnecessary.

SES fully provides the operational functions based on the concept that "the IEC-conformed program can be naturally drawn out." So, SES allows program designers to draw out the IEC-conformed program without having any detailed knowledge of the IEC standard, but only if they have the knowledge of the

∗3 Windows: A registered trademark of Microsoft Corp., USA

Fig.11 IEC programming



meaning of the primary technical terms and the minimum rules of the programming language.

As shown in Fig. 11, instruction lists (IL) and structured texts (ST) as text expressions, ladder diagrams (LD) and function block diagrams (FBD) as graphic expressions, and sequential function charts (SFC) as common elements are all supported.

Describing LDs and FBDs freely on SFC is possible, as well as a mixture of LDs with FBDs in the same program. This allows programming to be visual and clearly understood.

Formerly, program designers had to recognize memory addresses of parameters when programming. In SES the parameters are automatically assigned to memories by indicating only data types and attributes of labels defined by the IEC standard. Therefore, programming using only labels becomes possible without awareness of the addresses. In addition, readable programs may be drawn out from the Japanese language, which includes Chinese characters.

7. Conclusion

The concept of the MICREX-SX has been introduced. The trend is progressing towards standardization and the open system. For meeting this trend, Fuji Electric will continue to provide user-friendly products.

Scalable Multi-Controller of MICREX-SX Series

Tetsuhito Watanabe
Yoshisada Sakamoto
Yasushi Ishii

1. Introduction

The programmable controller (PLC), a core component of system control, supports total factory automation (FA), has rapidly progressed in response to the needs for diversification and sophistication of FA systems, and demands for downsizing and cost reduction. In recent years, many companies have been competing to realize the new market demands of open architecture products. As the first supplier in Japan, Fuji Electric launched the "MICREX-SX series" that supports a programming language in compliance with the IEC standard (hereafter referred to as the IEC language), IEC 61131-3 (the former IEC1131-3). This support results in program compatibility between PLCs of different manufacturers, increasing flexibility for PLC users. Conformance with several safety standards including the IEC standards and compatibility with open networks has been achieved. Regarding the performance of this scalable multi-controller, sequential instructions have been executed at a rate of 20ns per instruction, the highest speed level at present.

This paper describes the specifications and features of the scalable multi-controller SPH (hardware PLC), the core of the integrated controller MICREX-SX series for open-architectures.

2. System Structure and Outline of the Scalable Multi-Controller

Figure 1 shows the system configuration of the scalable multi-controller SPH. The SPH offers two models of CPU modules. One model is the SPH300 that processes single instructions within an execution time of 20ns (max.), and the other model is the SPH200 that processes single instructions in 70ns.

By installing function software modules in these CPU modules, they can perform functions that were previously executed by function hardware modules such as simplified positioning control or general-purpose communication.

Modules for PIOs or communication are connected via the SX bus. In addition to the power supply module and the baseboard, a maximum of 254 units can be connected. Each module is equipped with LSIs to achieve high-speed data transfer with the SX bus. The SX bus system assures the periodicity of I/O refresh with a minimum setting of 0.5ms. Therefore, the fluctuation of I/O refresh time for each program scan, a frequent user complaint, can be controlled to improve the ease of use.

One system can be constructed from a maximum of 8 CPU modules to form a multi-CPU system. Parallel execution by multiple CPU modules reduces the load of each CPU, and rapidly processes large-scale application programs. Moreover, the CPU module can distribute the load by assigning specific functions to each CPU. The periodicity of I/O refresh is also assured in multi-CPU systems. If ultra high-speed data reception and transfer is required, a multi-CPU system with even higher performance can be constructed with use of the processor bus, a dedicated bus for use by the multiple CPUs. When constructing a multi-CPU system, each module connected to the SX bus or the processor bus can be used by each CPU module as a shared resource.

For communication modules, the SX bus allows for connection of up to 8 remote I/O master modules and up to 16 PC-card interface modules or general-purpose communication modules. In these communication modules, open-network compatible modules are provided for the upper level network of PLCs or for a network between PLCs such as an Ethernet*, and are also provided for the lower level network of PLCs, such as JPCN-1, Device Net and AS-i, to enable connections between different equipment or manufacturers.

A summary of the basic modules is presented below.

3. The CPU Module

The CPU module of the SPH executes application programs in the IEC language to arithmetically manipulate data that was input from a process, and to output the result to the process. At the same time, the CPU

* Ethernet: A registered trademark of Xerox Corp., USA

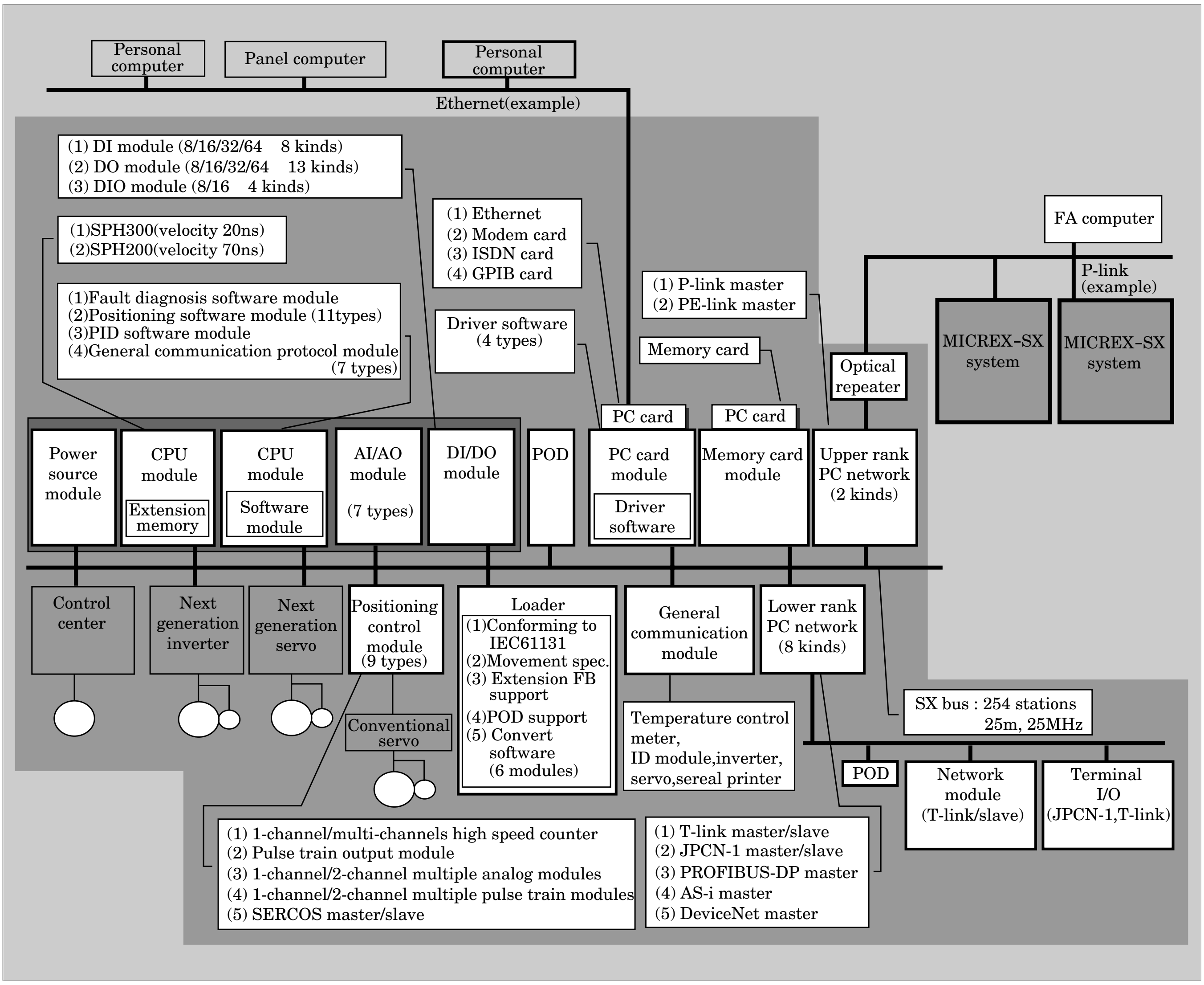


Fig.1 System configuration of the scalable multi-controller SPH

module controls initializing, status monitoring, I/O data transfer of the process and message transfer of the overall system (the system bus and various modules of the system components).

3.1 Hardware

Figure 2 shows the printed circuit boards (two-layer construction) of the SPH300. The main technical subjects in developing CPU modules are high-speed, downsizing, cost reduction, low power consumption and measures to prevent noises. The following measures are adopted to solve these subjects.

(1) Development of a LSI processor for IEC language

An intermediate language (referred to as I-code) suitable for RISC architecture has been developed to handle interfaces with program engineering tools. A LSI device (SPH300) with approximately 500k gates contains various custom operators and peripheral control circuits capable of executing a basic instruction in 20ns and a floating-point instruction in 80ns.

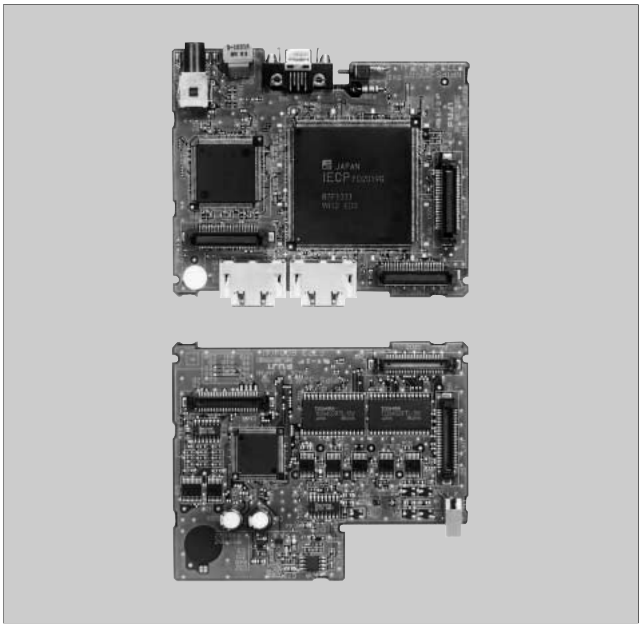


Fig.2 SPH300 printed circuit boards

AF95-227/AF98-228

Table 1 Functions and specifications of the CPU modules for the scalable multi-controller SPH

Parameter		Specifications: SPH300	Specifications: SPH200
Control system		Stored program	
Input/Output connection method		Direct Input/Output method (SX bus), Remote Input/Output method (T-link/JPCN-1)	
Input/Output system		Via SX bus : synchronous refresh Via T-link : 10ms periodic refresh (asynchronous with scan)	
No. of Input/Output points		512 words (maximum 8,192 points)	
CPU		32-bit OS processor 32-bit execution processor	Original processor
Memory capacity	Program	32,768 steps	16,384 steps
	Data	32,768 words	16,384 words
Programming language (In conformity with IEC 61131-3)		IL (instruction list), ST (structured text) LD (ladder diagram), FBD (function block diagram) SFC (sequential function chart)	
Length of instruction		Variable length (depending on language)	
Instruction execution time	Sequential instruction	20ns/instruction or more	70ns/instruction or more
	Applied instruction	40ns/instruction or more	140ns/instruction or more
Data memory	Input/Output memory (IQ)	512 words	
	Instance memory for system FB (SFM)	16,384 words (default value) Timer: 512 points (4,096 words) Integrated Timer: 128 points (1,024 words) Counter: 256 points (1,024 words) Differentiation: 1,024 points (2,048 words) Others: 8,192 words	4,096 words (default value) Timer: 128 points (1,024 words) Integrated Timer: 32 points (256 words) Counter: 64 points (256 words) Differentiation: 256 points (512 words) Others: 2,048 words
	Standard memory (M)	8,192 words (default value)	4,096 words (default value)
	Retain memory (RM)	4,096 words (default value)	2,048 words (default value)
	Instance memory for user FB (FM)	4,096 words (default value)	2,048 words (default value)
	System memory (SM)	512 words	
Available data types		1 bit : BOOL 16 bits : INT, UINT, WORD 32 bits: DINT, UDINT, REAL, TIME, DATE, TOD, DT, DWORD Others: STRING	
Types of tasks	Default task	Cyclic scanning	
	Periodical task	Settled cycle (0.5ms, 1ms to 10s), Task priority : 0 to 3 levels possible	
	Event task	Whenever the assigned BOOL variable changes to “true”, it is executed once. Task priority : 0 to 3 levels possible	
No. of tasks		1 (default) + 4 (sum of periodic task and event task)	
Task priority		0 > 1 > 2 > 3 > default	
No. of POUs	No. of programs	128	64
	No. of function blocks	512	256
	No. of functions	512	128
Diagnostic function		Self diagnostics (memory checking, CPU diagnosis) System structure monitor, System structure module fault monitor	
Calendar function		Time range: until 23:59:59, December 31, 2069	
Backup of memory	Type of battery used	Lithium battery	
	Back up time	5 years (at 25 °C)	

(2) Use of single power supply IC (3.3V)

To realize high-speed control, that is, high-speed operation and a 1ms scan, a single power supply IC (3.3V) is used for all parts, resulting in low power consumption.

(3) 6-layer blind-via-printed circuit board

On printed circuit boards that processes high-speed digital signals, a distributed-constant circuit is formed along the wiring, creating complicated noises.

As a means to prevent noise, a 6-layer blind-via-printed circuit board that connects surface patterns and intermediate layer patterns without boring the front side and back side of the printed circuit boards is utilized to reduce unnecessary inductance along the wiring.

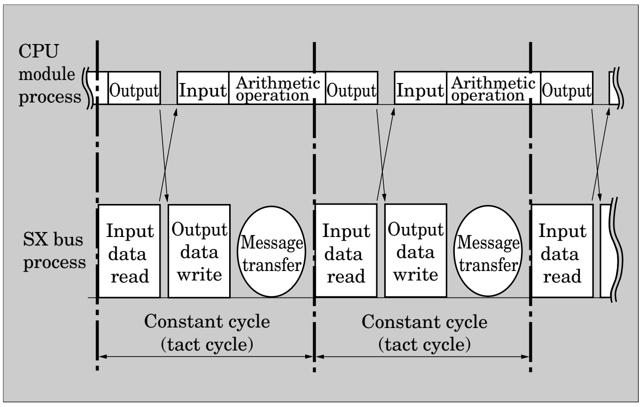
3.2 Functions and specifications

Table 1 lists the functions and specifications of the

Table 2 Basic specifications of the SX bus

Parameter	Specifications
Transmission speed	25Mbit/s
Maximum transmission length	25 m
Number of connectable stations	254 stations (master stations: 8 max.)
Transmission line	Twisted-pair cable (category 5)
Connection type	Bus type (topology: ring type)
Signalizing method	NRZI
Transmission method	Token-pass method and original specifications
Transmission data	Input data Output data Data between processors Message data

Fig.3 Data transfer of the SX bus



CPU modules.

The CPU modules of the SPH have the following features in assigning variables to data memory and task control.

(1) Assignment of data memory

There are two variable areas for the IEC language, one for the I/O data, and another for the memory data. The program is coded by assigning variable names without regard for the physical memory address. There are two data attributes for the memory data area, the initial clear and initial retain.

As shown in Table 1, the CPU module of the SPH divides the data memory into six areas such as I/O memory (IQ), standard memory (M) and retain memory (RM), and assigns these areas corresponding the actual state of the physical memory address that the program engineering tool generates. The "retain memory" is the area where data is saved at initializing.

The size of these memory areas can be changed to comply with various application programs. The system memory that indicates the system status flag and I/O memory are fixed in size.

(2) Task control

Application programs are executed with three types of task scheduling (see Table 1): default tasks, periodic tasks and event tasks. The programs of each task are independently executed in the order of process data input, execution of operation and process data output. The execution is synchronized with data input and output of the SX bus.

3.3 Specifications of language processing

(1) The IEC language and the I-code

When programming with the IEC language in the SPH, the I-code generated by the programming engineering tool corresponds to five types of expressions, making the relevant hardware of the processing system compact. Supported data types are shown in Table 1. In addition to standard functions of the IEC language, extended functions developed originally by Fuji Electric, are also available.

(2) Local variables and global variables

The IEC language supports local variables (variables used in one program) and global variables (variables used by several programs).

In the SPH, access to global variables even with different CPU modules.

4. Bus System

4.1 The SX bus

The SX bus is the system bus at the core of the MICREX-SX Series. Several modules may be distributed in a serial configuration. The SX bus realizes a scalable system structure and has the advantages of smaller size and lower cost compared to conventional parallel buses.

(1) Basic specifications

Table 2 shows the basic specifications of the SX bus. The SX bus has a ring configuration, and can be treated similarly to the bus configuration used to link cable connectors. T-branching is also possible.

(2) Master and slave stations

A maximum of 254 module units can be connected to the SX bus. These modules include master stations and slave stations.

The master station controls the transmission and reception of data, and performs various bus controls and monitoring. The slave station is controlled by the master station, and passively controls the transmission and reception of data for the SX bus.

In a multi-CPU system, a specific master station controls the entire SX bus.

(3) Data transfer cycle

As shown in Fig. 3, data transfer on the SX bus consists of the input data read (status information of each module and process input data), the output data write (process output data) and the message transfer. The data transfer is synchronized with the data input, operation and data output of the CPU module.

The master station controls this data in a transfer tact cycle, that is, in a constant cycle.

Table 3 Summary of I/O module, power supply module and baseboard specifications

Classification	Model code	Outline of specifications	Connection method	Compati-bility to standard
Digital input module	NP1X1606-W	24V DC, 16 points, 7mA, variable filter time	Screw terminal	○
	NP1X3206-W	24V DC, 32 points, 4mA, variable filter time	Connector	○
	NP1X6406-W	24V DC, 64 points, 4mA, variable filter time	Connector	○
	NP1X3206-A	24V DC, 32 points, 4mA, variable filter time, internal pulse input	Connector	○
	NP1X0810	100 to 120V AC, 8 points, 10mA	Screw terminal	○
	NP1X1610	100 to 120V AC, 16 points, 10mA	Screw terminal	—
	NP1X0811	200 to 240V AC, 8 points, 10mA	Screw terminal	○
	NP1X3202-W	5V/12V DC, 32 points, 3mA/9mA, variable filter time	Connector	○
Digital output module	NP1Y08T0902	Transistor sink, 12 to 24V DC, 8 points, 2.4A/point, 4A/common	Screw terminal	○
	NP1Y16T09P6	Transistor sink, 12 to 24V DC, 16 points, 0.6A/point, 4A/common	Screw terminal	○
	NP1Y32T09P1	Transistor sink, 12 to 24V DC, 32 points, 0.12A/point, 3.2A/common	Connector	○
	NP1Y64T09P1	Transistor sink, 12 to 24V DC, 64 points, 0.12A/point, 3.2A/common	Connector	○
	NP1Y08U0902	Transistor source, 12 to 24V DC, 8 points, 2.4A/point, 4A/common	Screw terminal	○
	NP1Y16U09P6	Transistor source, 12 to 24V DC, 16 points, 0.6A/point, 4A/common	Screw terminal	○
	NP1Y32U09P1	Transistor source, DC12 to 24V, 32 points, 0.12A/point, 3.2A/common	Connector	○
	NP1Y64U09P1	Transistor source, 12 to 24V DC, 64 points, 0.12A/point, 3.2A/common	Connector	○
	NP1Y08S	SSR, 100 to 240V AC, 8 points: all points independent, 2.2A/point, 2.2A/common	Screw terminal	—
	NP1Y06S	SSR, 100 to 240V AC, 6 points, 2.2A/point, 4.4A/common	Screw terminal	○
	NP1Y08R-04	Relay, 110V DC, 240V AC, 8 points, 30V DC/264V AC: 2.2A/points, 4A/common	Screw terminal	○
	NP1Y16R-08	Relay, 110V DC, 240V AC, 16 points, 30V DC/264V AC: 2.2A/point, 8A/common	Screw terminal	—
	NP1Y32T09P1-A	Transistor sink, 12 to 24V DC, 32 points, 0.12 A/point, 3.2A/common, pulse output	Connector	○
Digital input/output module	NP1W1606T	24V DC 8 points, source input, 12 to 24V DC 8 points transistor sink output	Screw terminal	○
	NP1W1606U	24V DC 8 points, sink input, 12 to 24V DC, 8 points transistor source output	Screw terminal	○
	NP1W3206T	24V DC 16 points, source input, 12 to 24V DC, 16 points, transistor sink output	Connector	○
	NP1W3206U	24V DC 16 points, sink input, 12 to 24 V DC, 16 points, transistor source output	Connector	○
Analog input module	NP1AXH4-MR	High-speed multi-range input 4 channels, resolution: 14-bit	Screw terminal	○
	NP1AX04-MR	Standard multi-range input, 4 channels, resolution: 10-bit	Screw terminal	○
Analog output module	NP1AYH2-MR	High-speed multi-range output, 2 channels, resolution: 14-bit	Screw terminal	○
	NP1AY02-MR	Standard multi-range output, 2 channels, resolution: 10-bit	Screw terminal	○
Power supply module	NP1S-22	100/240V AC input power source, 35W, 2 slot size	——	○
	NP1S-42	24V DC input power source, 35W, 2 slot size	——	○
Baseboard	NP1BP-13	No. of slots=13, No. of processor bus slots=10	——	○
	NP1BS-06	No of slots=6, No. of processor bus slots=3	——	○
	NP1BS-08	No. of slots=8, No. of processor bus slots=3	——	○
	NP1BS-11	No. of slots=11, No. of processor bus slots=3	——	○
	NP1BS-13	No. of slots=13, No. of processor bus slots=3	——	○

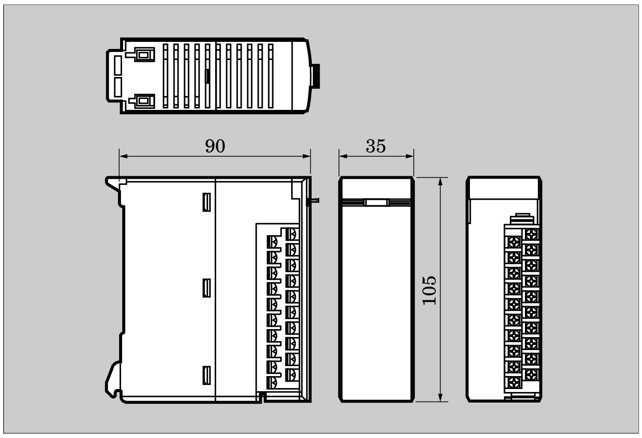
(4) Monitoring functions of the SX bus

The reliability of serial transmission is improved by such RAS functions in a custom LSI as CRC error checking, undefined frame monitoring, frame length monitoring and symbol fault monitoring on the lines, as well as over-run and under-run detection in the line interfaces.

4.2 The processor bus

The processor bus is a dedicated data bus that provides high-speed direct access to the global variables between the CPU modules as well the global variables between the CPU modules and the P/PE link modules. Connection of a maximum of 10 stations is

Fig.4 Appearance of input/output module



possible.

High-speed data transfer between the multi-CPUs is made possible by placing the processor in parallel with the I/O transfer of the SX bus.

5. Input and Output Modules, Power Supply Modules and Baseboards

As shown in Table 3, several types of input and output modules, power supply modules and baseboards have been newly developed to realize high-performance of the SPH.

5.1 The input and output modules

For process input and output (I/O), several modules for digital input and output (DI/DO) as well as analog input and output (AI/AO) are provided.

The main technical subjects encountered in the development of I/O modules are downsizing and countermeasures against heat generation and electrical noise (EMC).

To solve these subjects, a multi-layered printed circuit board (4 layers) and hybrid components were utilized.

Moreover, the number and arrangement of components as well as the wiring pattern was optimized based on the results of thermal analysis, EMI simulation and noise emission analysis.

These measures have achieved downsizing of 65% in volume compared with the conventional models (MICREX-F70), satisfactory input and output performance and good EMC characteristics.

Figure 4 shows the external view of the input and output module.

5.2 The power supply module

The dedicated power supply module for the SPH features small-size, high-power and parallel operation.

Since the SPH provides a single 24V power supply to each module via the baseboard, the necessary power supply capacity can be calculated simply by summing the currents consumed for each module.

Table 4 General specifications of the scalable multi-controller SPH

Parameter		Outline of specification
Physical environmental conditions	Operating ambient temperature	0 to 55 °C
	Storage temperature	– 25 to +70 °C
	Relative humidity	20 to 95% RH, no condensing
	Pollution degree	Pollution degree: 2
	Anti-corrosiveness	No corrosive gas No organic solution
	Operating altitude	Below the altitude 2,000m
Mechanical service conditions	Vibration	Vibration width : 0.15mm Constant acceleration : 19.6 m/s^2
	Shock	Peak acceleration: 147m/s^2
Electrical service conditions	Noise immunity	Square wave : 1.5kV
	Electrostatic discharge	Contact : 6kV Atmosphere : 8kV
	Radio-electrostatic immunity	10V/m
Construction		Rack-mounted type
Cooling		Air cooling
Dielectric property		Described for each module

One module supplies sufficient power for normal use. Even if modules that consume large amounts of power are combined, since the power source capacity is easily increased by parallel operation, it is not necessary to provide various power sources with different capacities.

Parallel operation is useful to not only increase the power source capacity but also for redundancy of the power supply. For example, if two power sources are used redundantly, the controller can continue operation, even if one of them breaks down.

5.3 The baseboard

The baseboard has a simple construction using extruded aluminum. Its size ranges from 6 to 13 slots.

One pair of SX bus expansion connectors attached to the left end of the baseboard makes it possible to structure a large-scale controller system by connecting multiple baseboards.

The baseboards are connected to each other with the SX bus extension cable that can be extended to a maximum length of 25m. Combining the T-branch unit with various types of baseboards results in improved flexibility for placement of the controllers.

The SX bus and the processor bus connect to the slot of baseboard. The NP1BP-13 model, with 10 slots for processor buses, is provided to configure high-speed multi-CPU systems with many CPUs. If multiple baseboards are provided, one or more power sources are connected to each baseboard.

6. Design and Structure

The SPH has an easy to use, compact structure with an elegantly rounded front face. It is not only compact, but also easy to assemble and does not require screws. The materials used are friendly to the environment.

6.1 Design concept

Design concepts for the scalable multi-controller SPH included: small size and compactness, scalability, sturdiness, versatile functions, safety, harmony with the environment, and differentiation.

The design concept that integrates the above items is scalable and solid, giving an impressive sense of unification and high integration.

6.2 Assembly without screws

A structure without screws, such as the MICREX-F70, fixes the SPH module to the baseboard.

Through the use of extruded aluminum materials and development of a new method of attaching the modules, high vibration resistance and an easy-to-attach construction was realized.

6.3 Attaching with the DIN rail

The baseboard can be attached to the control panel either by screws or by DIN rails.

To attach the baseboard to the control panel by a DIN rail, the baseboard hooks onto the rails, and then both ends are fastened by metal fittings.

If attaching by screws, use of the metal fastenings simplifies the fixing work.

6.4 The terminal block using M3 screws

M3 screws are used at terminal blocks (I/Os) to achieve downsizing and simplify the wiring work. A maximum of 20 poles can be equipped on a screw type terminal block.

The wiring for modules having 32 or more input and output points is done with connectors.

7. General Specifications

The specifications of the scalable multi-controller SPH are adequate to fully withstand various severe industrial environments. (See Table 4.)

Moreover, the hardware and software conforms to IEC 61131 (JIS B 3500-3), the international standard for PLCs. Qualification has been applied for in the following standards:

(1) CE markings
(2) UL, cUL
(3) NK, Lloyd

In recent years, EMC has been strictly regulated. However, as the result of repeated EMI simulations, measurements and countermeasures, the MICREX-SX product series meets those standard values.

8. Conclusion

The specifications and features of the scalable multi-controller SPH (hardware PLC), the core of the MICREX-SX series, has been introduced.

Future development will strive to expand the product line, and improve functionality and performance of the MICREX-SX series.

Position-Control Module for MICREX-SX Series

Tadakatsu Aida
Michiya Muramoto
Yasutaka Tominaga

1. Introduction

Generally, in order to operate various machines, various controllers that correspond to a brain and actuators that correspond to the hands and feet are required. Motors or solenoid valves are utilized for the actuators, and servo-motors are widely used for machines that require high speed and high response. Numerical controllers (NC) or robot controllers (RC) serve as typical controllers for servo-motor systems, while many machines are controlled by the programmable logic controllers (PLC). The scalable multi-controllers SPH (hardware PLC) for the integrated controller “MICREX-SX series” recently developed and manufactured (hereinafter referred to as SX) are characterized by high speed and advanced performance so that they are the most suitable for control of the servo-motor systems. In the SX, the novel concepts of “development of software for position-control function” and “single function of the hardware module”, which differ from the conventional PLC, are realized. Hence, the position-control module as well as the extended function block for position-control (extended function block : software library) of the SX and their application examples are presented in this paper.

2. Configuration of the System

The configuration of the position-control system for the SX is characterized by the fact that the position-control modules (hardware) are kept to a minimum, and establishment of the various position-control systems with numerous extended function blocks is possible.

Figure 1 shows a comparison between the conventional position-control module and the position-control system for the SX.

The operation procedures and processing in the position-control system by the conventional PLC include:

(1) Processing of user applications in the CPU modules
  (a) Writing of positioning data and feedrate into the position-control module
  (b) Switching the positioning start command signal on
  (c) Waiting for the positioning end signal (waiting for switching the end signal on)

All processing for position-control is executed by the position-control module side.

(2) Processing in the position-control modules
  (d) Dimension conversion (converts dimension data in millimeters to number of pulses)
  (e) Accel./decel. calculation (linear-curve accel./decel., S-curve accel./decel.)
  (f) Command pulse outputting
  (g) Feedback pulse counting and reverse conversion to input increment

Various processing at the position-control module side is executed by a micro-computer mounted inside the module having advanced performance capability.

Fig.1 System configuration for position control

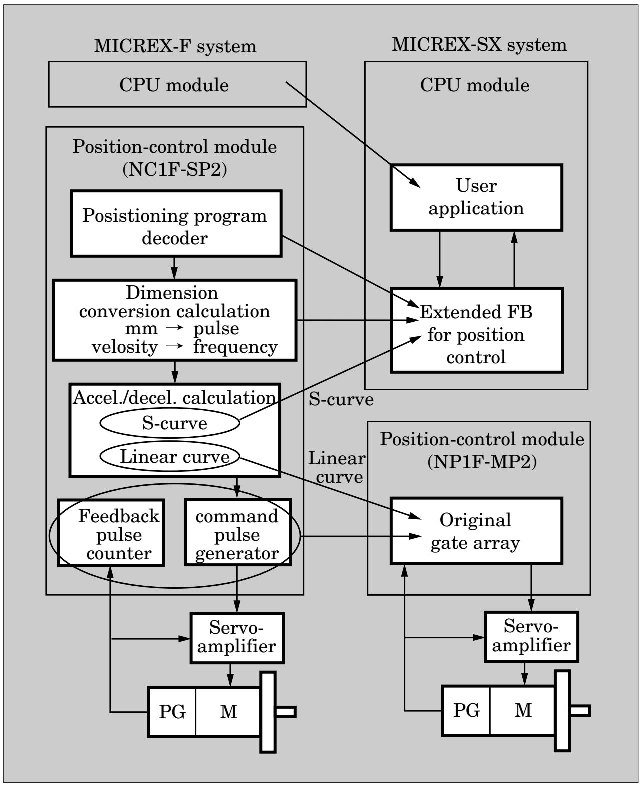


Table 1 Basic specifications of position-control module

Item	NP1F-MA2	NP1F-MP2	NP1F-HP2
Specific slot	1 slot	1 slot	1 slot
Word number of input/output	22 words (input 14 words/output 8 words)	22 words (input 14 words/output 8 words)	16 words (input 8words/output 8 words)
Number of control axis	2 axes/module	2 axes/module	2 axes/module
Control system	Closed loop control	Open loop control	Open loop control
Output control signal	○ Analog speed reference ○ 0 to ±10.24V (VR adjust)	○ Pulse reference (open collector) ○ CCW pulse + CW pulse ○ Max frequency 250 kHz	○ Pulse reference (open collector) ○ CCW pulse + CW pulse ○ Max frequency 250kHz
Feedback pulse	○ Line driver/open collector ○ ϕA, ϕB signal ○ Max frequency 500kHz (×1)	○ Line driver/open collector ○ ϕA, ϕB signal ○ Max frequency 500kHz (×1)	——
Manual pulse generator	○ Line driver/open collector ○ ϕA, ϕB signal or CCW pulse + CW pulse ○ Max frequency 500kHz (×1)	○ Line driver/open collector ○ ϕA, ϕB signal or CCW pulse + CW pulse ○ Max frequency 500kHz (×1)	——
Input/output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal
Inner function	○ Linear-curve accel./decel. ○ The continuation change of the frequency ○ Pre-reading of positioning data ○ Feed-forward control	○ Linear-curve accel./decel. ○ The continuation change of the frequency ○ Pre-reading of positioning data	○ Linear-curve accel./decel. ○ The continuation change of the frequency
Actuator	○ Servo-amplifier of analog reference system	○ Servo-amplifier of pulse reference system ○ Driver for stepping motor	○ Servo-amplifier of pulse reference system ○ Driver for stepping motor
Extended FB	○ 1 axis PTP positioning (simple linear interpolation) ○ Numerous function 1 axis PTP ○ 4 axes interpolation ○ Special synchronous operation	○ 1 axis PTP positioning (simple linear interpolation) ○ Numerous function 1 axis PTP ○ 4 axes interpolation ○ Special synchronous operation	○ 1 axis PTP positioning (simple linear interpolation)

That means, theoretically, if computing capability of the CPU module in the PLC is higher than that of the advanced micro-computer, position-control processing can be executed by the CPU module side. Since numerous numeric calculations must be executed quickly in position-control processing, execution was impossible with the numeric calculation capability of the conventional PLC. However, high speed operation capability of the CPU module in the SX enables execution of position-control calculations by the CPU module side. The position-control module side of the SX only provides the interface circuit as hardware and fundamental functions such as pulse oscillator and counting of feedback pulse. Various functions for position-control are executed by the extended FB in the CPU module side. The following merits are achieved by this system:

(1) Spontaneous combination between the position-control module and the extended FB

In the past, functions were decided by position-control module type. For example, specific hardware modules were utilized for every function including PTP (point to point) position-control module for pulse string output, cam module for pulse string output and synchronous position-control module for the running cutting machine.

(2) Easy transfer of software property

For example, even if servo-amplifier interface changed from the analog reference to network, transfer of applications is possible by means of FB exchange at interface regions only (corresponds to the driver for various printers, in the case of a personal computer).

(3) Build-in of user side know-how

The conventional modules were a type of multi-functional black-box, but the SX is configured by the extended FB for every function. Therefore, it points to an open system and enables addition of functions or customization based on user application.

3. Specification of the Modules

Table 1 shows the basic specifications of the position-control modules for the SX. In this Table, specification of the two axes modules that are typical in the SX are shown.

○ NP1F-MA2: Analog speed command type module
Counting of feedback pulse and connection with one set of manual pulse generators are possible

○ NP1F-MP2: Pulse string command type module
Counting of feedback pulse and connection with one set of manual pulse

Table 2 The interface signal with PLC

Address	F E D C B A 9 8 7 6 5 4 3 2 1 0	Data
0	Bit status signal 1 for channel 1 Nearly zero, positioning complete, detects a ϕZ signal, detects a external interrupt signal, error of emergency stop error, error of ±over-travel, error of Error counter over, etc.	Channel 1 Input area
1	Bit status signal 2 for channel 1 Emergency input signal, ±over-travel input signal, LS at machine datum input signal, ready signal, write command response, read command response, etc.	
2 to 3	Current position data 1 (feedback position, etc.)	
4 to 5	Current position data 2 (command position)	
6	Bit status signal 3 for channel 2 (same as bit status signal 1)	Channel 2 Input area
7	Bit status signal 4 for channel 2 (same as bit status signal 2)	
8 to 9	Current position data 3 (feedback position etc.)	
10 to 11	Current position data 4 (command position)	
12	Current position data 5 for external input counter	Manual pulse generator
13	Current position data 6 for module detection timer	
14	Bit command signal 1 for channel 1 Run command, counter reset, ϕZ detection command, external interrupt detection command, stop command, compulsory stop command, alarm reset. etc.	Channel 1 output area
15	Bit command signal 2 for channel 1 Write REG select, REG write command, Read REG select, REG read command, etc.	
16 to 17	Write REG data set area 1 for channel 1	
18	Bit command signal 3 for channel 2 (same as bit command signal 1)	Channel 2 output area
19	Bit command signal 4 for channel 2 (same as bit command signal 2)	
20 to 21	Write REG data set area 2 for channel 2	

generators are possible

○ NP1F-HP2: Pulse string command type module
Only the most fundamental functions are provided. (without feedback and manual pulse generator input)

All three kinds of modules are capable of executing various position-control actions by combination with the extended FB for position-control, but the extended FBs that are able to combine with NP1F-HP2 are restricted.

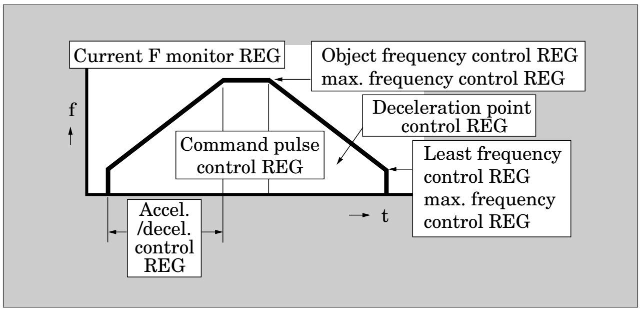
In addition, direct command of the position-control module from user application is possible. Table 2 shows input and output signals of the NP1F-MA2 (common with MP2).

There are 32 registers (REG) inside the position-control module, and position-control actions are executed by switching the start command on after writing the

Table 3 The inner register of the position-control module

No.	Register name	R/W
0	Object frequency control REG	W
1	Least frequency control REG	W
2	Current frequency monitor REG	R
3	Command pulse control REG	R/W
4	Deceleration point control REG	R/W
5	Acceleration/deceleration control REG 1 (This data is used by the usual Acceleration/deceleration control)	W
6	Acceleration/deceleration control REG 2 (This data is used by the EMG stop and Compulsory stop)	W
7	Max frequency control REG	W
⋮		

Fig.2 Basic function of position-control module



positioning data (pulse dimension) from the application side and the data corresponding to frequency. Table 3 shows a list of typical REGs. Figure 2 shows an example of the most fundamental position-control actions. At first, data is written onto “Max. frequency control REG,” “Accel./decel. control REG” and “Least frequency control REG” from the application side (corresponds to parameters for position-control in the conventional module).

Each time, the position-control actions begin under the setting of “Command pulse control REG” and “Object frequency control REG.” In “Deceleration point control REG,” the remaining pulse numbers until start of deceleration are stored by automated calculation. (When auto deceleration calculation is enable.)

The fundamental action functions mentioned above are built into a specific LSI for two axes control that was developed recently. Even when outputting command pulse at linear-curve accel./decel. (pulse output provides a solution of 0.25Hz at the maximum command frequency of 250kHz), smooth frequency change control is realized.

4. Extended FB for Position-Control

More than 70 kinds of libraries are prepared in the extended FB for position-control in order to realize various operative functions on every kind of machine.

Fig.3 Sample of extended FB for position control

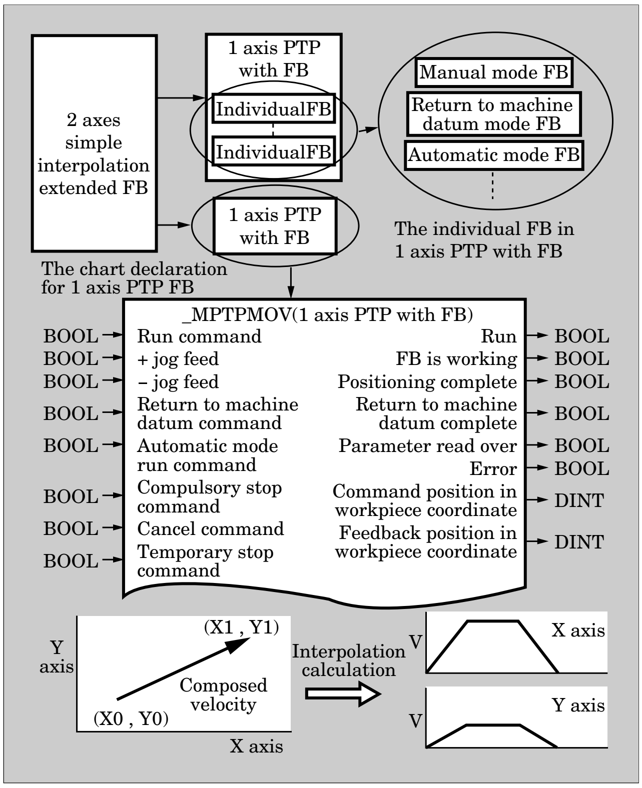


Fig.4 The running cutting machine (rotary-shear)

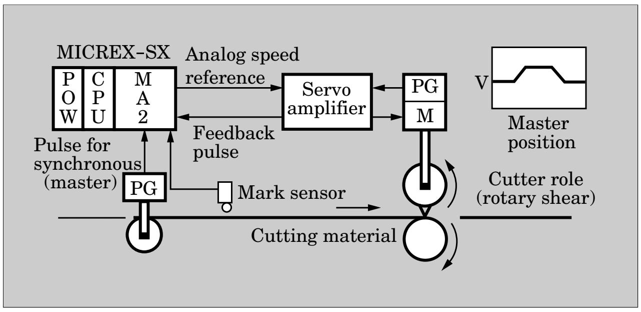
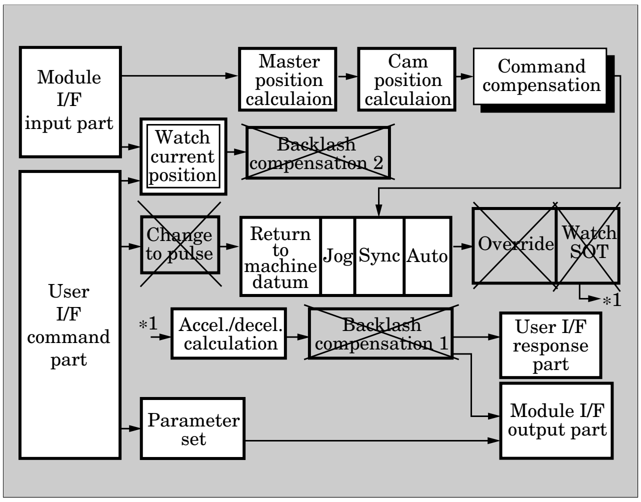


Fig.5 The application example of extended FB for the positioning (the running cutting machine)



The following are four that are included in the typical FB group.

(1) One axis point to point position-control FB group

The FB group that executes one axis point to point position-control

(2) Simple linear interpolative calculation FB group

The FB group that calculates the axis speed of two to four axes

(3) Cam FB, synchronous control for the running cutting machine FB group

The FB group applied to synchronous position-control for cam position control and the running cutting machine

(4) Four axes interpolative operation FB group

The FB group for linear interpolation of four axes and circular interpolative operation of two axes

Although there are various applications for the position-control FB such as a succeeding FB is started according to calculated results of a certain FB (two FBs are connected with equivalent levels) or construction of one FB composed of FBs with individual functions, a typical example is shown in Fig. 3. This Figure shows processing that executes interpolative action for two axes. In two axes simple linear interpolative calculation FB, the synthetic velocity of the X-axis and the Y-axis is the resolved data of each axis, and single axis PTP with combined FB is started (both FBs are of equivalent levels). The single axis PTP with combined FB calls the individual FB and executes the position-control action (the individual FB is one rank lower in level than the combined FB). A signal corresponding to the conventional position-control module interface (I/F) is allocated to input and output data for the single axis PTP with combined FB. For example, even if the position-control module side is configured with only the fundamental functions which command the pulse unit, assignment with setting unit (millimeter etc.) is possible to the single axis PTP with combined FB from the user application side. The combined FB executes the conversion from setting unit to pulse number. This demonstrates that the same handling as the conventional position-control module is possible by building in the extended FB.

In addition, direct commands from the users application are possible to the individual FB. If only FBs with required individual functions are combined, a compact program and rapid processing are realized.

5. Application Examples

A application examples of the SX are delineated in Figs. 4 and 5. Figure 4 shows the running cutting machine system with rotary shear in which the SX controls the cutter section. When the cutting length is longer than the cutter roll circumference at the cutting section, the speed pattern is controlled, as shown in the Figure.

Figure 5 shows configuration of the extended FB for position-control in this system. Each process enclosed by rectangular frames is the extended FB for positioning-control (the FB with individual function). Except the "Command compensation calculation FB" (shaded) and "Current position calculation FB" (in bold), all FBs were prepared by Fuji Electric. In this system, top priority is given to rapid response of the cutter shaft so that rapid processing (a position-control calculation cycle of 2 ms) is realized by deletion of the FBs with unnecessary functions.

(1) FB related to backlash control (backlash compensation function for the mechanical system)

Backlash control FB is not mounted for rotary shear, due to rotary motion in one direction.

(2) FB for conversion of pulse dimension (conversion processing from millimeters etc. to pulse number)

This function is not mounted because conversion calculation can be executed by the controller of the operation region.

(3) FB for override calculation (change action speed function)

This function is not necessary due to the synchronous operation system.

(4) FB for monitoring of software over travel (±SOT)

This function is not necessary due to rotary action. Since all functions indicated in the Figure are provided in the conventional position-control module, elimination of unused functions is difficult.

(5) FB for calculation of present position

Since the conversion calculation to setting unit (millimeter or inch) is not necessary, the standard extended FB is replaced by this FB.

(6) FB for command pulse compensation calculation

The FB that executes special compensation calculations corresponds to machine configuration and is inserted between "FB for cam position calculation" and "FB for synchronous operation" (the additional FB for new functions).

6. Conclusion

The position-control modules and the FB for the SX have been outlined. The position-control system for the SX points to an open system that prepares FBs for every function, contrary to the conventional position-control module whose functions were in a black box. Since the SX is characterized by the selection and mounting of FBs that provide necessary functions for the intended control for the machines, the authors hope this paper will serve actual applications.

Fuji Electric will endeavor to respond to the requirements of automation with high speed and highly precise control for various machines by further enriching the position-control FB for the SX.

Integrated Programming Support System for MICREX-SX Series

Mitsunori Fukuzumi
Masashi Yamada
Akihide Hamada

1. Introduction

Control software is becoming more complicated and larger-scaled as the functionality of programmable controllers (PLCs) is enhanced. Increasing programming efficiency is an important job the programming support tools. However, the following factors prevent current programming techniques from achieving a higher efficiency.

(1) Low productivity because of a low-level programming language
(2) Difficulty in reusing programs
(3) Difficulty in maintenance due to lack of transparency in the program structure

Consequently, users are unnecessarily burdened by both the programming and program maintenance. Limiting these factors to achieve significantly increased efficiency is strongly desired.

Fuji Electric has developed an integrated programming support system (SES) for the MICREX-SX series (hereafter referred to as the SX-series). Fuji adopted the following three basic concepts for the development of the SES.

(1) Utilization of an international standard language
(2) Achieving a breakthrough in the software development procedure
(3) Unification of various support functions

This paper will introduce features of the SES and present an overview of its functions.

2. Features of the SES

An overview of the entire SES is shown in Fig. 1. SES is a software product used to realize a highly effective programming support system environment for various modules of the SX-series. Features of the SES are described below.

2.1 Realization of a comfortable support environment

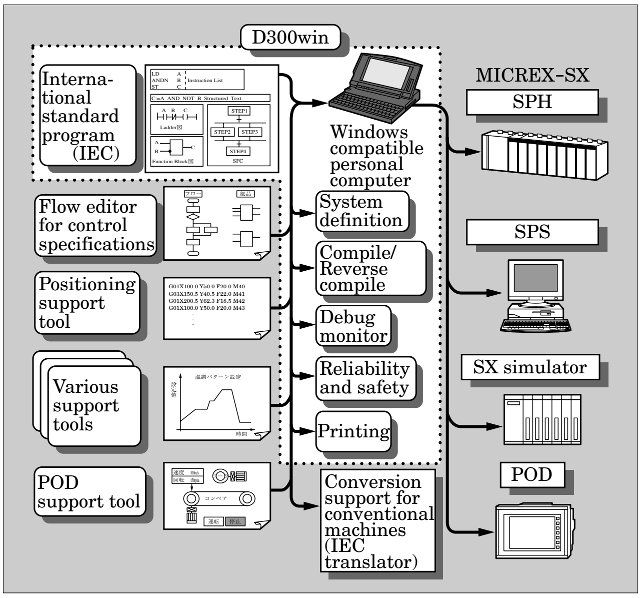
One of the most important aspects of a programming support system is its ease of use. The SES uses general purpose computers as its hardware and utilizes Windows[*1] 95 or Windows NT[*2], current international de facto standards, as its operating system. A user interface with consistent operations, intuitive friendliness, multi-windows, and that can be learned in a short time, has been realized by conforming to the Windows style guide (the standard specifications for Windows display operations), comprised mainly of mouse operations. To comply with environments such as onsite field locations where no mouse can be used, each operation can also be performed from the keyboard.

2.2 Utilization of the international standard language [IEC61131-3 (revision of IEC1131-3 1993)]

The traditional ladder language (ladder diagram) is mainly used as today's PLC language. The ladder diagram has the advantage of graphical expression that is intuitive and easy to understand. However, due to many other problems, it is generally difficult for the ladder diagram to describe and maintain large-scale

*1 Windows: A registered trademark of Microsoft Corp., USA
*2 Windows NT: A registered trademark of Microsoft Corp., USA

Fig.1 Overview of the SES



programs or complicated numerical operations. Main problems of the ladder diagram are listed below.

(1) Symbols and functions not common among various PLC products
(2) Poor structuring and hierarchical function
(3) Restricted reusability of software
(4) Poor addressing and data structure

Each manufacturer is making various efforts to rectify these problems. However, this increases the differences among manufacturers. The introduction of a de facto standard for the language can hardly be expected. To resolve these problems, Fuji Electric has fully adopted the international standard language (IEC61131-3).

2.3 Improvement of programming efficiency

(1) Programming using labels

The use of descriptive labels (variables) is a fundamental aspect of programming. The compiler assigns labels to the internal memory automatically, avoiding such mistakes as double assignment. Since input/output addresses can be assigned individual labels that are separate from the program, the program will not need to be modified if the input/output addresses are be changed.

(2) Reuse and combination of programs

Programs have been made reusable by handling them as parts (functions and function blocks). The parallel development of programs is made easier because partial programs written by several programmers can be combined together by using cut and paste functions.

(3) Simulation

By implementing a simulator in SES, logic simulation of newly developed programs is possible without using actual hardware.

(4) Improved document quality

User-specific printing formats are made available. Furthermore, print preview and enlarged/reduced scale printing, regardless of the paper size, have also been made available.

2.4 Utilization of existing software resources

Existing programs developed with the conventional MICREX-F and FLEX-PC can be translated into the IEC61131-3 language (ladder diagram).

2.5 Automatic generation of control programs by the flow editor for control specifications

A system has been developed that, based on the control specifications described by message flows and software parts, automatically generates PLC programs for controlling machines. The elimination of programming procedures drastically improves the efficiency of application programming.

2.6 Integration of various support functions

The modules that comprise the PLC include such various function modules as a positioning module and a programmable operation display (POD). Previously, these function modules required individual custom support tools, but the SES provides a common platform to which each support tool can be added-on. This enables various support tools to be run on the same personal computer that is running the SES, and the sharing of the same labels defined by SES. Various support tools including POD and positioning are introduced in other articles of this special issue.

3. IEC61131-3

To develop internationally standardized programs, IEC61131-3 has the following goals.

(1) To realize programs that do not depend upon the PLC model type
(2) To realize easy to understand and maintain programs by means of structured programming
(3) To improve programming efficiency by reusing program parts (functions and function blocks)
(4) To decrease program errors by supporting strict syntax checking of data type declarations

3.1 Programming language

For each user application program, IEC61131-3 specifies one common element and four types of language (in some cases this is treated as five types of language, including the common element). Among the common elements, the ladder diagram and function block diagram are defined as the sequential function chart and graphical language, and the list and structure list are defined as the text language. Some examples of languages defined by IEC61131-3 are shown in Fig. 2. The main usage of each language is listed below.

(1) List: downsizing of applications
(2) Ladder list: replacement of relay-box
(3) Function block diagram: applications comprising mainly data processing
(4) Structured text: applications having complicated flow control
(5) Sequential function chart: applications driven by time and events

The SES completely supports all of the above elements.

3.2 Structured programming

All programs, functions and function blocks written in the above languages are known as program organization units (POUs). Functions and function blocks can be called from each program or from another function block, making hierarchical programming easier.

A program can function after having been registered as a task in the CPU module (corresponding to the resource in IEC61131-3) of the PLC system (corresponding to the configuration in IEC61131-3).

Fig.2 IEC61131-3 language

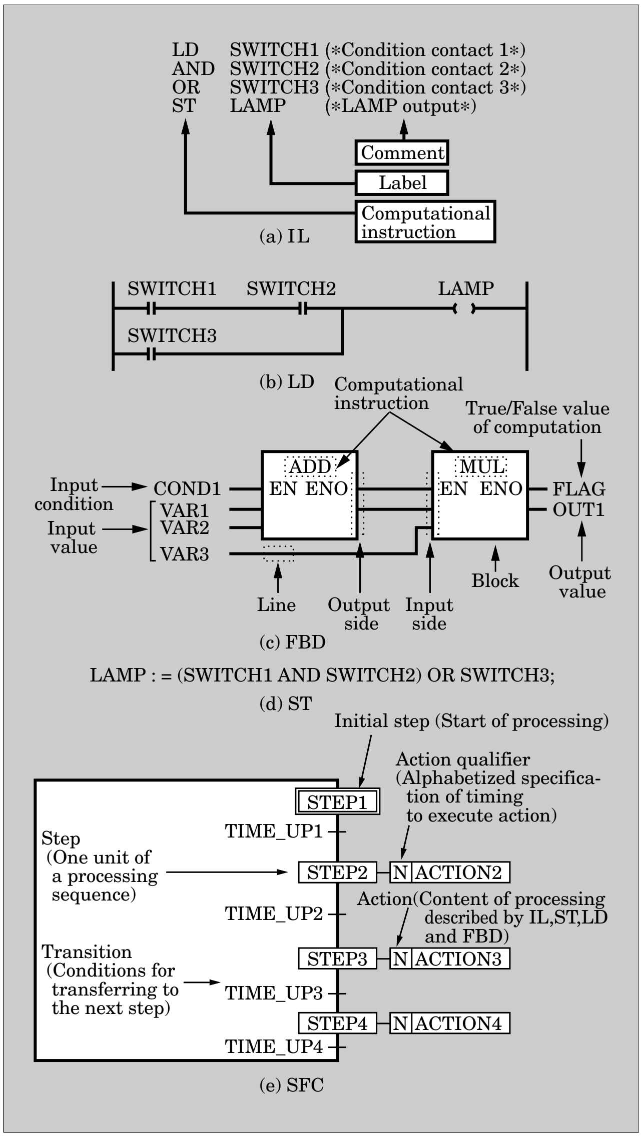


Fig.3 IEC61131-3 software model

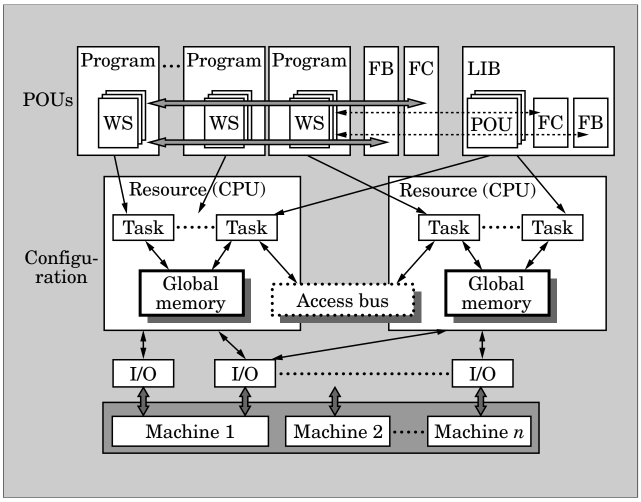
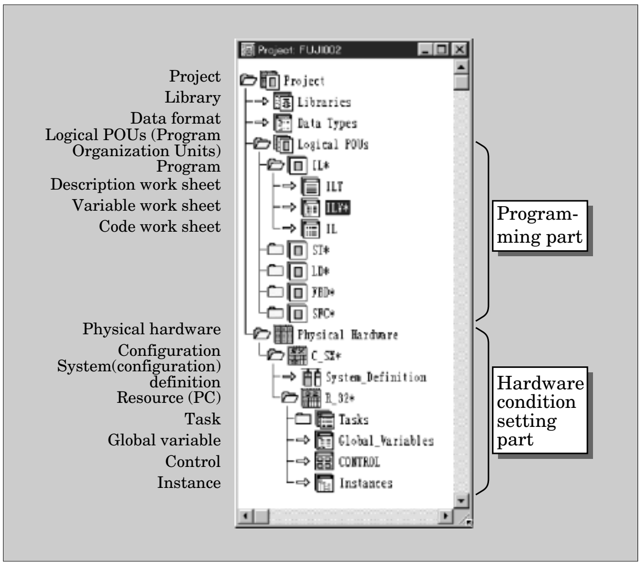


Fig.4 D300win basic user interface



Tasks are a means to activate and control programs. There are different types of tasks, such as: cyclic, fixed-cycle triggered, and event triggered. Several programs can be registered within the same task, and are processed in the registered sequence as if they were a single program. Thus, large-scale and complicated processing can be divided into smaller program blocks (POU)s, improving the programming efficiency largely. The IEC61131-3 software model is shown in Fig. 3.

For further details regarding the IEC61131-3, please refer to the “IEC1131-3 Handbook” (PLCopen JAPAN) or other reference.

4. Programming Design Support

4.1 Basic user interface

The basic user interface of the programming support part (referred to as D300win hereafter) in the SES is known as the project tree. (See Fig. 4.) A project is the management unit for all the information of programs in the D300win, and is assigned an arbitrary name. All programs developed by the D300win are managed by this project name.

In Fig. 4, the programming part is the logical POUs node and the hardware condition setting part is the physical hardware node, including subordinated nodes. In other words, the hardware condition setting part consists of the parts for managing the configuration definition of the SX series, registering developed programs as tasks, download the PLC, testing and debugging, etc.

In addition, library nodes are provided to register existing developed projects for their reuse, and a data type notebook is provided to generate and register customer-specific data type templates utilizing various data types supplied by the D300win.

4.2 Programming

Programming is performed under the hierarchy of a logical POU in program, function or function block

Fig.5 Worksheet

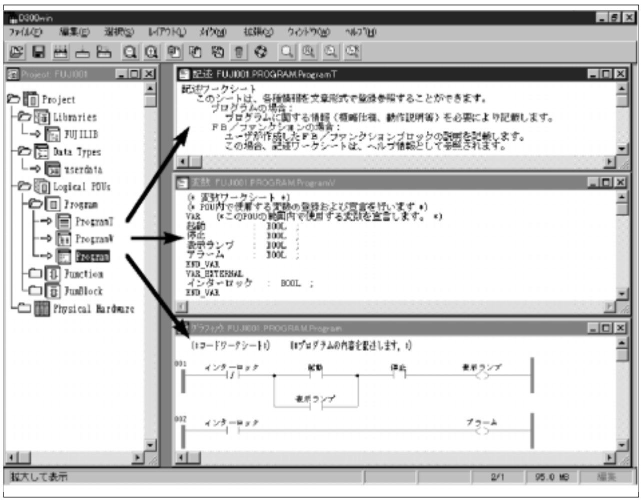


Fig.6 Sample programs by D300win

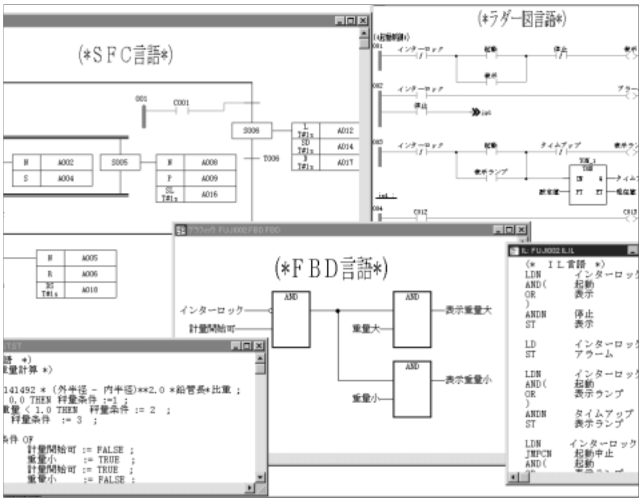


Fig.7 Variable registration

Fig.8 Error check and jump

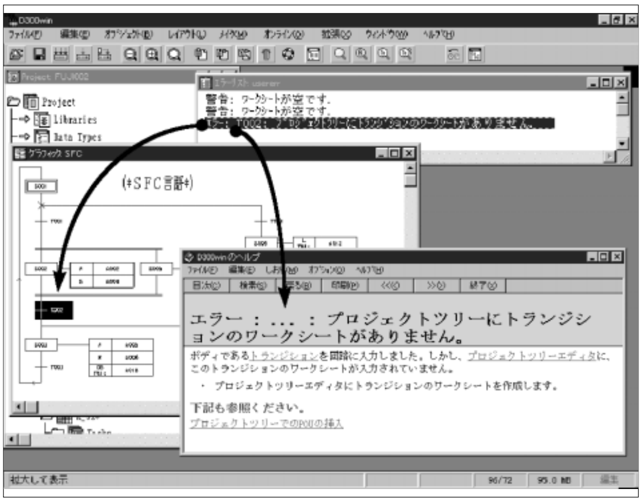


Fig.9 System configuration registration

units. A descriptive language can be specified for each POU. Each POU consists of three types of worksheets (description, variable and code). An example is shown in Fig. 5.

4.2.1 Programming with various languages

A text editor and a graphic editor are provided for each text type language, such as the instruction list and structured text, and each graphic type language, such as the ladder diagram, function block diagram and sequential function chart. Each editor is automatically activated by the POU programming language. Examples of description by each language are shown in Fig. 6. Comments can be described freely in each language.

4.2.2 Programming assistance function

Various functions are provided for easier and quicker programming, several of which are introduced below.

(1) Variable registration function

Variable declarations can be registered easily via a special dialog, or quickly via a text editor. (See Fig. 7.)

(2) Error check and jump function

Errors in the developed program are detected through compiling and displayed in the user error window. By selecting an error message, display will jump to the error location in the program. By calling the provided help function, the cause of the error and

Fig.10 Task registration

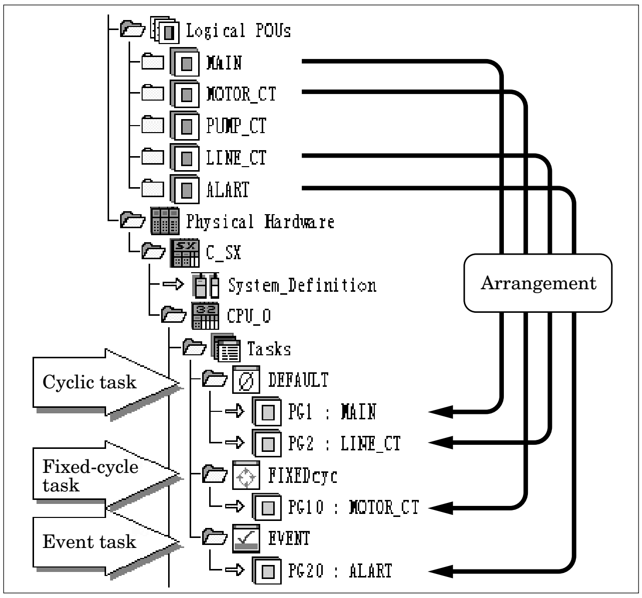
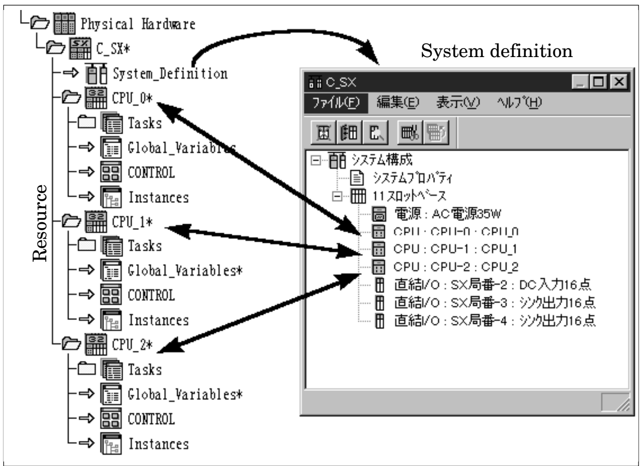


Fig.11 Multi-CPU registration



countermeasures can be displayed. Figure 8 shows an example.

4.3 Setting the program execution condition

4.3.1 System configuration registration

The configuration of hardware modules that comprise the SX system is registered and necessary parameters for each module are set. The actual configuration can also be uploaded from the SX system. A configuration tree resembles the physical image of the system. (See Fig. 9.)

4.3.2 Task registration

The CPU has three types of tasks: default, cyclic and event. Developed programs may be registered in any of these tasks freely. (See Fig. 10.) Programs of other projects can also be registered, increasing their reusability.

4.3.3 Multi-CPU

In the case of multiple CPUs, the task registration for each CPU is the same as when only a single CPU is

Fig.12 Resource control

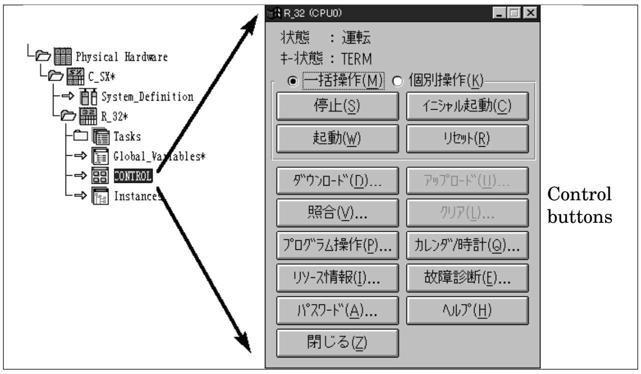


Fig.13 Program monitoring

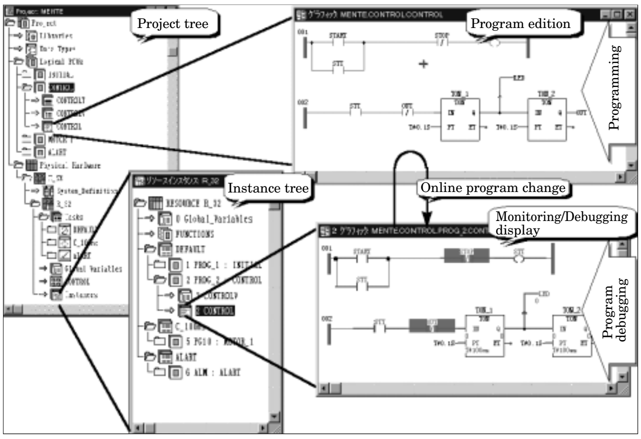
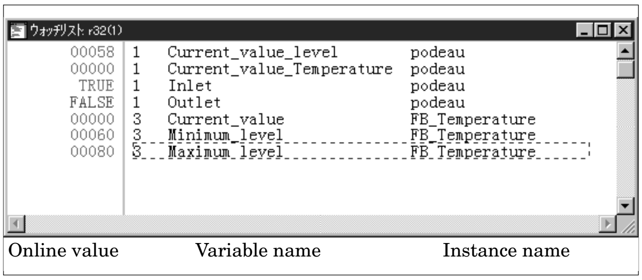


Fig.14 Watch list



used. (See Fig. 11.) Since each program can be registered in any CPU, load dispersing and function distribution can be realized quite naturally.

5. Test and Debugging

5.1 Starting and stopping the controller

The start/stop of the SX system and download of programs is operated by control buttons in the resource control dialog. (See Fig. 12.)

5.2 Monitoring

Four types of monitoring functions are provided.

5.2.1 Monitoring program

The monitoring program function monitors the label values, contact status and coil status in the program. The format is the same as that generated by

Fig.15 Logic analyzer

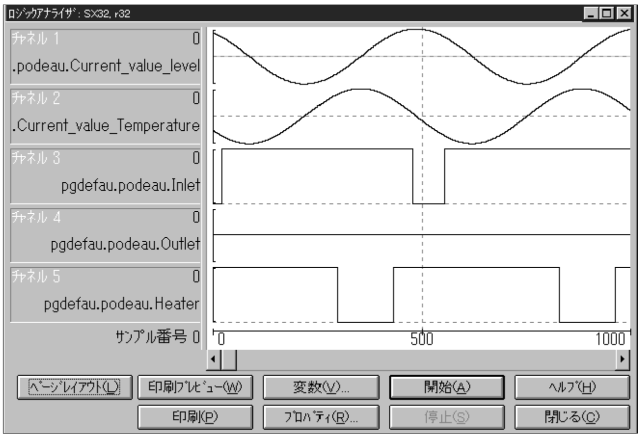
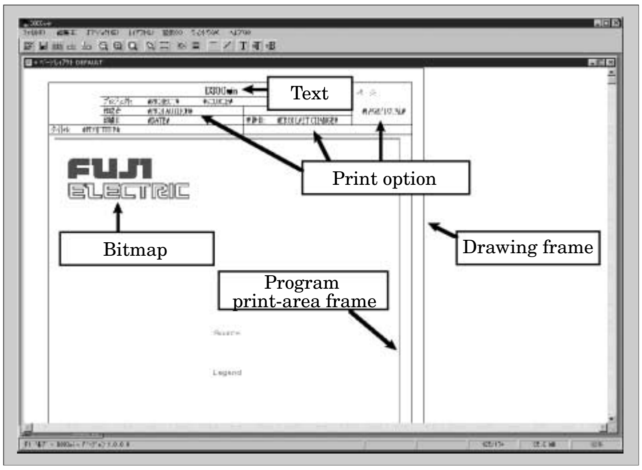


Fig.16 Page layout



the editor of each language. Visualization is increased by assigning meaning to each display color. (See Fig. 13.)

5.2.2 Monitoring variables

The monitoring variable function monitors the variables (labels) declared in the program.

5.2.3 Watch list

The watch list selectively monitors necessary variables (labels). (See Fig. 14.) Necessary variables can be easily registered from the monitoring program and the monitoring variable screens.

5.2.4 Logic analyzer

The change over time of specified variables is displayed as waveforms. Various trigger conditions can be set. (See Fig. 15.)

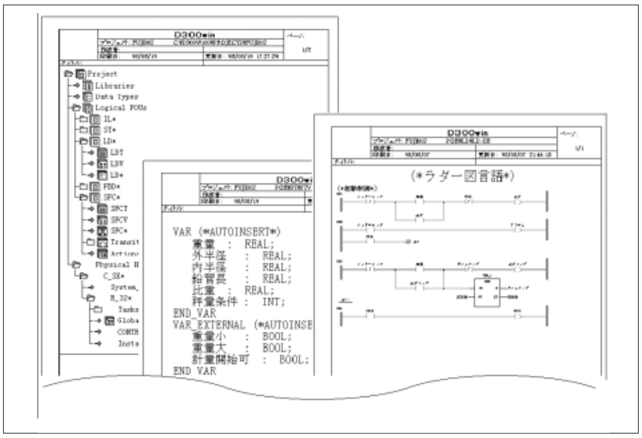
5.3 Online testing

The following online debugging functions are provided.

(1) Forced set/reset
(2) Breakpoint
(3) Step execution
(4) Monitor stop by condition
(5) Program control

By means of the forced set/reset, the input can be set forcibly as a fixed value, independent from external input, or the output can be set forcibly as fixed value, independent from the results of computation. The program control can enable or disable execution of each program, which is very effective for debugging a structured program.

Fig.17 Print project



5.4 Online program change

The path of each POU can be changed while the monitoring program is running. (See Fig. 13.) Changed programs are downloaded automatically without stopping the CPU module.

6. Maintenance Support

6.1 Zip/Unzip of projects

Developed programs and large quantities of auxiliary information for each project can be compressed and zipped into a file as well as decompressed and unzipped.

6.2 Printing

The following main functions are provided to simplify and reduce user work for printing various software documents.

6.2.1 Page layout

Standard drawing frames and other layouts can be generated freely. Figure 16 shows an example of the page layout.

(1) Bitmap

The bitmap selects such logos as a company name in the BMP format and specifies their print area.

(2) Drawing frame, line and text frame

The frame and lines (style and width) for drawings and characters (type of font and size) for notes or other text are set by this function.

(3) Print option

For each layout, print information is specified corresponding to specific key words (worker, time of printing, time of storage, project name to be printed, etc.).

Fig.18 Reliability and safety

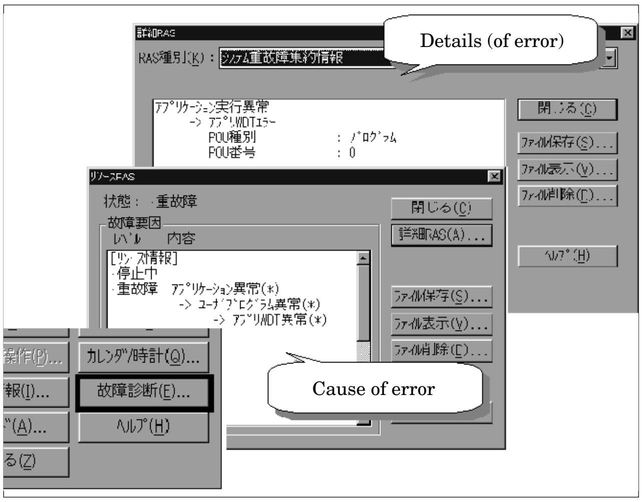
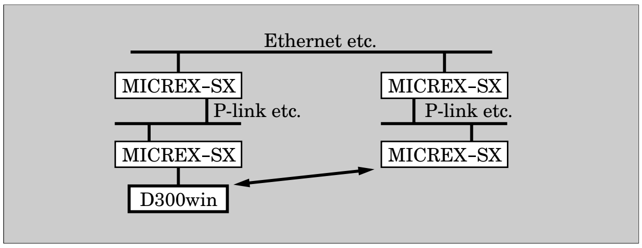


Fig.19 Loader network



(4) Program print-area frame
Program print areas are specified.

6.2.2 Print preview

The print preview function makes it possible to confirm, without printing, the print conditions of such items as project configurations or various worksheets.

6.2.3 Print project

When printing different types of information such as programs and auxiliary information, to minimize the number of printing sheets, page feed can be omitted to minimize open spaces. A suitable page layout for printing can be selected from pre-prepared layouts. Figure 17 shows an example.

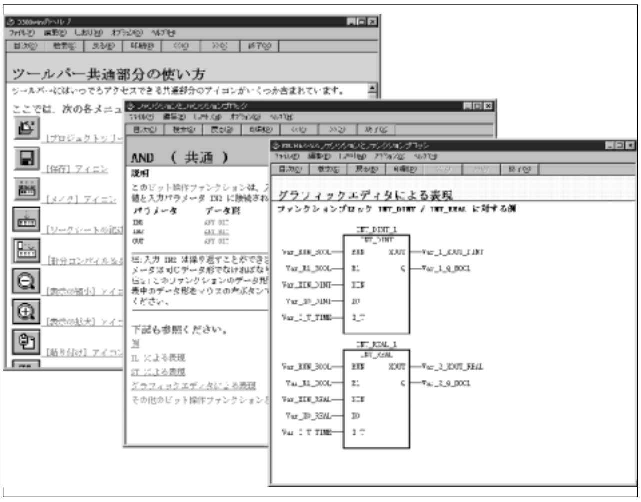
6.3 Password

D300win permits setting a password in the controller. By setting the password, illegal program calls and system configuration changes are forbidden. Thus, the system is protected from negligent change or operation by a third party.

7. Reliability and Safety

When a failure occurs, identification of the failed point is urgently required. This identification is made easier by displaying messages hierarchically in the following order: failure level → failed module → specific error cause within the module. (See Fig. 18.)

Fig.20 Various types of help



8. Assistance Functionality

8.1 Loader network

In the past, Fuji Electric has provided connection to a controller via a single network with P/PE links or other means. The D300win system, however, links the connected SX system to a controller of another SX series via the relayed connection of a maximum of two systems by means of various networks (Ethernet[*3], P/PE link etc.). Figure 19 shows an example connection. This function enables program maintenance, debugging and monitoring in a high-level, sophisticated network system.

8.2 Reverse compile and cross compile

The reverse compiler uploads programs from the controller into D300win and redisplays them in the instruction list format.

Variable information is downloaded in advance together with programs. Thereafter, if no project data is available, the variable information is uploaded together with programs again so the original variable labels used during programming are displayed.

The cross compiler translates programs written in instruction language into the ladder diagram, and then displays them.

8.3 IEC translator

In conformance with IEC61131-3, the IEC translator translates existing programs (including statements and comments such as device names) for Fuji Electric's MICREX-F series and FLEX-PC series into instruction list expressions. The IEC translator also translates some system definitions and parameter settings into the system definition of the SX system. This makes it easy to transition from an existing system to an SX system.

*3 Ethernet: A registered trademark of Xerox Corp., USA

Fig.21 Overview of the flow editor

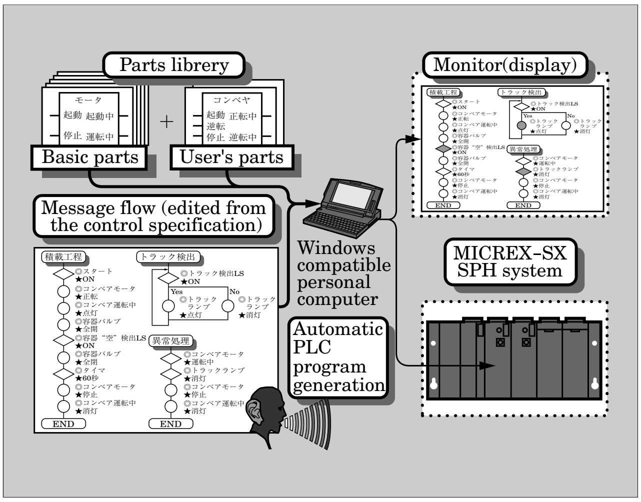


Fig.22 Example program of the flow editor

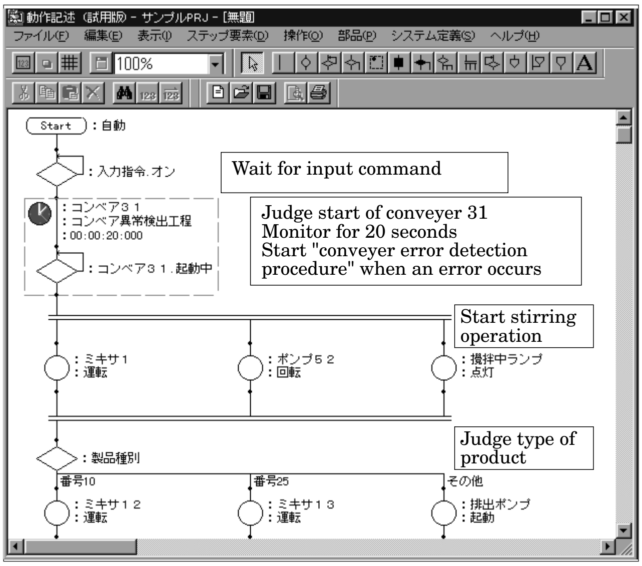
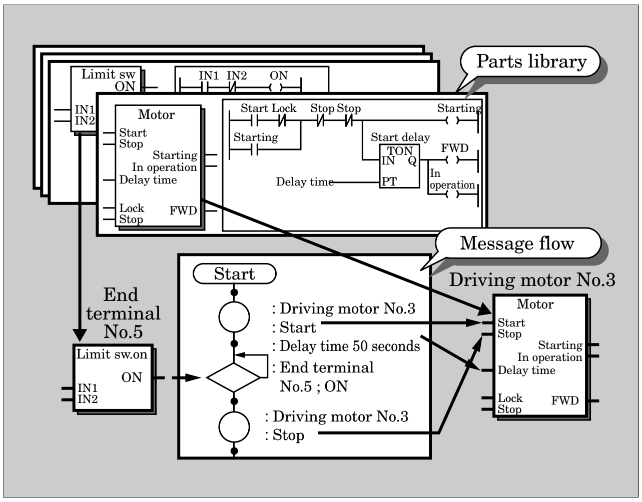


Fig.23 Software parts and message flow



9. Various Types of Help

In the D300win system, necessary help information for the particular work situation can be called with a simple operation. An environment is provided in which work can continue rapidly, with no need to keep an operating manual on hand. The configuration and function of main help topics are introduced below. Figure 20 shows some examples of help information.

(1) Configuration of the help information
- (a) How to use and program the D300win
- (b) Description of functions and function blocks of each PLC that is used, usage of each language, etc.
- (c) Detailed description of error messages that occur during debugging and examples of countermeasures
- (d) Description of the IEC61131-3 standard

(2) Context sensitive help

Suitable help information according to the context of the work can be called by a simple key operation.

10. Flow Editor for Control Specifications

Automatic program generation from control specifications results in a tremendous improvement in the production of control software. The flow editor for control specifications generates programs automatically from a description of the control specifications by flows and software parts. Figure 21 shows an overview and Fig. 22 shows an example description of the flow editor.

10.1 Software parts

These are software packages for controlling individual machines. The contents of these software packages are the same as the function blocks defined by IEC61131-3. A function block consists of an input parameter and an output parameter. Function blocks are used by the flow editor for the control specification, and as the interface to the message flow, have the following meanings.

(1) Command-terminal
Writes commands from the message flow

(2) Status-terminal
Reads status of the message flow

(3) Parameter-terminal
Specifies details of the command

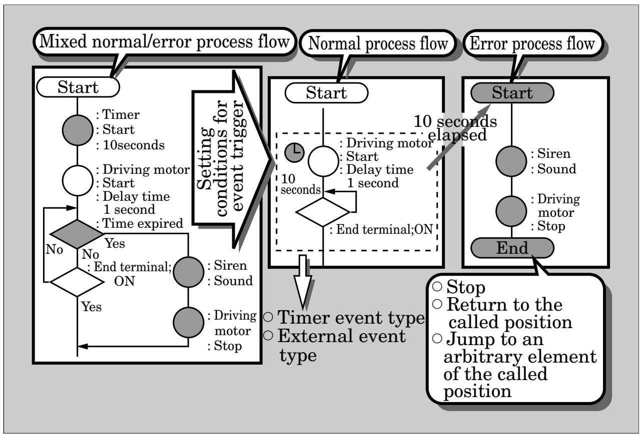
(4) Input terminal and output terminal
Used for external input and for connection between exterior and parts

Software parts are managed as a library of the flow editor for the control specifications. Software parts can be created freely by users.

10.2 Message flow

The message flow describes, in flowchart format, control commands for software parts and status judgments, i.e. the control specifications. The message flow

Fig.24 Setting conditions for event trigger



consists mainly of command elements (○ elements) and judgment elements (◇ elements).

For example, if a part [motor] has a command terminal [start], then [part: motor, command: right rotation] is described using a command element in the message flow. If waiting for input of a limit switch, [waiting condition: limit sw. on] is described using a judgment element. The correlation between software parts and message flows is shown in Fig. 23.

10.3 Monitoring

The message flow can be used as a monitor display. When a message flow being executed is shown on the monitor display, the step element being executed changes color.

10.4 Setting conditions for the event trigger

Control specifications must usually describe not only how to handle normal operation, but also various errors. This makes it difficult to decipher a message flow that includes many judgement elements for every error case.

The flow editor for control specifications solved this problem by separating normal operation from erroneous operation by setting a condition area for an event trigger. Event and activation processes (another message flow) are set by enclosing a portion of the message flow within a rectangle. When an event occurs during program execution within the rectangle, progress of that message flow is stopped and a specified message flow is activated. Thus, a message flow that describes normal operation can be separate from, and not mixed with diverse processing for various error cases.

11. Conclusion

Features and functions of an integrated programming support system for the MICREX-SX series have been introduced above. The IEC standard language, structured programming and flow editor for the control specification, as proposed by the SES, can provide an innovative environment to develop PLC programming, which is gradually approaching its limitations. In the future, Fuji Electric will enlarge the concept of SES, promote development mainly of the flow editor, and contribute to improving the efficiency of application development for control systems.

PC-Based Controllers of MICREX-SX Series

Hiroshi Matsuda
Masanori Hikichi
Taiji Mori

1. Introduction

Recently, in the field of office automation (OA) where personal computers (PCs) are used, operating system (OS) standardization has enabled PCs to be operated without concern for their vender or model.

On the other hand, factory automation (FA) equipment used at manufacturing facilities is operated with hardware and software having an original architecture of the manufacturer's design. Users have to construct their control systems only in the environments specified by the manufacturer. In recent years, users are increasingly requiring that they be able to construct systems mainly by themselves with open architectures, similar to the OA field. Fuji Electric has developed products in response to the demand for open systems and the demand for PC applications to FA.

2. Trend of the PC-Based Controller

The PC has been progressively introduced as a control system device having data processing functions and functions that communicate with information systems. After its introduction, the PC also came to be utilized for operation display, of which the panel computer is a representative example. Further, the trend toward openness in the information field has spread to the control field, and interest in controllers using open components (so-called open controllers) is increasing. Software logic (software PLC), that uses a PC as the hardware platform for a controller and realizes programmable logic controller (PLC) functions, has been put to practical use.

As mentioned above, the application of the PC to the control field is progressing steadily, and is expected to accelerate in the future. In this paper, recent trends of PC-based controllers will be described.

2.1 PC-based controller

PC-based systems that utilize PCs as open platforms have become the basic open controller system. Therefore, the terms "open controller" and "PC-based controller" may be used with the same meaning. The PC-based controller is not clearly defined, but in this paper, it is used as a generic name for controllers that utilize a PC as their hardware platform.

In a PLC, components are classified as hardware, real-time OS or I/O. In an open controller, de facto standard components are utilized for these components. Usually, a PC is used for the hardware. A standard OS such as Windows NT*1, Windows CE*2, VxWorks*3, or QNX*4 is used for the real-time OS. I/O is used that supports an open field bus such as DeviceNet, JPCN-1, or PROFIBUS.

2.2 Trends of the PC-based controller

2.2.1 Trends in Japan and other countries

As represented by the PC-base controller, the open controller is greatly affected by the Open Modular Architecture Controller (OMAC) project in the USA and the Open System Architecture for Control within Automation (OSACA) project in Europe. A precondition of both of these projects is that they use standard hardware, a standard OS, an open field bus, and programming tools in accordance with IEC 61131-3 (IEC 1131-3 1993 in the old numbering system). The "standard" described above does not imply only a single product, but instead signifies a selection from among products that comply with the de facto standard. In Japan, the Open System Environment (OSE) research group is active, and since 1996, the Japan FA open system promotion group in Manufacturing Science and Technology Center: formerly IROFA (MSTC) has been active, working mainly for the purpose of numerical control (NC).

2.2.2 Trends of software PLC

Due to the influence of these projects, interest regarding the open controller has increased mainly in Europe and America, and recently, the applications of

*1 Windows NT: A registered trademark of Microsoft Corp., USA
*2 Windows CE: A registered trademark of Microsoft Corp., USA
*3 VxWorks: A registered trademark of Wind River Systems, Inc., USA
*4 QNX: A registered trademark of QNX Software Systems Ltd., Canada

practical systems are spreading. Beginning in 1994 in Japan, the open controller was introduced and IEC 61131-3 (the language standard for software PLC and PLC) began to be recognized. User interest has been increasing year to year. In Japan, software PLC is not yet widely used, but considering practical applications, a significant number of users have begun to investigate or put software PLC into trial use. The software PLC market is expected to rapidly increase when the introduction of specific applications begins in the near future.

2.2.3 Trends of real-time OS

The control target is divided into a soft-real-time system and a hard-real-time system, according to the real-time performance required by the control. The soft-real-time system is a system that can be controlled with an interrupt latency of several milliseconds and a control period of approximately several tens of milliseconds. In contrast, the hard-real-time system requires an interrupt latency of several tens of microseconds and its control period ranges from less than 1 millisecond to several milliseconds.

Windows NT and Windows CE are available as the OS for the soft-real-time system. These OSs provided by the Microsoft Corp. are widely utilized because they can work with various technologies, although their real-time performance is somewhat inferior.

General purpose OSs such as VxWorks, QNX, pSOS*5, and Itron are available for the hard-real-time system. Windows NT and Windows CE with added real-time extension functions are also available.

3. Fuji Electric's PC-Based Controller System

3.1 Position in the SX series

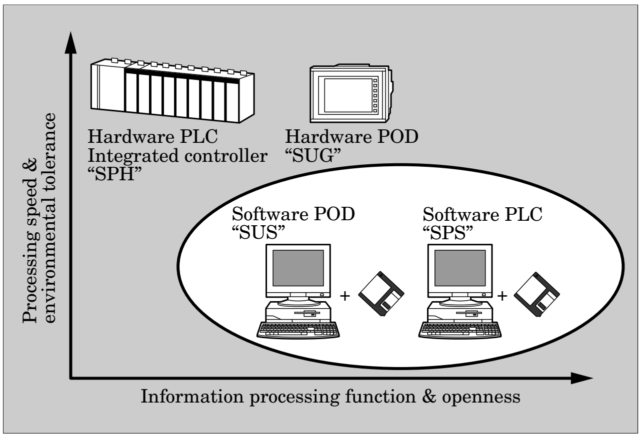
Fuji Electric developed "SPS" as a software PLC of the MICREX-SX series. Figure 1 shows the position of the PC-based controller system within the MICREX-SX series. The programmable operation display (POD) is a man-machine interface (MMI) that operates and displays the state of the plant and equipment. The SPH and SUG are original hardware devices, and the SPS and SUS realize each function with the software that runs on the PC.

These component groups are designed with the consistent philosophy of a common language, programming support tools, network, etc. This enables the user to construct and maintain a system that is not dependent on a particular device model.

The special feature of the hardware PLC is its high-speed processing by use of a custom LSI. The hardware PLC also has environment-proof characteristics and an installation structure suitable for embedding into the machine. On the other hand, the software PLC runs on a PC architecture and is well suited for linking to an upper level network that utilizes information processing and the resources of the PC.

*5 pSOS: A registered trademark of Integrated Systems, Inc., USA

Fig.1 Positioning in the MICREX-SX series



Although its processing speed is less than that of the hardware PLC, the software PLC is positioned as an open controller able to connect with many PC hardware and software components.

Therefore, the software PLC "SPS" is best suited for applications such as listed below in fields that do not require a relatively high level of control performance, but instead utilize the abundant hardware resources (memory, external storage) of the PC and network functions of application software or OS.

(1) Supervisory control field
(2) Linking the software PLC to the software POD or general-purpose software
(3) Linking control functions to the network

3.2 Software PLC "SPS"

3.2.1 Features

A characteristic feature of the SPS is that the hardware operates on an open platform of de fact standards such as the PC-AT architecture and the Windows NT. The programming language conforms to the IEC 61131-3 international standard and uses D300win, a common support tool for the MICREX-SX series. This enables the user to treat the SPS as a type of MICREX-SX series controller. Because the application programs of the SPS and SPH are compatible, programs can be mutually reused. Using the SX bus interface, the SPS can be constructed in a multi-CPU configuration with the SPH. Process sharing can be implemented by processing high-speed control with the SPH, and supervisory control, which does not require high-speeds, with the SPS. As for performance, because Windows NT is an OS for the soft-real-time system, the performance cycle for periodic tasks can be set at an N multiple of 10 ms, and default tasks operate with a minimum cycle of 20 ms. Regarding expandability, operation can be linked to many components of the MICREX-SX series through application

Fig.2 Internal structure of the SPS

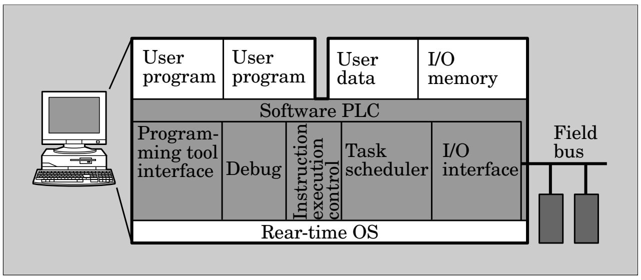


Table 1 Product specification of the SPS

Item	Specifications	Remarks
Operating environment	OS: Windows NT 4.0 SP3 or newer CPU: Pentium* 75MHz or more Main memory: 48MB or more Extended bus: ISA bus	
Cyclic task	1 (default task)	Min. 20ms
Periodic task	4	*N* times 10ms
I/O control method	Task synchronization	
Programming language	IL, ST, LD, FBD, SFC	Conforming to IEC 61131-3
Processing speed (sequence instruc-tion/data instruc-tion)	200ns/200ns (Pentium 75MHz)	Data instruction: ADD
Max. program capacity/POU	Ca. 5k steps/POU	
Max. memory capacity	256k words	
Max. I/O points	8,192 points	
Amount of programs	128	
Amount of FB registration	512	
Multi-CPU	Max. 8 CPUs	On SX bus

* Pentium: A registered trademark of Intel Corp., USA

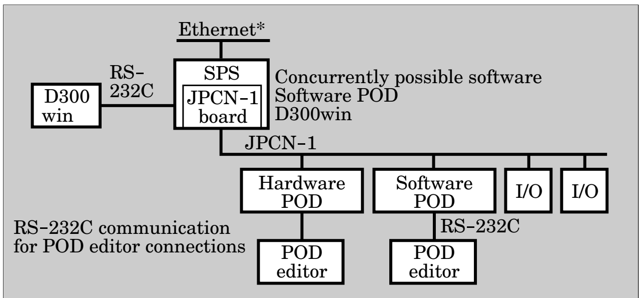
software, networks, the support of PC expansion boards with ISA and PCI buses, software POD, etc.

3.2.2 Structure of SPS

Because the SPS operates in the background, it is not seen in most cases. All necessary operations including downloading and debugging are performed through the graphical user interface of the D300win. The internal structure of the SPS is shown in Fig. 2.

The SPS runs on Windows NT and consists of an instruction execution control unit that converts programs from an intermediate language to machine language and executes extended instructions, a task scheduler unit that controls start schedules of periodic tasks, an I/O interface unit that controls I/O processing between I/O memories and I/O devices, a programming support tool interface unit that communicates with the D300win programming support tool, and a debug unit that supports user program debugging. The SPS also manages memory areas such as user programs (appli-

Fig.3 Example of the SPS system configuration



* Ethernet: A registered trademark of Xerox Corp., USA

Fig.4 Internal structure of the SUS

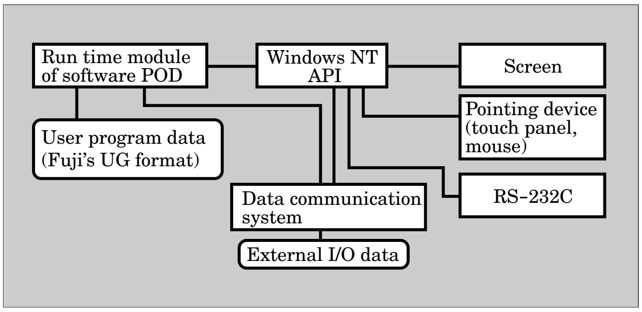


Table 2 Display specification of the SUS

Item	Contents
Number of switches	Max. 500 per display
Number of lamps	Max. 500 per display
Data capacity	No limit: Total capacity per display within 64kB
Number of graphs	Circles, bars, panel meters can be displayed without limit. Total capacity per display: Within 64kB Statistics and trend graphs: Max. 1,024 per display
Number of characters	One-byte character: 40 characters × 12 lines Two-byte character: 20 characters × 12 lines (at VGA display)
Sampling	Buffer data is indicated as a sample (Regular sample, bit synchronization, bit sample and relay sample)
Screen	Max. 1,024
Graphic library	Max. 2,560
Multi-window	Max. 1,024
Data block	Max. 1,024
Number of messages	Max. 6,144
Pattern	Max. 256
Macro block	Max. 1,024
Page block	Max. 1,024
Direct block	Max. 1,024
Screen block	Max. 1,024
Tile pattern	Max. 6
Type of lines	6 types
Languages	ANK code + JIS 1st and 2nd standard Kanji + 63 external characters
Display font	Windows fonts

Fig.5 Interface boards

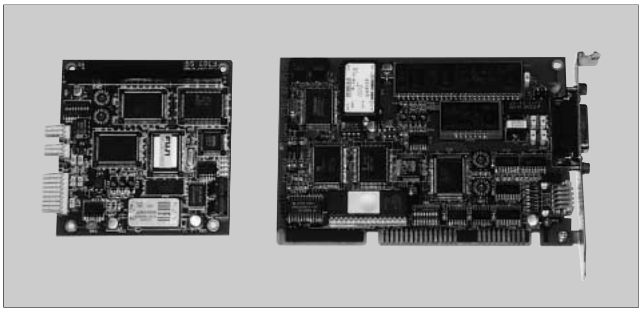


Table 3 Specification of the interface boards

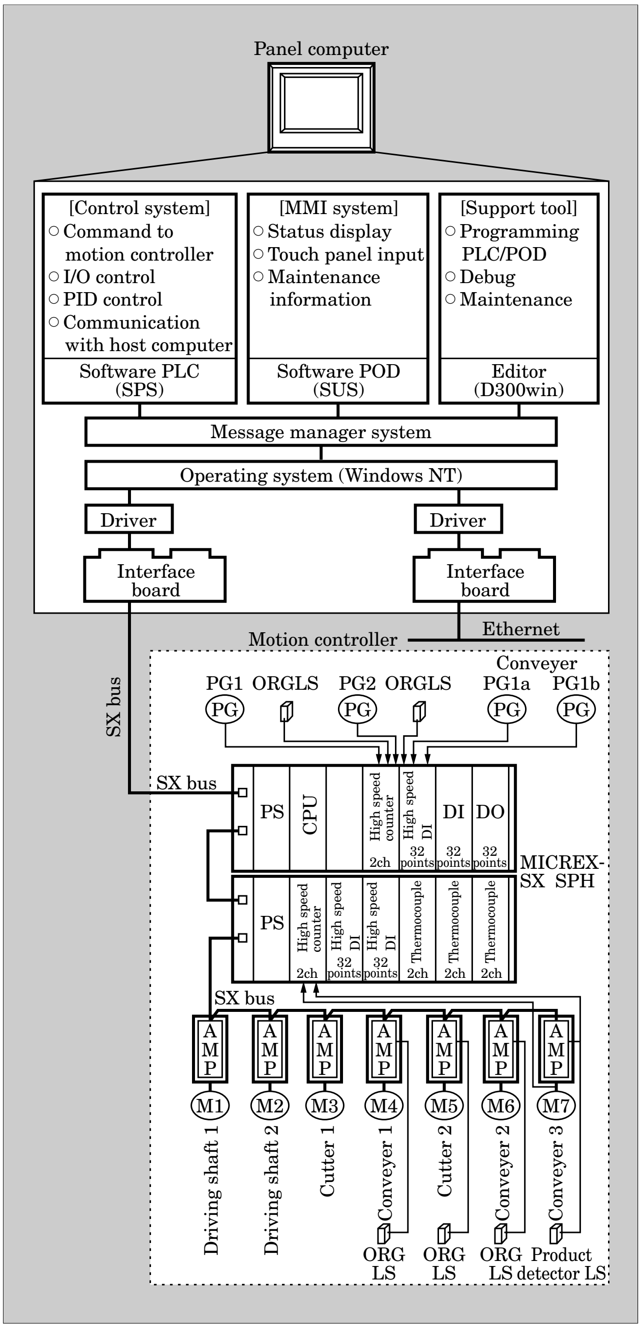
(a) Network interface board

Name	Function	Shape
SX bus interface	○ Board interfacing with SX bus of MICREX-SX series ○ Master/slave function	ISA (half size)
T-link interface	○ Board interfacing with T-link ○ Master/slave function	ISA (half size)
JPCN-1 interface	○ JPCN-1 network interface board ○ Master/slave function	ISA (half size) PC104

(b) PLC board

Name	Function	Shape
SX high performance CPU board	○ PLC function board based SPH300 of MICREX-SX series ○ With SX bus interface	ISA (half size)
F70S CPU board	○ PLC function board based F70S of MICREX-F series ○ With T-link interface	ISA (half size)

Fig.6 Example of application



cations), user data (data memory area), I/O memory (I/O image area), etc.

3.2.3 Specification of the SPS

Product specifications of the SPS are shown in Table 1.

3.2.4 Example of SPS system configuration

An example of the SPS system configuration is shown in Fig. 3.

In this example, JPCN-1 is used for the remote I/O and a JPCN-1 interface board is built into the PC as master to which I/O modules, a hardware POD and a software POD are connected as slave terminals. D300win is run on another PC and connected through a RS-232C connection. It is also possible to run D300win and the software POD on the same PC as the SPS.

3.3 Software POD “SUS”

The software POD realizes POD functions, which have previously been provided by Fuji Electric, on a PC.

By combining the SUS with the aforementioned software PLC, control and operation display functions can be performed on a single PC.

Main features of the SUS are listed below.

(1) Support tools are the same as for the hardware POD

The programming can be visually performed with a conventional POD editor, without requiring special PC programming knowledge. By using familiar support tools at an FA facility, the time for programming and maintenance can be shortened.

(2) Linking of the software PLC and hardware PLC

In addition to address values, labels (variable names) can be used to refer to data in the PLC. Use of program expressions is simplified for the user by a function that links variable names, a special feature of the MICREX-SX series.

(3) Wide variety of functions utilize PC resources effectively

PC functions are utilized effectively to support large screen display, Kanji character input using a Kanji character conversion front-end processor, and large PC memory.

Figure 4 shows the internal structure of the SUS. Table 2 lists the main specification of the SUS.

3.4 Expansion boards for the PC

Fuji Electric provides boards with various functions that are mounted in PCs that contain software PLC and software POD.

An ISA bus, most popular for industrial PCs and panel PCs, is generally utilized as the interface between the boards and the PC. The PC104 interface board, which is suitable for partial embedding, is also provided.

The boards are classified into two categories, network interface boards that exchange data with the outside and function boards for control.

Among network interface boards, there are boards for connecting intelligent devices, such as a host computer or a PLC, and boards for connecting display terminals such as I/O devices and POD.

Among function boards, there is a PLC board that realizes hardware PLC functions on-board. This permits a high-speed processing PLC to be integrated in the PC.

Each board is provided with driver software for Windows NT 4.0. Further, when using a message manager system attached to the software PLC or software POD, the user is able, with simple settings, to exchange data with each board.

Figure 5 shows the appearance of the interface boards, and Table 3 lists the specifications.

Fuji Electric plans to expand the product line of these boards in response to various networks and functions.

4. Application Example

An application example using the software PLC and software POD is presented below.

In this example, industrial processing equipment performs motion control, temperature control and digital I/O control. Motion control using a servomotor is controlled with a motion controller that utilizes a hardware PLC “SPH.” Overall management as well as temperature control (PID control) are executed with a software PLC. A software POD is used as the MMI for the equipment.

The configuration of this system is shown in Fig. 6.

By implementing management and MMI with the software PLC and software POD, and performing high-speed control with an integrated controller SPH, a hierarchical control structure is realized. This system has a structure that can flexibly respond to system changes and expansion.

Support tools are stationed in the panel computer, making possible not only support for the software PLC and software POD but also maintenance of the programs of the hardware PLC connected through the SX bus. By configuring such a system, it is easy to maintain the system on-site without using special tools.

5. Conclusion

An overview of Fuji Electric’s PC-based controller was presented. These components, positioned as upper-level devices of the managing system of the MICREX-SX series, can satisfy the requirement of openness, and at the same time, are compatible with the hardware PLC and hardware POD.

This paper mainly presented the software PLC and software POD which use Windows NT as the OS. However, to meet the wide range of user needs, Fuji Electric is developing software PLCs and software PODs that are compatible with a hard-real-time OS.

Programmable Operation Display for MICREX-SX Series

Shigeo Kawashima
Shigeo Ohshima

1. Introduction

In 1988, Fuji Electric was the first to manufacture a programmable operation display (POD). The latest control equipment is comprised of a programmable controller as the controller and a POD as the man-machine interface (MMI) that is indispensable for factory automation (FA).

PODs must be provided with not only pilot lamps and switch functions but also with advanced information such as operation conditions of the equipment and data and video images for maintenance performed by simple operation. In addition, accompanying the increase in the PODs' functions is a strong demand for the rationalization of application software development and improvement in its efficiency.

Based on the new concept Fuji Electric has developed the new POD UG series as the MMI for the integrated controller "MICREX-SX series" (refer to Fig. 1).

This paper introduces the new UG series (UG220, 320, 420, 520) and its corresponding programming support tools.

2. Outline of the New UG Series Products

2.1 Configuration of the new UG series

While the present UG series has two screen sizes of 5.7 inches for the UG210 and of 10.4 inches for the UG400, the new UG series has four screen sizes the above mentioned two sizes along with the additional 7.7 and 12.1 inches. In particular, the 7.7-inch UG320 series, though small in sized, has the same resolution as the 10.4-inch UG400 series and should have a significant impact on the market for medium-sized PODs requiring a small size and low cost. On the other hand, the 12.1-inch UG520 series has a larger screen and additional functions such as monitoring of the video camera image display to meet the increased application of monitoring systems.

Table 1 shows the model listings of the present and new UG series of PODs.

2.2 The aim and features of the new UG series' development

The central aim of the development of the new UG series is described below. Tables 2 and 3 show the specifications of the products to be developed.

2.2.1 Realization of high-speed processing

With the increase of required functions such as macro processing and compatibility with various networks, the problem with the PODs was to increase processing speed.

Owing to the adoption of 32-bit RISC processors, the new UG series realized nearly a fivefold increase in CPU processing speed as compared with the former series. To achieve this high processing speed, a new gate array of 33,000 gates has been developed to incorporate PCI bus controllers and serial communication circuits into the gate array. This resulted in the first adoption of the latest graphic accelerator for the personal computer in the PODs and an increase in plotting speed.

2.2.2 Small-size and easy-to-use construction

The appearance and frame were all newly designed. The construction was designed to be impervious to dust and drips and resistant to vibration. The new UG series has a new construction consisting of front, inside and rear blocks. This enables each block

Fig.1 External view of the new UG series

Table 1 Model listing of the PODs

Screen size	5.7-inch	7.7-inch	10.4-inch	12.1-inch
Present series	UG210	—	UG400	—
New series	UG220	UG320	UG420	UG520

Table 2 General specifications of the new UG series

Item \ Model	UG220	UG320	UG420	UG520
Supply voltage	24V DC		85 to 265V AC	
Power consumption	10W	20W	45VA	50VA
Withstand voltage	1,500V 1 min. between external DC terminals and the case		1,500V 1 min. between external AC terminals and the case	
Noise immunity	By a noise simulator of 1,600V p-p (noise width: 1 μs, 50 ns and noise frequency: 30 to 60Hz)			
Vibration resistance	In accordance with JIS C 0911			
Impact resistance	In accordance with JIS C 0912			
Ambient temperature	0 to +50°C (0 to +40°C for STN)			
Ambient humidity	85%RH or less (no dew condensation)			
External dimensions	182 × 139 × 50 (mm) + op2*	230 × 175 × 66.1 (mm) + op2*	310 × 240 × 92.3 (mm)	334 × 270 × 95.8 (mm)
Size of installation hole	175 × 132 (mm)	220.5 × 165.5 (mm)	289 × 216.2 (mm)	313 × 246.2 (mm)

* op2 (option 2): Purchased separately and provided for the main system

Table 3 Performance specifications of the new UG series

Item \ Model	UG220	UG320	UG420	UG520
Display device	LCD monochrome, STN color	STN color	TFT color, STN color	TFT color, STN color
Number of dots (screen size)	320 × 240 (5.7 inch)	640 × 480 (7.7 inch)	640 × 480 (10.4 inch)	800 × 600 (12.1 inch)
Maximum number of touch switches per screen	768 (Analog resistance film, resolution 1,024 × 1,024)			
User program memory	Flash memory 1MB (expandable to 5MB)			
Interface with host controller	RS-232C, RS-422 (RS-485)			
Modular connector No.1	RS-232C, RS-422 (RS-485), for programming tools, bar code reader, memory card recorder			
Modular connector No.2	RS-232C, RS-422 (RS-485), for bar code reader, memory card recorder			
Printer interface	In accordance with Centronics (NEC PR201, EPSON ESC/P code and its compatible machines)			

to be assembled separately and in less time than required, to comply with various specifications, and backlights that can be easily replaced.

Through assembling built-in on-board control devices into a chip and gate array and mounting high-density electronic parts with multilayer boards, the screen size could be increased compared with POD bezel dimension (an increase in the proportion of effective display area).

2.2.3 Improvement in programming functions

The programming support tool for the new UG series (known as the POD editor) has become easier to use through the incorporation of Windows' operability for Windows NT[*1] and Windows[*2] 95, and the adoption of the same operation procedures as those of the programming support tool of the scalable multi-controller SPH as part of the integrated support system. In addition, in order to enable the creation of images with relative ease, the following three functions have been improved or added, along with about 100 other items.

*1 Windows NT: A registered trademark of Microsoft Corp., USA

*2 Windows: A registered trademark of Microsoft Corp., USA

Table 4 Optional specifications of the new UG series

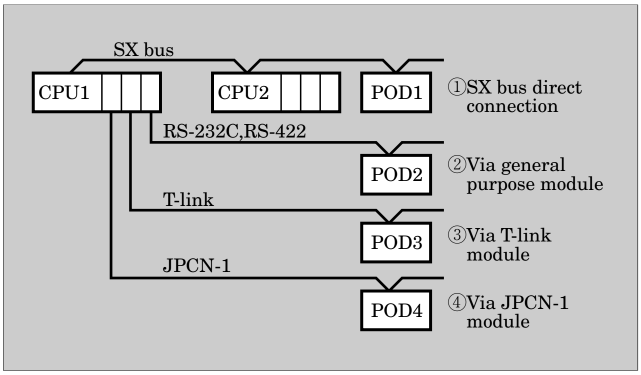
Item \ Model		UG220	UG320	UG420	UG520
Memory cassette (2M bytes, 4M bytes)		×	op2	op2	op2
Interface memory card		×	×	op1	op1
External card recorder		op3	op3	op3	op3
Interface with video input		×	×	op1	op1
Interface with analog RGB input		×	×	op1	×
Additional I/O unit		op3	op3	op1	op1
Communication interface unit	JPCN-1	op2	op2	op2	op2
	T-link	op2	op2	op2	op2
	SX bus	op2	op2	op2	op2

op 1 (option 1): Incorporated into the main system at the factory
op 2 (option 2): Purchased separately and provided for the main system
op 3 (option 3): Purchased separately and provided outside the main system

(1) End-position-searching function, which permits plotting with the same operation as CAD, in which a cursor is automatically moved to the end of a line or to the corner of the graphics.
(2) Function to open multiple windows and to edit

Fig.2 An example of a video image display in the UG520

Fig.3 Connected form of PODs on the MICREX-SX system



characters and bitmaps between those windows by means of cutting and pasting or copying and pasting.

(3) Data conversion function from the DXF file (CAD data file) to the graphic data.

The POD editor can support both the present and the new UG series.

2.2.4 Function enhancement

The major additional functions of the new UG series are described below. Tables 3 and 4 show performance and option specifications, respectively.

(1) Video input display function

Fuji Electric has developed a function that superimposes the video input (65,000 colors, color image signals) from an external video camera on the user's painting surface, and image monitoring by a video camera is now possible.

There are four channels of video input interfaces, one of which can be selected for display in an application. The image display size and position can be freely set by the POD editor (refer to Fig. 2).

(2) Color display enhancement

For display colors, 128 colors and a blinking display are possible by the addition of palette codes (UG220: 16 colors).

(3) Adoption of flash memories

In the new UG series, flash memories have been adopted to transfer system programs and font data from the POD editor. As a result, it has become possible to select a display language on the editor and to handle any language through transferring font data.

(4) Improvement in macro functions

Some commands have been added to obtain a total number as well as average, maximum and minimum values. The new UG series has realized nearly a fivefold speedup in CPU processing as compared with the present UG series.

2.2.5 Support for various networks

The standard communication interface is RS-232C/RS-422 programless communication (relating to 19 PLC manufacturers).

In addition, the communication interface part has been modularized and provided so that a POD body can support the increased use of various networks. This will allow the interface to handle various networks in the future.

Table 4 shows the support for the present open networks and Fuji Electric's original networks.

3. POD as the MMI of the MICREX-SX Series

The new PODs of the integrated controller MICREX-SX series will be described in the following.

3.1 POD connection pattern in the new UG series

There are four POD connection patterns in the MICREX-SX Series, as shown in Fig. 3. An SX bus can be selected when high-speed processing is required. RS-232C and RS-422 when the distance for connection is short and there are few devices, T-link and JPCN-1 when long distance connection is required and JPCN-1 when open networks are required.

Figure 3 shows only the connection patterns, but the SX bus can be connected to a total of up to eight scalable multi-controller SPH and software logic SPS (PC + software PLC with an SX bus interface inserted).

3.1.1 SX bus direct connection

PODs can be directly connected to an SX bus, the system bus of the MICREX-SX bus, without the provision of a special communication module on the side of the scalable multi-controller SPH. By means of a high-speed transfer of 25 Mbits/sec, high-speed response that conventional interfaces could have never achieved is now possible.

3.1.2 Connection via general-purpose communication modules

Connection of PODs with a PLC via general-purpose communication modules is the most common method of connection. The connection can be made at the ports of RS-232C and RS-422 featured as standard.

3.1.3 Connection with a T-link

PODs are connected to devices in Fuji Electric's original field network, the T-link, by providing a T-link interface module on the side of the SPH.

Extension of POD functions have been made so that SX loader commands might run on this T-link,

Fig. 4 Programming screen for specifying variable names

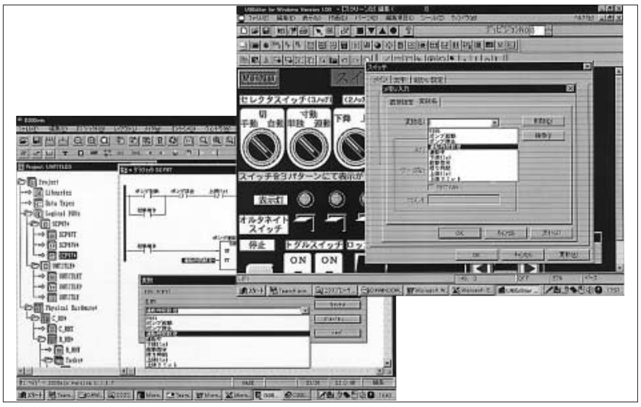
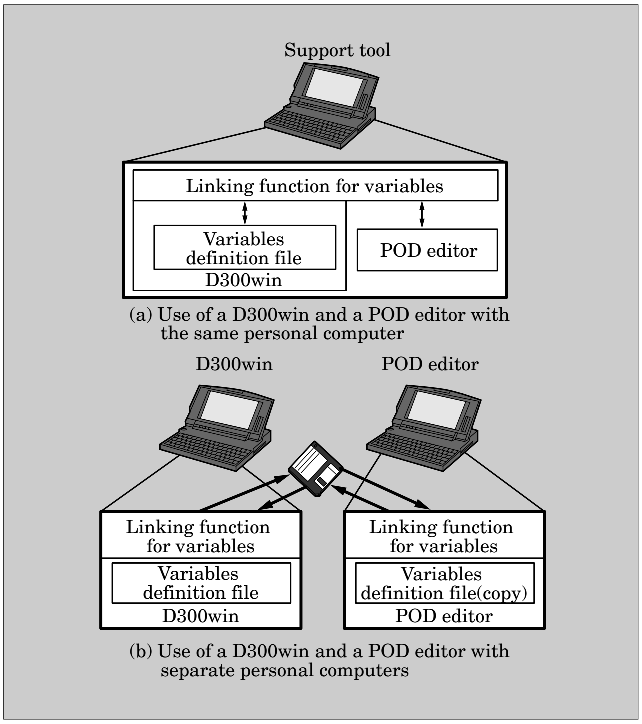


Fig.5 Linking function for variables



which has allowed compatibility of the PODs with former T-link devices and high-speed long-distance transfer.

3.1.4 Connection with JPCN-1

JPCN-1 is the standard network provided by the Japan Electrical Manufacturers' Association (JEMA). PODs are connected to devices in the JPCN-1 by the provision of a JPCN-1 interface module on the side of the SPH. Various I/O devices, including the products of other manufacturers, can be connected to the JPCN-1.

Communication with the PODs has enabled the connection between an SPH and an SPS possible by supporting GET/PUT commands of the JPCN-1.

3.2 Cooperation of programming support tools for controllers and PODs

3.2.1 Linking of variables

Transmission and reception between the former POD series and controllers (PLC) were defined by directly designating the memory addresses of the PLC-with a POD editor.

Scalable multi-controllers (SPH) of the MICREX-SX series conform to IEC61131-3 (formerly IEC1131-3). In their control programming, memory addresses are not directly used; rather, variables (signal names or labels) are used to increase the reusability of programs.

It is only natural that the same variables should be used in the image creation and programming of the PODs. For this purpose, support tools of the scalable multi-controller SPH (D300win) and those of the POD (POD editor) use the same variables definition file for data sharing among controllers and programs.

The variables definition file created while generating control programs can be read out, referred to and specified during programming of the PODs. More specifically, the programming includes an operation to specify variables used for display data and input data with a pull-down menu (refer to Fig. 4). The definition of new variables and redefinition of variables occurring during programming of the PODs can be reflected in the variables definition file.

Figure 5 shows the linking of a D300win and a POD editor.

3.2.2 The case of the same program development environment

Figure 5 (a) shows a standard method of simultaneously running a D300win and a POD editor on the same personal computer as a support tool.

Information on variables is stored in the variables definition file, as shown in Fig. 5.

The POD editor can access the variables definition file in the D300win with the linking function for variables and register and refer to the variables accessed. Common variables are automatically updated.

3.2.3 The case of a different program development environment

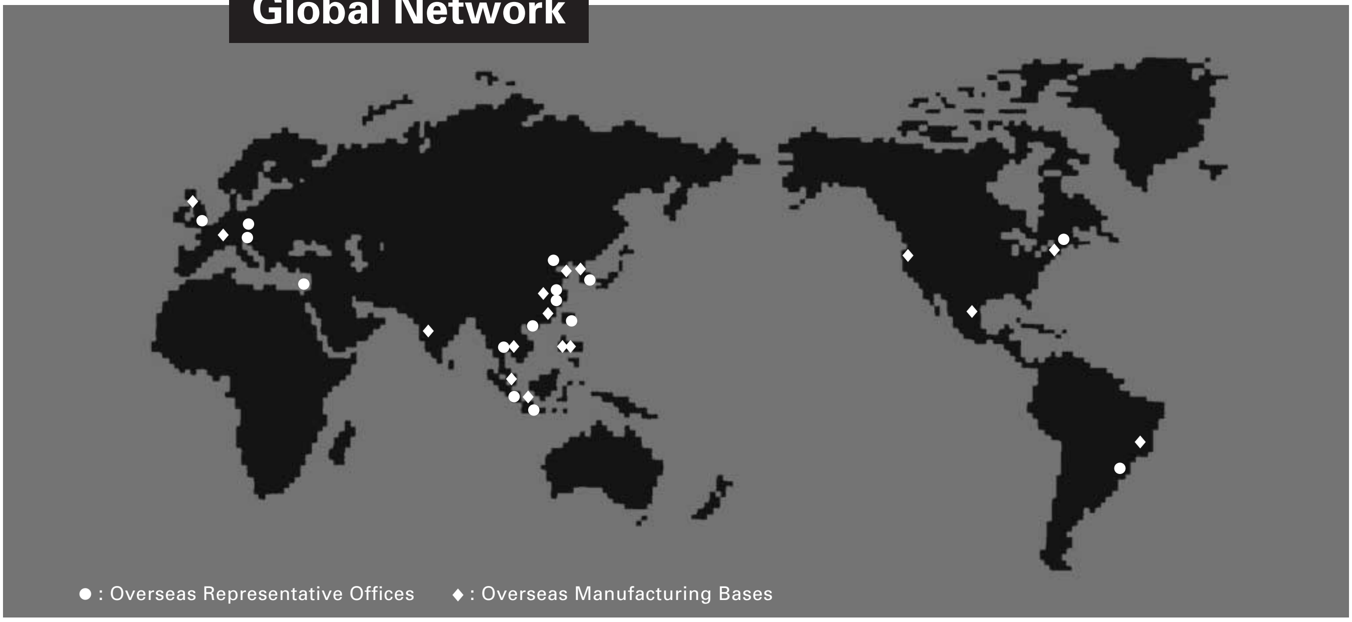
Figure 5 (b) shows a method of running a D300win and a POD editor on separate personal computers as a support tool.

In this case, the definition files must be separate in both support tools, and the data of both definition files can be exchanged between the support tools through floppy disks.

4. Conclusion

An outline of the development of the new UG series has been introduced in this paper. Fuji Electric will continue to develop small-sized PODs with diagonal screens less than 5.7 inches and improve the functions and usability of the PODs.

Global Network



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