# PC-Based Controllers of MICREX-SX Series

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## 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

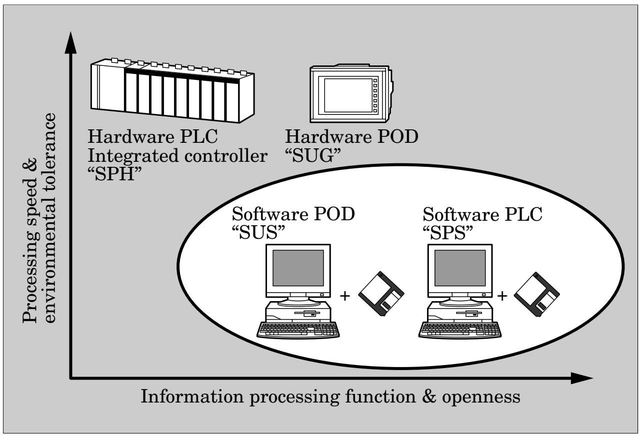
Fuji Electric developed "SPS" as a software PLC of the MICREX-SX series. Figure 1 shows the position of the PC-based controller system within the MICREX-SX series. The programmable operation display (POD) is a man-machine interface (MMI) that operates and displays the state of the plant and equipment. 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

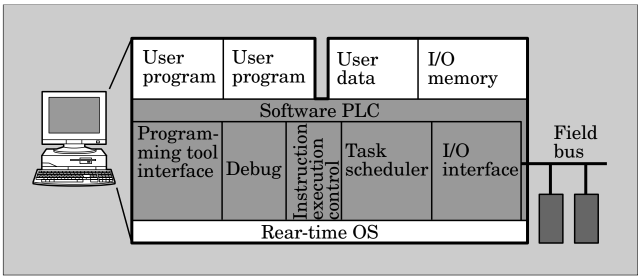



Table 1 Product specification of the SPS

| Item | Specifications | Remarks |
|---|---|---|
| Operating environment | OS: Windows NT 4.0 SP3 or newer<br>CPU: Pentium* 75MHz or more<br>Main memory: 48MB or more<br>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 instruction/data instruction) | 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

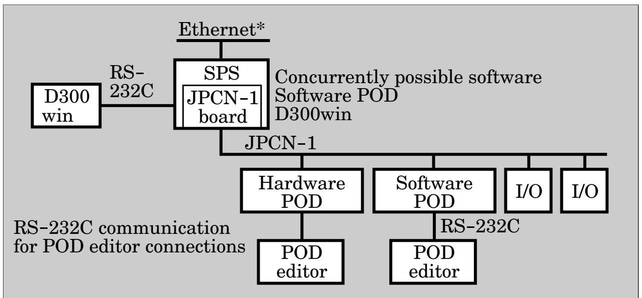
software, networks, the support of PC expansion boards with ISA and PCI buses, software POD, etc.

### 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

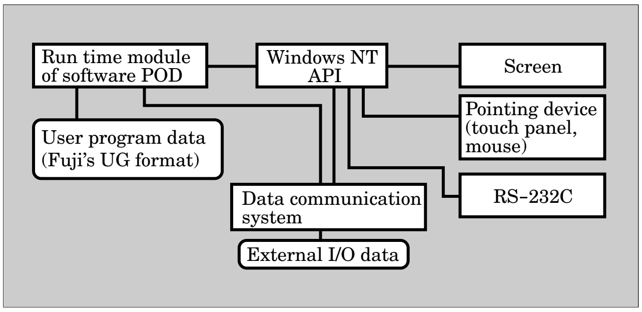



Table 2 Display specification of the SUS

| 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.<br>Total capacity per display: Within 64kB<br>Statistics and trend graphs: Max. 1,024 per display |
| Number of characters | One-byte character: 40 characters × 12 lines<br>Two-byte character: 20 characters × 12 lines<br>(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

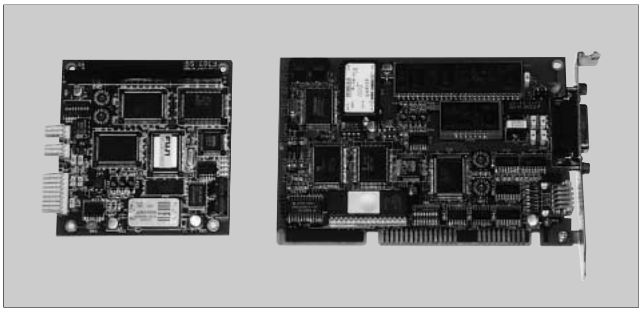


Table 3 Specification of the interface boards

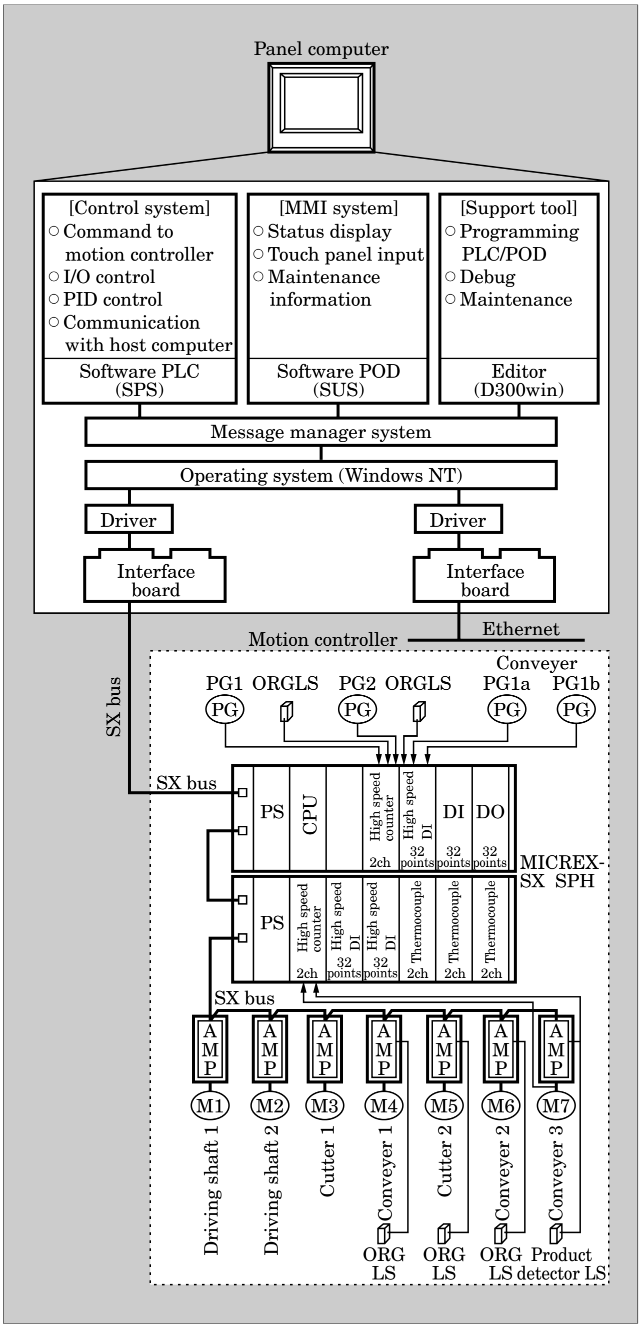
(a) Network interface board

| Name | Function | Shape |
|---|---|---|
| SX bus interface | ○ Board interfacing with SX bus of MICREX-SX series<br>○ Master/slave function | ISA (half size) |
| T-link interface | ○ Board interfacing with T-link<br>○ Master/slave function | ISA (half size) |
| JPCN-1 interface | ○ JPCN-1 network interface board<br>○ 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<br>○ With SX bus interface | ISA (half size) |
| F70S CPU board | ○ PLC function board based F70S of MICREX-F series<br>○ 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.