The MICREX-SX Integrated Controller Series

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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

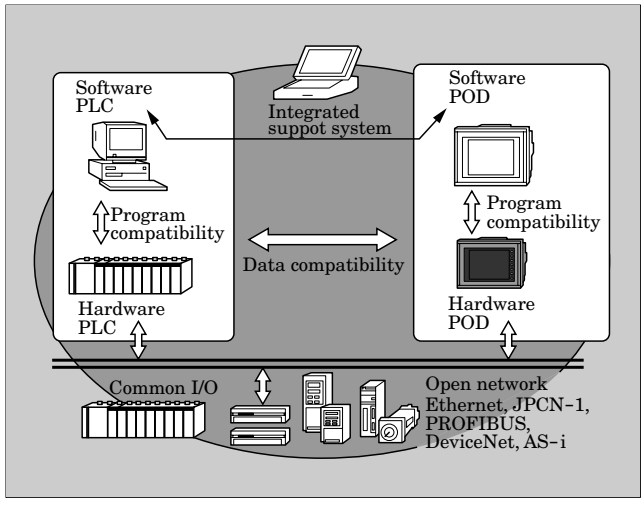
2.1 Integration of control, operation and monitoring

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 MICREX-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

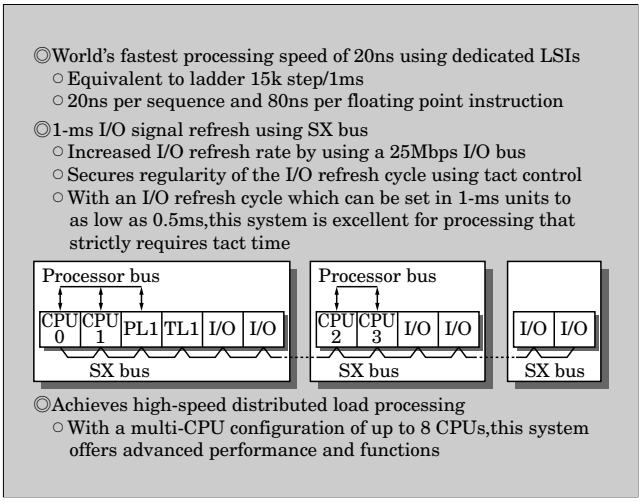
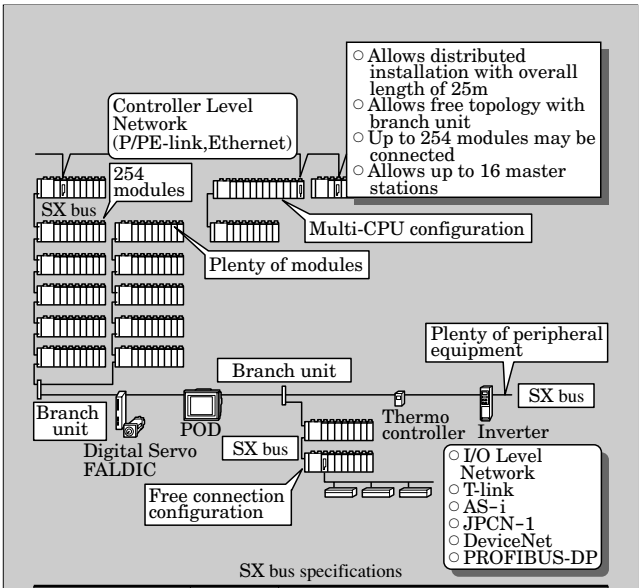


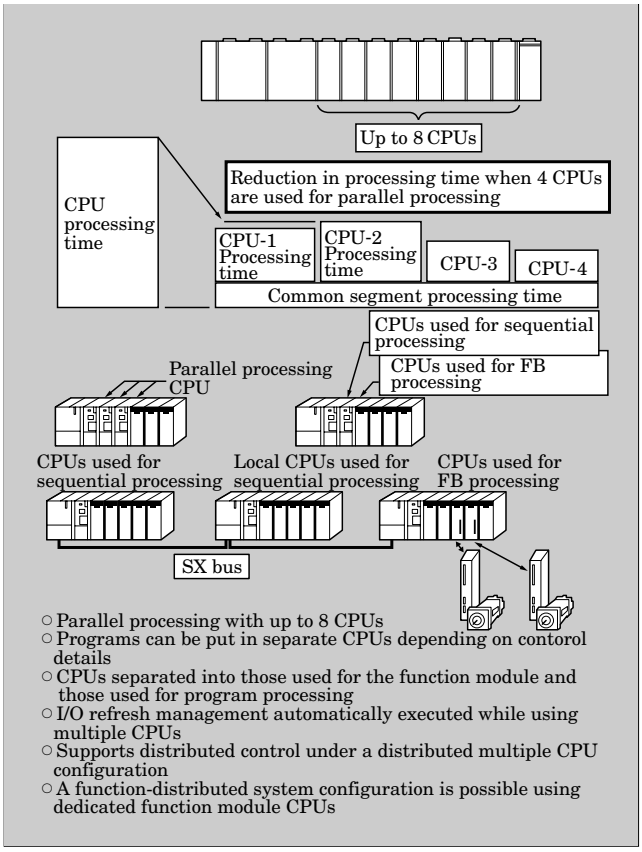
Fig.3 SX bus



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

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

Fig.5 Network

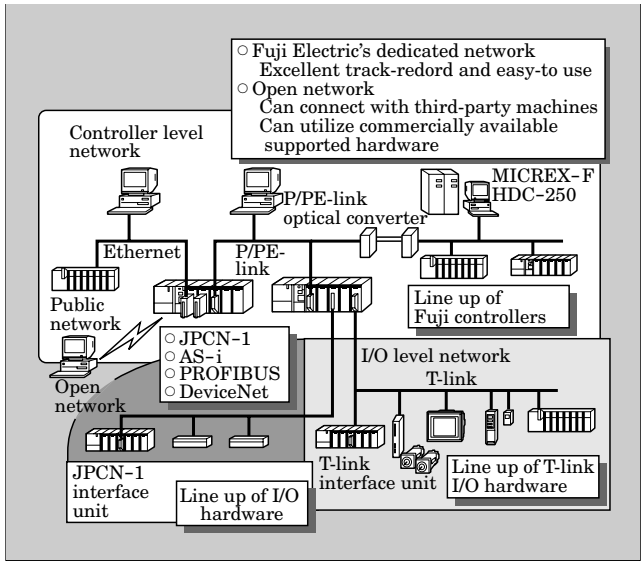
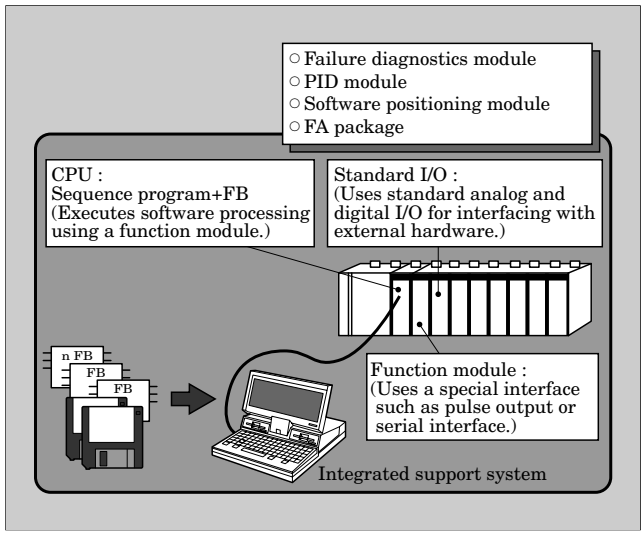


Fig.6 Software function module



FA control network promoted by the MSTC.

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

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

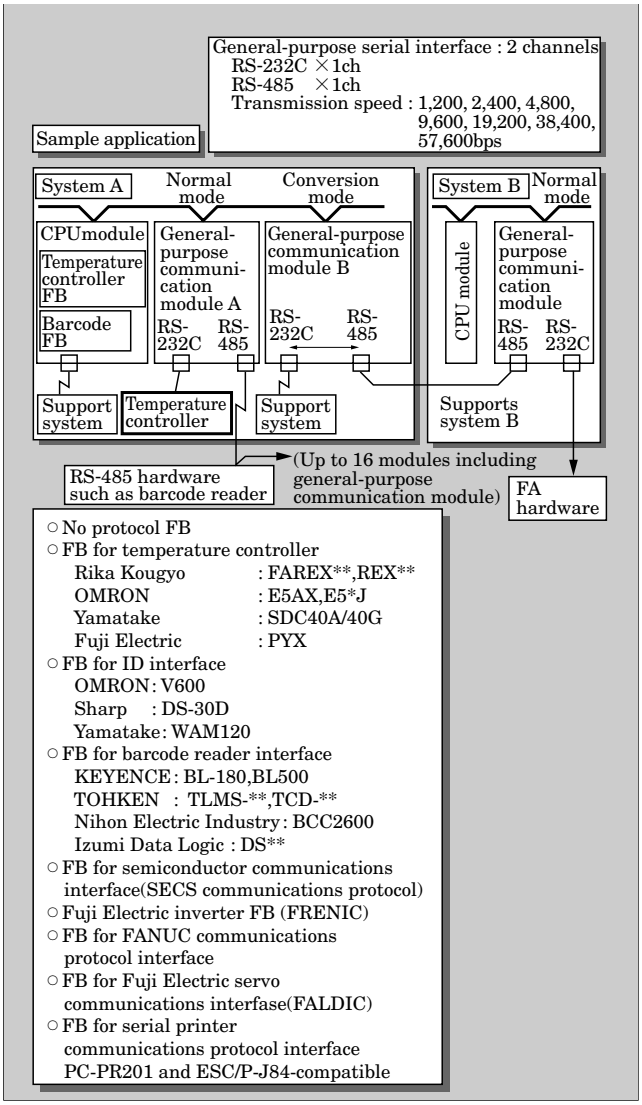


Fig.8 Position control

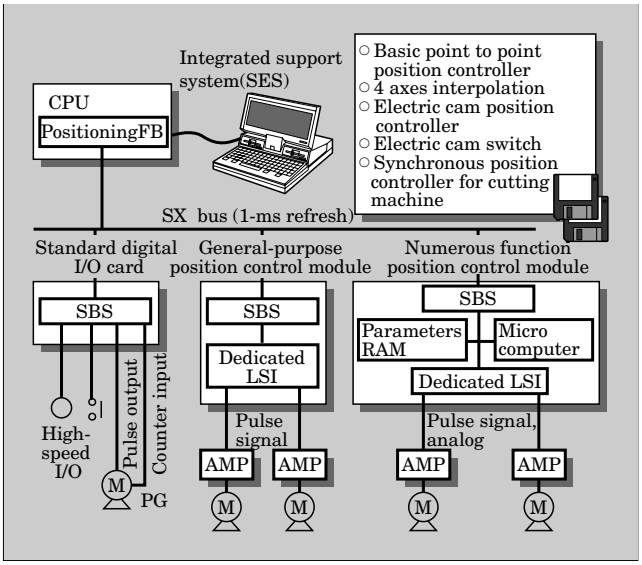
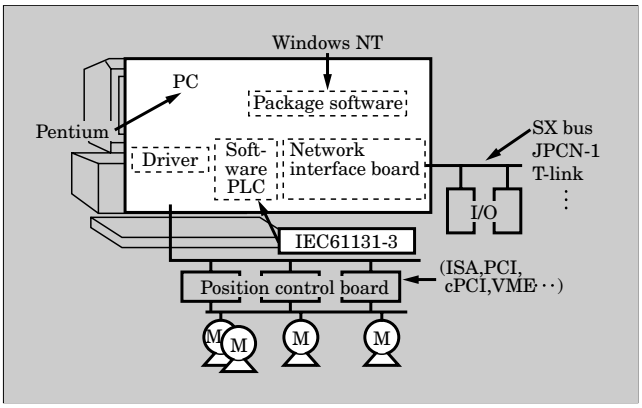


Fig.9 Software PLC



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.

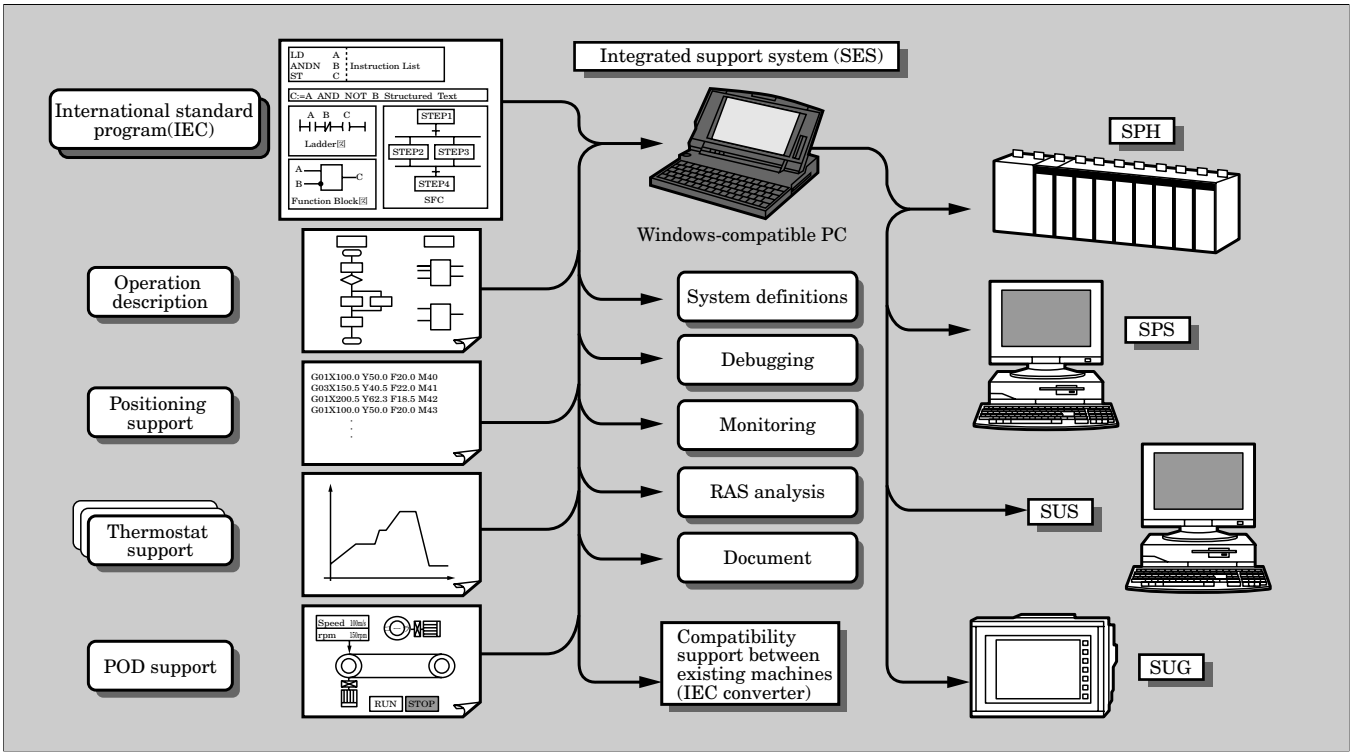
Figure 9 shows the concept of the SPS.

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 MICR EX-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

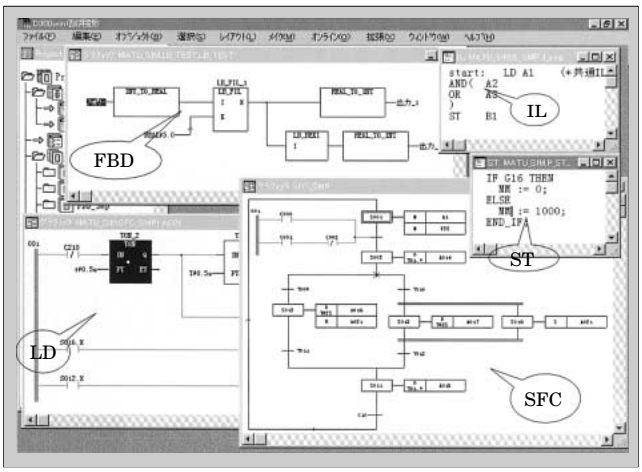
The ladder diagram method is established in Japan but was limited to large scale and complicated programming and has required improvements. Most of the usual programming languages differ from each other depending on the manufacturer or the model. Therefore, practical experience with the model was required 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.