UDC 681.323:62-523

MICREX-F SERIES, PRESENT STATE AND FUTURE PLAN

Masahiro Yoshida
Yasumasa Umesato

1. FOREWORD

MICREX-F is the trade name for the Fuji Electric programmable controller (PC). The PC was born as a controller which can be installed on the manufacturing floor and easily handled and easily programmed by the plant floor engineer between the end of the 1960's and the beginning of the 1970's based on computer technology. The first PC were simple logic operation devices. However, they were supported by later technological innovations and the expansion of demand and advanced quickly. Today, the PC occupies an indispensable place as an automated system controller of various industries. Recent PC trends are toward the rounding out of the product series to meet a wide range of applications, strengthening of the network for sophisticated informationalization of systems, and advancing software technologie for rationalization of software production, such as realizing understandable software expression, simplified software method, and powerfull software workstation. There is also a strong demand for network and software compatibility on an international level.

The development aims, products, system configulation and future plans of the MICREX-F series are described here against this background.

2. DEVELOPMENT AIMS AND PRODUCT SYSTEM

2.1 Demands from applications

2.1.1 Optimization of system architecture

PC applications have many branches, such as use by incorporation of individual units in machinery and equipment, distributed control by multiple PC, comparatively small complex control and data management system combined with a personal computer, use as a component of a large hierarchy system, etc. Control function, process input-output (PIO), network, generic interface, and other components which make up the PC product series are put together systematically so that the objective functions, performance, scale, system configuration, shape, size, etc. can be best implemented for each of these applications. The capability to implement the optimum system quickly and cheaply is demanded.

The ability to cope flexibly with system modification and expansion and to build a duplex, triplex, or other high reliability system as required is also indispensable.

2.1.2 Production system informationalization

Diversification of the product demand, reflecting the increased sophistication and individualization of social and economical activity and daily living, is advancing and the kinds of products to meet this is increasing and, on the other hand, product life is becoming shorter.

A production system which can cope with such demand trends must immediately be able to respond to demand change, and realize short lead time, high quality and low cost, based on multi-product and small lot production. Therefore, grasping of materials, parts, and products, and controlling of their quantities and material flow, conditions, quality, etc. in the production process at online and in real time based on the production plan, that is, total informationalization, are necessary.

The PC used at the production site must have complex capability, such as collecting and transmiting the information from production machines to a high level computer system over a network, and translating the production message from a computer and controlling machine tools, assembly machines, transportation lines, etc. including set up change for switching of products correspond to the production plan.

The purpose of informationalization is also the maintenance of productivity. Stopping of production by accidents may have a large effect on corporate management. The incorporation of reliability improvement measures and recovery measures when trouble occurs in system is demanded.

2.1.3 Internationalization

Internationalization of the economy is progressing and overseas production by Japanese industry is being advanced positively and the advance of foreign enterprises into Japan is fluorishing. The PC, which occupies an important position in production systems, is not unrelated with this current toward internationalization.

A production system is build to obtain maximum effect at lowest cost (life cycle cost including development, test, operation, and maintenance) by the rational combi-

nation of mainframe computer, mini/micro computer, NC (Numerical Controller), RC (Robot Controller), PC, and other system components. Therefore, it is desirable that it be possible to exceed the manufacturer and nation frame and select the best components on an international level. At this time, the keypoint is the compatibility of the network which connects each component and the software which can be used in each component.

Network compatibility is the ability of the PC of different manufacturers directly to exchange data by common network and common protocol. In regards to this, the beginning originated in the advocation of the GM Corp. of the United States and international standardization of a factory LAN (Local Area Network) protocol called MAP (Manufacturing Automation Protocol) is being advanced at the MAP world federation including Japan, Europe, and Australasia, about SME (Society of Manufacturing Engineers) and is being quickly practicalized by each industry.

As for PC software, standardization of Programming Languages was advanced at IEC (International Electrotechnical Committee) SC65A/WG6 and a draft was completed and is scheduled to be officially issued in 1988.

This standard specifies ladder diagram (LD), function block diagram (FBD), sequential function chart (SFC), instruction list (IL), and structured text (ST) and standardizes application program representation and decoding. The fact that this makes an international common understanding of programming tool display, document description, has a large effect.

However, these representation and description methods, are application software level and do not solve the basic problem of software compatibility among different kinds of PC and PC made by different manufacturers, and more research is necessary.

2.2 Basic concept of development

The MICREX-F series were developed on the background described above.

2.2.1 Rounding out of systematic components

The simple and inexpensive implementation of the optimum system for each application, which demand multidimensional specifications such as functions, performance, system configuration, scale installation conditions, etc. is desirable.

In order to achieve this, our basic policy is to offer standardized components and a simple and systemized means of combination of components so that the desired system requirements can be realized with the minimum kinds of components. Suppressing the kinds of components to the rational number by application analysis and later discernment, and reducing costs by mass producing components are the keypoints in realizing a cheap system.

2.2.2 Network

A network is mainly used with PC for the following purposes:

(1) Physically simple and economical interconnection of components.
(2) Perform the communication required by the application based on a standardized physical interface and logical protocol.
(3) Reduce the influence of trouble by loosening the physical coupling between components and increase data transmission reliability by inserting a data error detection function into the protocol.

A network is an extremely effective means of building a flexible system. A systematized and hierarchical network which can be suitable and economically used according to the objective, from networks for on-site input-output terminals distributed installation to interoperable LAN, are offered.

2.2.3 Software compatibility

Reflecting the trend of complex informationalization of product systems, PC software is also becoming more complex and larger. The opportunities for software modification or expansion increase with change of layout of facilities, etc.

How to achieve greater labor-savings in the software life cycle of development, testing, operation, and maintenance must be a large topic for the future. This requires a change from the cottage industry method to the industry production. For example, materials and parts used in common, the facilities which produce the final product by processing, assembling, and testing these materials and parts, and efficient operation of these facilities are necessary.

Materials and parts correspond to the programming languages used in common and the reusable program modules created with them. Processing, assembly, and test facilities are the programming tools and software workstation. Efficient operation corresponds to increasing software productivity by use of program module, automatic composition of programs, program simulation, etc.

The basis of technology of industrial production of PC software is a programming language. This is not ladder diagram, block diagram, SFC, IL, ST, or other application software language, which are currently used, but is positioned between these languages and the various machine languages. It must be a language which is independent from each application language and machine language and compatible with them.

Fuji Electric has developed a control problem oriented functional intermediate language with a simple architecture and high level functional expression capability (named FCL: Functional Control Language) as this language.

The basic consideration is establishing software compatibility by FCL, and realizing the standardized software workstation by applying the results of research on software engineering, artificial intelligence technologie, etc., based on the FCL.

2.3 Product system

The MICREX-F series product system and hierarchical position including the network are shown in Table 1 and Fig. 1.

2.3.1 Network

A T-link which interconnects control site input-output devices installed at the most suitable places and a P-link

which communicates between PC processors are available. They are plant floor level networks positioned below LAN in the network hierarchy and are positioned at what should be called FAN (Field Area Network).

Fuji Electric's unique DPCS-F was commercialized as an LAN level network. An Ethernet<Note> (IEEE-802.3, TCP/IP) is under development as an interoperable general purpose network. MAP and miniMAP will also be commercialized in the near future.

As shown in Fig. 1, network connection of not only the MICREX-F series, but also of a host computer, microcomputer, personal computer, and loop controller, visual sensor, etc. needed to build an automated system is available.

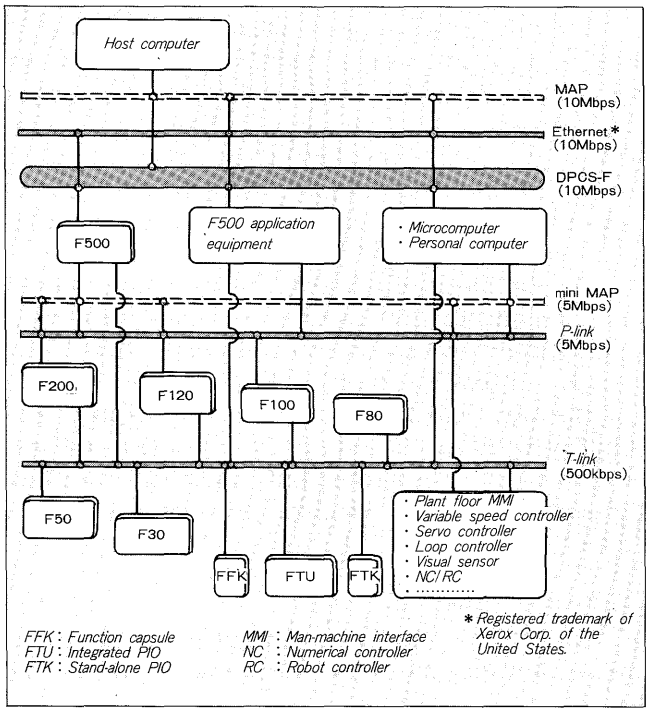
2.3.2 MICREX-F50/F30 series

These series is applicable from installation within machinery and equipment as a compact PC to use as a controller of a small system. They can be connected to a T-link by installing an adapter to the basic unit. They can also (build) a distributed PIO system by conneting PIO units though T-link, though not illustrated in *Fig. 1* controller of a host system.

2.3.3 MICREX-F120/F100/F80 series

These series can be used as a distributed PC system using the P-link, distributed PIO system by T-link, stand alone, or more sophisticated but a small to medium size system can be flexibly built by coupling them to a microcomputer or personal computer through a P-link or T-link.

Fig. 1 MICREX-F Series and network hierarchy



<Note>
Ethernet is a registered trademark of Xerox corp.

2.3.4 MICREX-F200 series

This series is for medium size systems and is an upgraded version of the F120/F100/F80 series. System architecture is the same as these series. However, as shown in Table 1, its functions and capacity are large. The OS is simple and real time multi-program execution is available. The fixed-cycle program and event interrupt program needed in adjustment control are also available.

From the standpoint of programming, program modules can be defined and created, so structuring of programs by modules is easy. Simple file and data operation are available, and so material flow sequence, classification, transportation, and other control is also easy.

2.3.5 MICREX-F500

This is the high level model of the MICREX-F series. It has the following features:

(1) International hardware compatibility

The 32-bit bus architecture MULTIBUS II developed by Intel Corp, in the United States and being now standardized by IEEE is used as the bus architecture for compatibility at the board level. It is called open system hardware in the sense that it is opened internationally. (*Fig. 2*)

(2) Multiprocessor system

The MULTIBUS II architecture is considered to be for multiprocessors. PC and computer functions can be obtained by combining a control processing board and information processing board.

(3) Control processor

Since this processor was developed for FCL, dealing with ladder diagrams, block diagrams, SFC, or other software represenataions is easy. Since 32-bit floating point arithmetic is available, numerical calculation, mathematical models, etc required by sophisticated control can be executed without any fear of underflow and overflow.

Fig. 2 Open system hardware

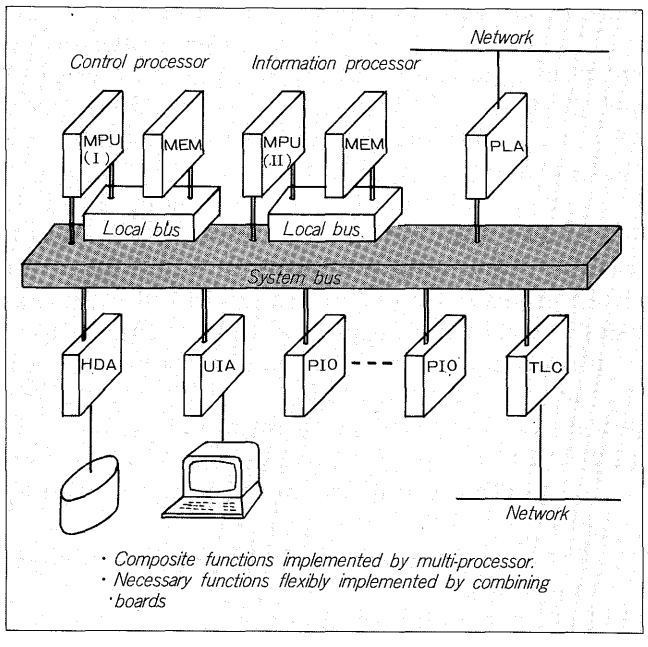
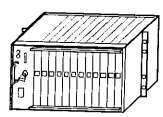
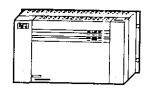
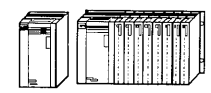
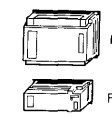
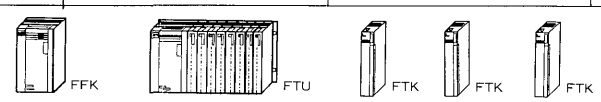


Table 1 MICREX-F series system

Series			F500	F200 series	F120/F100/F80 series	F50/F30 series
Position and application			• Advanced functions PC for large to medium size systems • Has controller and computer functions and used as basic components for equipment for various applications.	• PC for medium size systems • Distributed type system, stand-alone use • Distributed type PIO (remote I/O)	• PC for medium to small size systems • Distributed type system, stand-alone use • Distributed type PIO (remote I/O)	• Small size, compact PC • Stand-along use, incorporation into machinery • Hierarchy system terminal PC
System architecture			Multiprocessor system	Single processor	Single processor	Single processor
Bus architecture			MULTIBUS II*3	Input/output (PIO) is dedicated 8-bit bus	Same as at left	Same as at left
Network			• T-link, P-link, DPCS-F • Ethernet*4, MAP*5	• T-link: F200 • T-link + P-link: F205	• T-link: F120, F100, F80 • T-link + P-link: F125, F105	• Connectable to T-link by adding an adapter.
Control operation	Program expression		Ladder diagram, FB diagram, SFC diagram, mnemonic (FCL), other expressions	Ladder diagram, FB diagram	Ladder diagram, FB diagram	Ladder diagram, FB diagram
	Processor		Original 32-bit LSI	Original 16-bit LSI	Original bit processor + 8086/8088	Original bit processor + 8085
	OS*1		Real time multiprogram for control	Real time multiprogram for control	Cyclic program (F100)+fixed-cycle interrupt/event interrupt (F80, 120)	Cyclic program
	Memory size	Program	64k words (16 bits), expandable	28.1k steps (16 bits)	5.1k, 10.5k, 16k steps	2.3k steps
		Data	32k words (16 bits), expandable	12k words (16 bits)	384 words, 1.5k words, 8.0k words (16 bits)	384 words (16 bits)
	Control operation functions		• Sequence control, adjustment control • Fixed/floating point arithmetic • Function operation, function definition • Data, file operation	• Sequence control, adjustment control • Fixed point arithmetic • Control function operation • Simple data, file operation	• Sequence control • Fixed point addition, subtraction, multiplication, division • Simple control function operation • Simple data operation	• Sequence control • Fixed point addition, subtraction, multiplication, division • Simple data operation
	Programming tools		• FAISES (personal computer FMR-60) • System incorporation (supported by data processing processor)	• Program loader D20, D10	• Program loader D20, D10	• Program loader D05 • Program loader D20, D10
Input/Output	ON/OFF I/O capacity(points)	Standard usage range	256 to 4096 points	128 to 2048 points	64 to 1024 points	16 to 160 points
		Maximum capacity	8700 points	3200 points	1600 points	1600 points
	Kinds of input/output (PIO)		• Digital input/output • High-speed counter input • Analog input/output • Resistance bulb, thermocoupler input • Personal computer interface • Intelligent PIO (PID control, positioning ...)	• Digital input/output • High-speed counter input • Analog input/output • Resistance bulb, thermocoupler input • Personal computer interface • Intelligent PIO (PID controo, positioning ...)	• Digital input/output • High-speed counter input • Analog input/output • Resistance bulb, thermocoupler input • Personal computer interface • Intelligent PIO (PID control, positioning ...)	• Digital input/output • Pulse counter (2kHz, 1 channel)
Data processing	Processor		80286/80386	–	–	–
	OS*1		Theos*6-286V/Theos*6-386 Real time, multitask, multiuser	–	–	–
	Memory	Main memory	1MB – (expandable)	–	–	–
		Auxiliary storage	Hard disk, floppy disk	–	–	–
	Programming language		BASIC, C.	–	–	–
	Data processing functions		• Data processing • Program development • Man-machine monitor & operation • Controller group management (Cell controller)	–	–	–
RAS*2	Fault detection and indication		• Write to fault data file by error detection and self-check and display of faulty part by lamp	Same as at left	Same as at left	Same as at left
	Maintenance unit		• Exchange by card • Dismounting and mounting in active state possible	Exchange by unit	Same as at left	Same as at left
	Multiplex system		• Duplex (hot standby) • Triplex	• Duplex	• Duplex (F120 only)	–
Exterior view						
						

*1 OS: Operating System
*2 RAS: Reliability, Availability, and Serviceability
*3 MULTIBUS is a registered trademark of Intel Corp.
*4 Ethernet is a registered trademark of Xerox Corp.
*5 MAP: Manufacturing Automation Protocol (currently under development)
*6 Theos is a registered trademark of Theos Software Corp.

(4) Data processing processor

An 80286, 80386, and other high performance microprocessors can be used as the processor (80386 board is under development). BASIC, C, and other general purpose high-level languages can be used under an operating system (Theos)<Note> with real time, multitask, and multiuser functions which use the performance of these processors to the full.

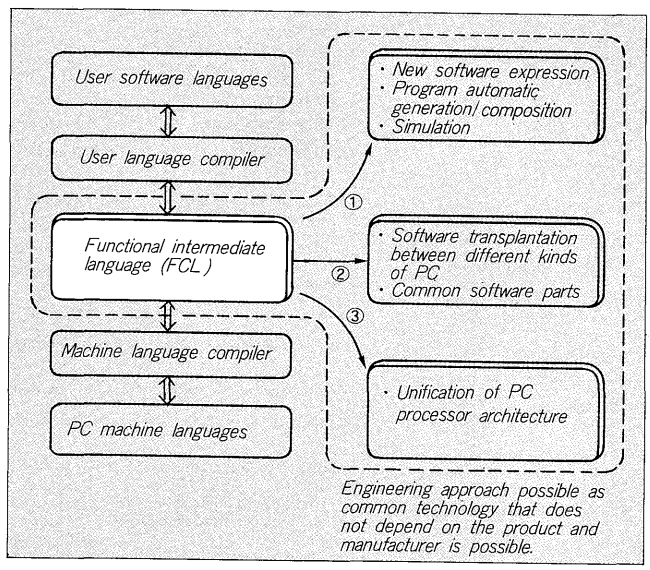
(5) Use as basic material of objective-oriented controller and/or processor

By combining the necessary boards and necessary basic software, systems for various objectives can be implemented.

2.3.6 Functional intermediate language and software development support system

The functional intermediate language (FCL) was used to make software compatibility possible. It is positioned between ladder diagram, block diagram, SFC, and other user software languages and PC machine languages as shown in Fig. 3 and is software compatible on this level. The software engineering support system FAISES built a software development environment based on FCL. It is scheduled to be upgraded step by step to realize the contents shown in *Fig. 3*.

Fig. 3 Open system software



3. FUTURE PLANS

3.1 Internatonal standardization

3.1.1 Network

An shown in Fig. 1, an internationally compatible network system is realized by Ethernet (TCP/IP) and MAP. At this time, the simplicity, high-speed, economy, and other advantages of the existing network are still used so that the optimum system can be built. We want to open P-link and T-link to the public as field level networks in the future.

3.1.2 Software

The realization of the potentiolity shown in *Fig. 3* with FCL as the base of software compatiblity is scheduled. We want to aim at opening FCL to the public and software compatibility on an international level by accumulating of achievements.

3.2 System integration

3.2.1 System components

As shown in Fig. 1 and Table 1, components are available so that a system corresponding to the objective can be assembled. In the future, technological advances in microelectronics will, of course, be incorporated and the performance and mounting density in the components will be improved while maintaining compatibility with existing components. We also plan to incorporate simple NC functions, simple robot control functions, fuzzy control, plant floor man-machine interface terminal, etc., and round out the components.

3.2.2 Interconnection with other systems

By progress of informationalization of the production system, the combinations of NC, RC, visual sensor, etc., including the microcomputer and personal computer, is becoming larger, even with small size systems. Expansion of the interconnection with these devices, including development of interface software, is planned.

3.2.3 Integration of control and management

To operate a production system efficiently and flexibly, integrated interconnection with production management information and plant floor machinery control information for realizing the production plan is necessary.

To realize this, improvement of the connectability of information with a high-level hierarchy computer by installing comparatively simple data and file operation functions in the PC itself is planned. In the future, standardization of the data file structure, access method, etc. will be necessary so that consistent data management as a system is realized.

From the program standpoint, PC prpgram generation, expansion, storage, etc. seen from a high level system should be performed uniformly regardless of the PC type and manufacturer. To do this, a powerful program code with a common meaning and structure is necessary. FCL is an effective technique.

On the other hand, with recent production systems, to simplify operation and management, the entire system is divided into numerous subsystems and these subsystems are organically integrated. These subsystems (cells) performs a series of operations, such as processing, assembly, and testing of parts and half-finished products completely by themselves. A control system of this level (cell level) is composed of PC, NC, RC, other dedicated controllers, and a cell controller connected to these controllers as low-level machine controller and to a high-level supervisory computer. The roles of this cell controller are:

(1) Group control in cell

<Note>
Theos is a registered trademark of Theos software corp.

(2) Direct control of common section in cell
(3) Cell units file servor
(4) Generation, maintenance, and storage of low-level controller programs
(5) Preprocessing of data to be transmitted to high level system, decoding and processing of information from high level system, and transmission to low level system
(6) Man-machine interface (supervision and operation)

That is, a cell controller must have the machine control and information processing functions. The MICREX-F500 is supremely applicable. Expansion of applications as an open cell level controller C is planned, based on control use FCL, computer use real time, multitask, multiuser OS (Theos), and general purpose high level languages BASIC.

3.3 Software production system

Besides the portable program loaders D05, D10, and D20, PC-CAD and FAISES (Fuji AI based Software Engineering system) was commercialized as a software production system using a personal computer. However, in the future, we plan to strengthen and complete and systemize these systems as a software development environment. Specifically, we want to make them a multiuser type software production system which incorporates software development support tools based on the advanced OS (Theos), C language, and high capacity files of the MICREX-F500 and uses a personal computer as the peripheral terminal and has a common data base and common files and allows group design.

For rational production, we plan to practicalize automatic generation and composition of programs adapting the results of software engineering and AI technology with FCL as the material and parts.

4. CONCLUSION

The MICREX-F series is serialized from models which can be used as stand alone devices to cell level controller so that they are suitable for a wide range of applications.

The main point of systemization is realization of an open system with a sufficiency of types and connectability, compatibility, and integratability from the global standpoint.

In the future, we will implement the things described in this article and offer components and systems which are expandable.