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Programmable Logic Controllers Edition

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●Vol. 76/Sep. 1996 Mitsubishi Electric **ADVANCE**

Programmable Logic Controllers Edition

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Centerpiece of our cover is the Q4AR programmable logic controller, one of an extensive range of advanced products that provide the flexibility and sophisticated functions to act as the "brains" of manufacturing systems in the era of automated multiple-machine processing.

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OVERVIEW

General-Purpose MELSEC Sequencers: Present Capabilities and Future Prospects

*Keishi Ohbuchi**

General-purpose sequencers (the name under which Mitsubishi Electric markets programmable logic controllers, i.e., PLCs) have, in the 1990s, come into widespread use as critically important elements in many areas of factory automation (FA) and computer integrated manufacturing (CIM). Thanks to an increasingly sophisticated range of functions that include calculation, information processing and networking support, they can be found throughout industry controlling manufacturing processes, assembly, inspection and transportation.

Market needs for configuring and optimizing total FA systems impose additional demands upon these sequencers for more functional operation and the extension of their application to the control of electric power distribution, building supervision and management, and simple instrumentation installations.

The corporation has responded to these needs with PLCs embodying key advanced technologies selected to have the greatest impact on functionality, performance, miniaturization and networking capabilities. They are multifunctional with built-in intelligence. Again, ease of use is a key factor in increasing added value, so the corporation has implemented revolutionary changes in the environment for software development, at the same time using dual CPUs to achieve high reliability, ease of maintenance, and to provide diagnostic functions. These have established a strong leadership position for Mitsubishi sequencers. This special edition of *Advance* introduces trends in product development for the main product categories and the advanced technologies that make their performance possible. ❑

**Keishi Ohbuchi is with the Nagoya Works.*

MELSEC QnA/QnAS Series High-Speed, Multifunction Programmable Logic Controllers

*by Shun Ohta and Hideaki Morita**

Programmable logic controllers (PLCs) are playing a more important role as the systems they operate grow larger and more complex. Today's users are demanding PLCs with higher performance, more sophisticated functions, high reliability and reduced software development cost. This article reports on the MELSEC QnA series of PLCs developed to meet these needs.

Background

The QnA and QnAS series have been designed to improve execution performance and raise the efficiency of user program development. This was achieved by introducing a number of enhancements to the corporation's previous PLC products:

1. Support for structured programming allows multiple designers to work on a single project.
2. Programs can be standardized.
3. An efficient, easily learned user interface follows the model of commercial software packages.
4. Overall performance has been scaled up through improvements in the processor units, data bus and networking interface.
5. Extended program memory and device capacity ease program design restrictions.
6. Compact QnAS Series products are available for embedded applications.

System Configuration

Fig. 1 shows the basic components of a QnA Series PLC: high-performance CPU modules, 15 memory cards (incompliance with the standards of the Japan Electronic Industry Develpment Association), network interface modules designed to match closely with the CPU modules, a high-speed access CPU base unit that boosts overall performance and a software package providing total program development support.

The new series maintains backward compatibility with existing MELSEC A Series CPU base units, power-supply modules, I/O units and most special-function units.

Fig. 2 shows a QnAS CPU module. The form factor is designed for compatibility with MELSEC AnS compact PLCs; other specifications are identical to those of the QnA Series.

Fig. 1 QnA Series modules.

Fig. 2 A QnAS CPU module.

Features

Table 1 summarizes the specifications of the MELSEC QnA and QnAS series. CPU modules for both series use dedicated processors devel-

**Shun Ohta and Hideaki Morita are with the Nagoya Works.*

Table 1 MELSEC QnA/QnAS Series Programmable Controllers

Product	Part no.	Specifications	Remarks
CPU modules	Q2ACPU Q2ACPU-S1 Q3ACPU Q4ACPU	512 I/O points, 28k steps, 0.2µs 1,024 I/O points, 60k steps, 0.2µs 2,048 I/O points, 92k steps, 0.15µs 4,096 I/O points, 124k steps, 0.075µs	
	Q2ASCPU Q2ASCPU-S1	512 I/O points, 28k steps, 0.2µs 1,024 I/O points, 60k steps, 0.2µs	Compact
High-speed access CPU base units	A38HB	Double-speed data bus, other specifications identical to A38B	
	A1S38HB	Double-speed data bus, other specifications identical to A1S38B	Compact
JEIDA 4 compliant SRAM cards	Q1MEM-64S Q1MEM-128S Q1MEM-256S Q1MEM-512S Q1MEM-1MS Q1MEM-2MS	64KB 128KB 256KB 512KB 1MB 2MB	
JEIDA 4 compliant SRAM/EEPROM cards	Q1MEM-64SE Q1MEM-128SE Q1MEM-256SE Q1MEM-512SE Q1MEM-1MSE	32KB/32KB 64KB/64KB 128KB/128KB 256KB/256KB 512KB/512KB	
JEIDA 4 compliant SRAM/flash memory cards	Q1MEM-256SF Q1MEM-512SF Q1MEM-1MSF Q1MEM-2MSF	128KB/128KB 256KB/256KB 512KB/512KB 1MB/1MB	
Two-strand optical-fiber loop networks	AJ71QLP21 AJ71QLP25	MELSECNET/10 management station, remote master station MELSECNET/10 remote station	
Single-conductor coaxial bus networks	AJ71QBR11 AJ72QBR15	MELSECNET/10 management station, remote master station MELSECNET/10 remote station	
Serial communication modules	AJ71QC24 AJ71QC24-R2 AJ71QC24-R4	RS232C (1 channel, D-sub connector), RS422/485 (1 channel, terminal) RS232C (2 channels, D-sub connectors) RS422/485 (2 channels, D-sub connectors, terminal)	
Simple programming module	Q6PU	Programming module for QnA Series	
Software packages	SWONX/IVD-GPPQ SWONX/IVD-LNKQ SWONX/IVD-CNVQ SWONX/IVD-CADQ SWONX/IVD-MSPQ SWONX/IVD-MSDQ	GPP and SFC functions, program editor, monitor, debugger Ladder sequence program linker Data conversion utilities CAD interface Macro libraries for special-function modules Macro libraries for standard circuits	

oped at Mitsubishi Electric for sequence processing. With an operating speed of 0.075µs, the top-end CPU module offers double the performance of its predecessor. There are four CPU modules for the QnA Series and two for the QnAS Series, allowing processing capability and memory capacity to be scaled to the application. The high-speed access CPU module offers double the data throughput of previous equipment, and the memory cards offer high-speed access to support realtime control of complicated systems.

The QnAS CPU modules are compatible with the power-supply, I/O and special-function modules of the MELSEC AnS Series. Their specifications are identical to corresponding QnA CPU modules with the exception that they can accommodate only one memory card.

The MELSECNET/10 serial communication module features a dual-port buffer that supports reliable high-speed transfers between PLCs and personal computers.

The MELSEC QnA and QnAS series software package supports graphic programming design using ladders or sequential functional charts and provides a debugger. Up to four programs can be edited concurrently, with a cut-and-paste function between code windows (Fig. 3).

Support for user-defined macro instructions contributes to simpler, standardized programs, and allows users to build macro libraries for specific applications (Fig. 4).

A hierarchical file system supports transparent program management, allowing multiple designers to collaborate on programming, debugging and maintenance. Program files can be organized by function, designer, process or other criteria (Fig. 5).

Devices can be specified by labels rather than device numbers, which permits standard programs to be easily ported from one installation to another.

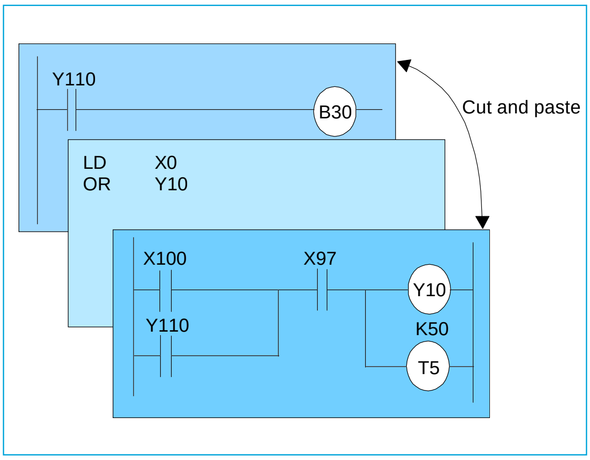

Fig. 3 Multiple file editing.

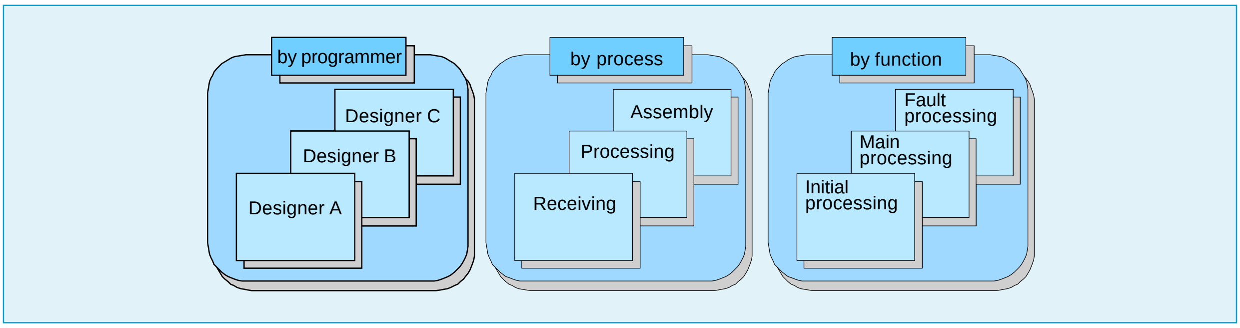

Fig. 4 A hierarchical file system.

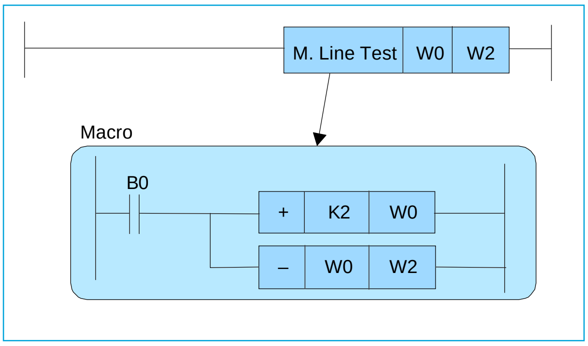

Fig. 5 A macro instruction.

In addition to state-of-the-art hardware, MELSEC QnA and QnAS series PLCs incorporate advanced programming features that dramatically boost software productivity and facilitate maintenance. With these features, it is possible to meet the realtime control requirements of highly complicated systems. ❑

Q4AR High-Performance Redundant Programmable Logic Controller with Problem-Oriented Language Support

*by Noboru Sakamoto**

Trends toward downsizing and open architecture in distributed control systems can be seen in the popularity of factory systems implemented by networks of personal computers and programmable logic controllers (PLCs). This article reports on the Q4AR redundant PLC designed to meet distributed control requirements while providing the high performance and reliability needed for "mission critical" factory control applications.

Configuration

The Q4AR has a backup processor and backup network interfaces for enhanced reliability, and features a full complement of sequence programming instructions for problem-oriented languages (POLs) including proportional, integral and derivative functions.

Fig. 1 shows the configuration of a Q4AR-based redundant control system. The base unit has symmetrically organized power-supply modules, CPU modules, system control modules and network interface modules. An auxiliary base unit is connected via a centrally positioned bus switching module to allow control of I/O and special-function modules.

The CPU modules have performance and functions comparable to the top-end MELSEC Q4A CPU. A coprocessor for floating point operations performs basic arithmetic four times faster than comparable single-processor CPU modules. The main CPU and backup CPU perform data tracking via a dedicated bus, and arithmetic results from the main CPU are transferred to the backup CPU so that, if the main CPU goes down, the backup CPU can continue processing in the same state.

The system control modules monitor the CPU and power-supply modules. When they detect a fault, they send a switch command to the bus

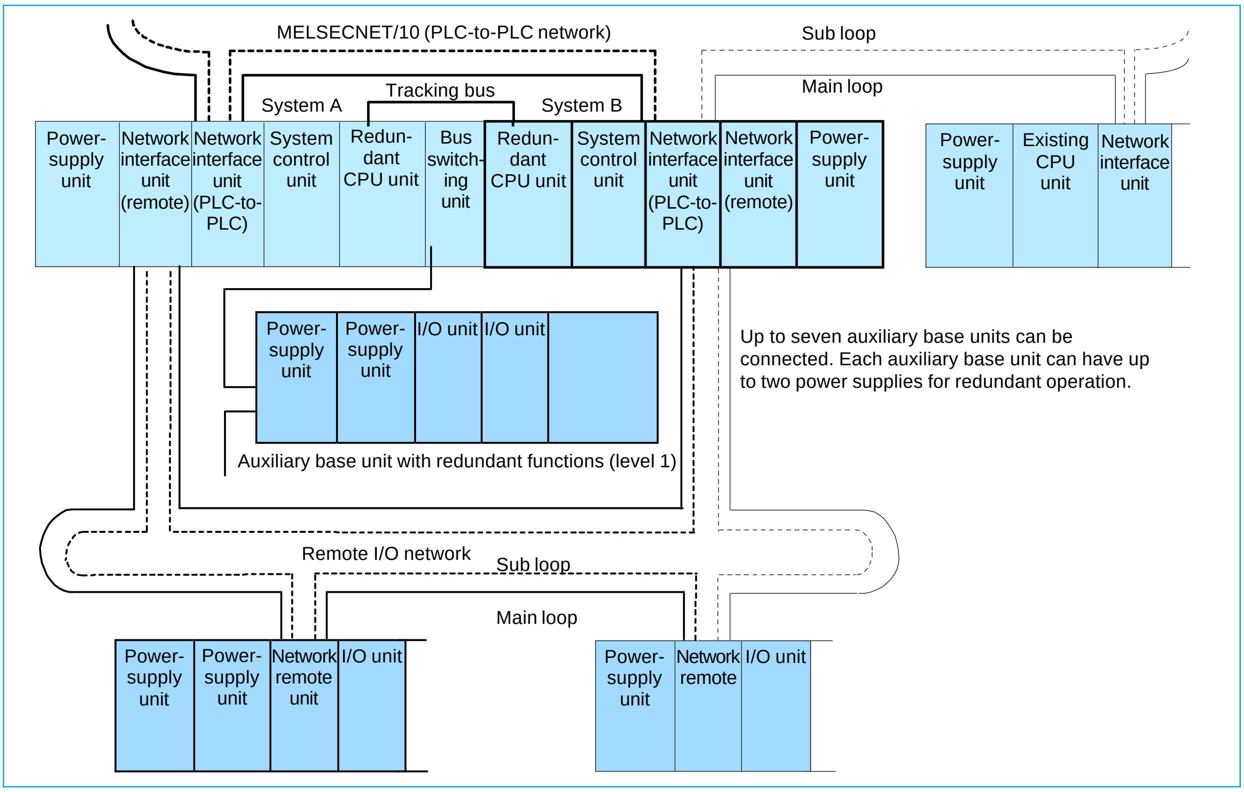

Fig. 1 Redundant system construction.

*Noboru Sakamoto is with the Nagoya Works.

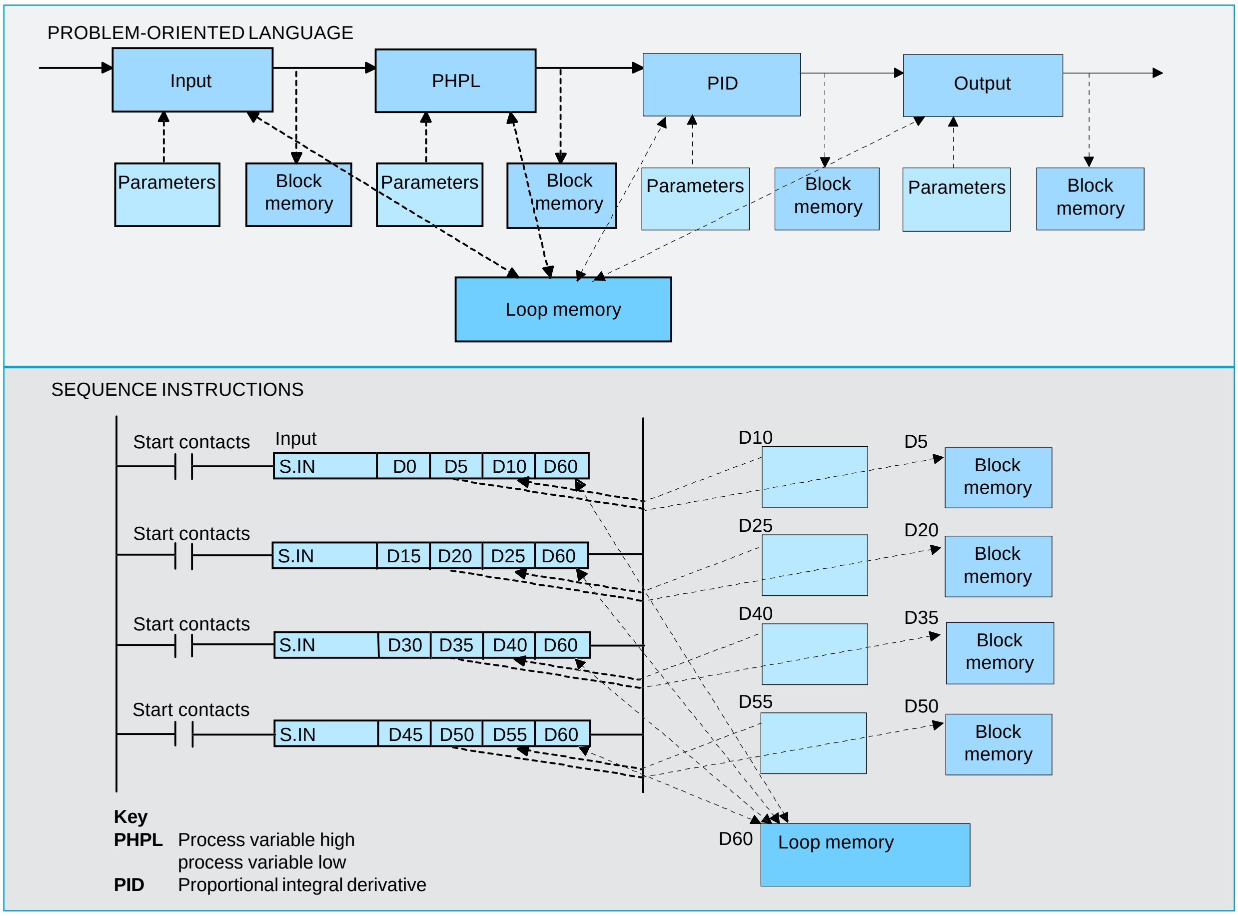

Fig. 2 Problem-oriented language and sequence operation.

switching unit and activate a set of relay contacts.

The bus switching module links the main CPU bus to the auxiliary base unit in response to switch commands.

The network interface modules provide redundant MELSECNET/10 compatible interfaces and a switching function to select between them. The hardware is backward compatible, allowing redundant equipment to be installed in existing networks.

When phenomena satisfying failure criteria occur, the backup CPU is switched on to replace the main CPU. Switching is initiated automatically by a power-supply failure, diagnostic abnormality or network unit failure. Switching can also be initiated manually.

The control and backup CPU perform data tracking over parameter-selected devices. The processing requirements associated with this function are lowered by tracking only active devices.

The network interface modules in the base unit periodically check to ensure that the main CPU is up, and switch to the backup CPU when the main CPU goes down.

Diagnostic functions maintain synchrony between the main and backup CPUs by comparing parameters and program data. Updating a program in the main CPU module while the system is operating will cause the backup CPU module to update the corresponding program.

The Q4AR has a number of special instructions supporting the POLs used in process control applications. POLs enable process control to be implemented by use of expressions that can connect individual function blocks. These expressions are converted to the corresponding instructions and implemented on the PLC.

Fig. 2 shows an example of a loop-control application using proportional integral derivative (PID) instructions. These instructions accomplish control using locally available memory (block memory and parameters) and globally available memory (loop memory).

The redundant functions of this PLC are behind the outstanding reliability it offers for "mission critical" factory control applications. ❑

Intelligent Positioning Modules for Programmable Logic Controllers

*by Shun Ohta and Haruhiko Kondo**

Factory automation systems are being used to manage more varied and complicated tasks. Intelligent modules are a key to implementing these systems because they extend and complement the functions of programmable logic controllers (PLCs). Intelligent modules offer such functions as analog-to-digital (AD) and digital-to-analog (DA) conversion, high-speed counting, temperature input and positioning control. This article introduces the AD75 Series positioning modules.

Description

The AD75 Series offers dramatic enhancements over the previous AD71 Series in performance, functionality and versatility. Use of a 32b RISC processor with peripheral circuits implemented in custom LSIs gives the series high performance and compact dimensions. A programming software package for the series supports creation of positioning data, monitoring of module operating status, and other programming and maintenance tasks.

Lineup

The AD 75 Series offers 1- to 3-axis control modules for MELSEC A, QnA and A1S series PLCs. All modules consume only a single slot, which contributes to reduced equipment size and cost. Fig. 1 shows the A1SD75P3 and AD75P3 three-axis positioning modules.

a) A1SD75P3 *b) AD75P3*

Fig. 1 The positioning modules.

Functions and Performance

Three-axis independent control, two-axis linear interpolation, two-axis circular interpolation and continuous positioning control functions are supported. These functions can be combined for continuous positioning control and are thus capable of supporting up to 600 points, which supports extremely complicated control functions.

External signal inputs for startup and speed-position switching reduce scanning demands on the sequencing program and the associated response delays. The PLC processing time required for positioning control is reduced by 75% compared to previous positioning units, which leads to shorter tact times for controlled equipment.

Six functions for origin recovery when activated support a wide variety of applications.

Step and S-curve acceleration patterns may be selected to minimize impacts associated with axis start and stop operations.

Open collector and differential pulse train motor drive interfaces support a wide variety of motor drives. The differential interface can output pulses at rates up to 400kHz to support high-speed motor control. Table 1 summarizes the AD75 Series functions and performance.

Programming

Positioning statements use the table positioning scheme of the AD71 Series for backward compatibility and easy upgrading.

The AD75 Series has internal parameters controlling movement conditions and simultaneous start conditions for other-axis start,

Shun Ohta and Haruhiko Kondo are with the Nagoya Works.

Table 1 Specifications of the AD75 Series Positioning Modules

Parameters\Products		AD75P1, A1SD75P1	AD75P2, A1SD75P2	AD75P3, A1SD75P3
I/O points		32		
Control capability		1 axis	2-axis simultaneous, 2-axis independent	3-axis simultaneous, 3-axis independent
Pulse output		Open collector, differential driver		
Control method		Point-to-point control, continuous control (linear or circular), speed control, speed-position control		
Interpolation		None	2-axis liner/circular interpolation	
Positioning	Language	Table method		
	Position pattern	600 patterns per axis		
	Memory	Battery-less flash EEPROM program storage		
	Absolute position limits	–214,748,364.8 ~ 214,748,364.7µm, –21,474.83648 ~ 21,474.83647 inches, 0 ~ 359.99999 degrees, –2,147,483,648 ~ 2,147,483,647 pulses		
	Increment limits	–214,748,364.8 ~ 214,748,364.7µm, –21,474.83648 ~ 21,474.83647 inches, –21,474.83648 ~ 21,474.83647 degrees, –2,147,483,648 ~ 2,147,483,647 pulses		
	Speed instruction range	0.01~ 6,000,000.00mm/min, 0.001~ 600,000in./min, 0.001~ 600,000°/min, 1~ 1,000,000 pulses/s		
	Acceleration processing	Automatic step acceleration, automatic S-curve acceleration		
	Acceleration time	1.0 ~ 65,535ms, four patterns each for acceleration and deceleration		
	Startup time	Less than 20ms		
Compensation Electronic gear Backlash compensation Error compensation function		 0 ~ 65,535 × position instruction unit 0 ~ 65,535 × position instruction unit Compensates for systematic mechanical errors (includes electronic gear support)		
Origin recovery functions		Near-point dog, count (2), stopper (3), external signal (2)		
Manual operation		Supports one manually operated rotary encoder for each axis		
Error and I/O display		Provided by 2.5 digit LED display		

which reduces sequence programming requirements and provides high-precision positioning that is not dependent on sequence program scan time. Parameter setting is performed using an optional positioning module software package.

Positioning data is stored in flash memory, eliminating battery-related maintenance requirements.

Monitor Functions

The module has a 2.5 digit LED display that can be used to monitor zero-point signal inputs and mechanical inputs such as near-point dog and upper/lower limits for quicker equipment installation and adjustment. The display also outputs error codes to facilitate troubleshooting.

Positioning Module Software Package

This software package, which operates under the Mitsubishi Electric A7PHP/A7HGP peripheral unit or a personal computer, offers edit, monitor and test modes, with simple switching from editing to online monitoring or testing. Fig. 2 shows the top-level edit-mode screen, and Fig. 3 the screen for positioning data editing. Positioning data editing is assisted by auxiliary windows for displaying menus and setting ranges.

The test and monitor modes permit detailed monitoring of the module's current status and operation history. The user can select monitoring of current feed position and feed speed for each axis as well as error history, warning history, external I/O signals and the state of the

Fig. 2 The top-level edit-mode screen.

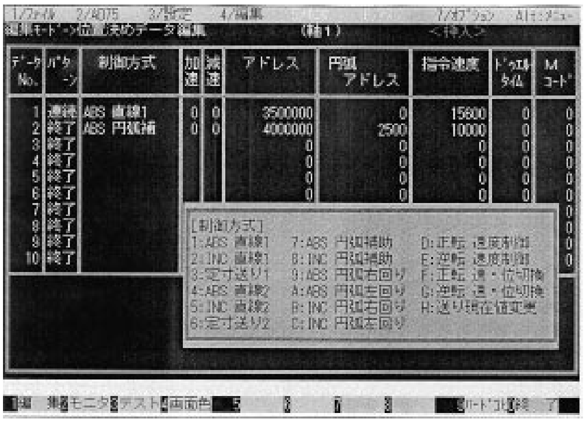

Fig. 3 The position data edit screen.

Fig. 4 A monitoring screen.

positioning module's internal XY device. Fig. 4 shows a typical monitoring screen.

A utility program is provided to convert user programs developed for AD71 Series modules for use under the AD75 Series so as to protect existing software development investments. The only manual modifications required are the addition of a few parameter settings where functional enhancements have occurred.

Use of these positioning modules and their support software extend the capability of PLCs. They dramatically reduce the time and cost required to develop sequence programs, and simplify equipment installation, setup and maintenance. ❑

"MELSEC Medoc Plus" IEC 1131-3-Compliant PLC Programming Tool

by Tatsuhiro Kurashima*

Mitsubishi Electric has developed program-development software for international use in cooperation with MEG, one of the corporation's overseas sales companies. Called MELSEC Medoc Plus, the software offers an environment that supports IEC 1131-3 and the corporation's proprietary language standards.

Description

MELSEC Medoc Plus is a programming environment that operates under Windows 3.1. The IEC 1131-3-compliant environment supports four languages: instruction list (IL), ladder diagram (LD), sequential functions chart (SFC) and functional block diagram (FBD). It also supports two Mitsubishi-developed proprietary language standards for IL and LD programming. Functions and function blocks can be expressed for IEC 1131-3.

Most operations are performed via the Windows graphic user interface using a mouse, pull-down menus and multiple windows, as with other Windows applications. The software supports dynamic data exchange (DDE), providing data sharing capabilities that support integration with other software.

Structured Programming and Support Language

The resources (mentioned in Fig. 1) under the configuration are supported in MELSEC Medoc Plus as one project. The user develops programs in program organization units (POUs), and the execution conditions are defined for the task.

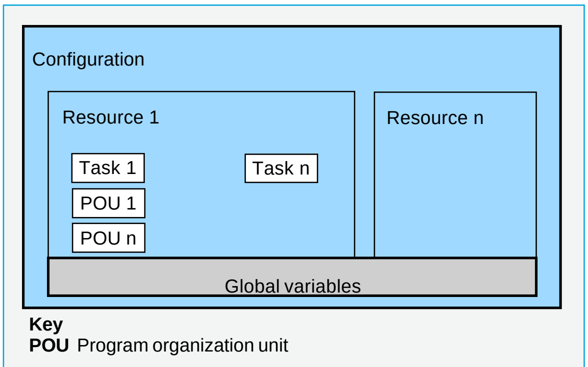

Fig. 1 The IEC 1131-3 configuration.

```
    Resource (project)
I – –  PLC parameter
I – –  Data unit type
I – –  Global variable
I – –  Task
I – –  POU
       I – –  Local variable
       I – –  Program body
       I –    I-Program
       I      SFC
       I          Action
       I          FBD/LD/IL/MELSEC LD/MELSEC IL
       I          Transition
       I          FBD/LD/IL/MELSEC LD/MELSEC IL
       I          FBD/LD/IL/MELSEC LD/MELSEC IL
       I –    Function block
       I      FBD/LD/IL/MELSEC LD/MELSEC IL
       I –    Function
       I      FBD/LD/IL/MELSEC LD/MELSEC IL
```

Key
FBD Function block diagram
IL Instruction list
LD Ladder diagram
POU Program organization unit
SFC Sequential functions chart

Fig. 2 Data construction tree.

The POUs, which constitute programs, have program, function block and function associations that support structured programming. Fig. 2 shows the data construction tree.

Function Blocks and Functions

User programs can be structured and libraries

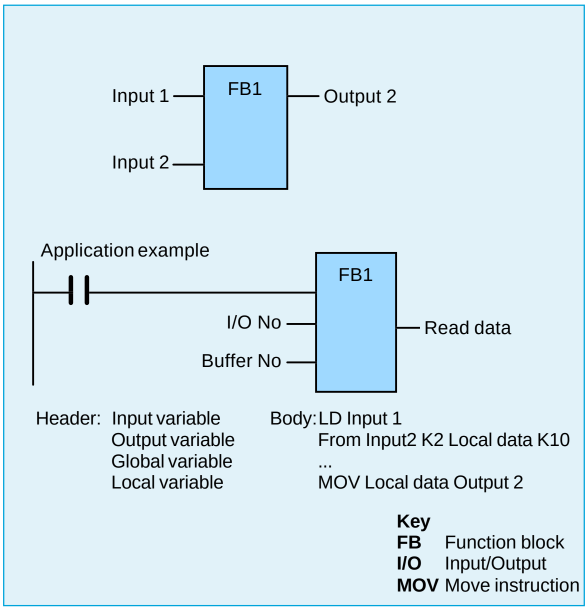

Fig. 3 Function block.

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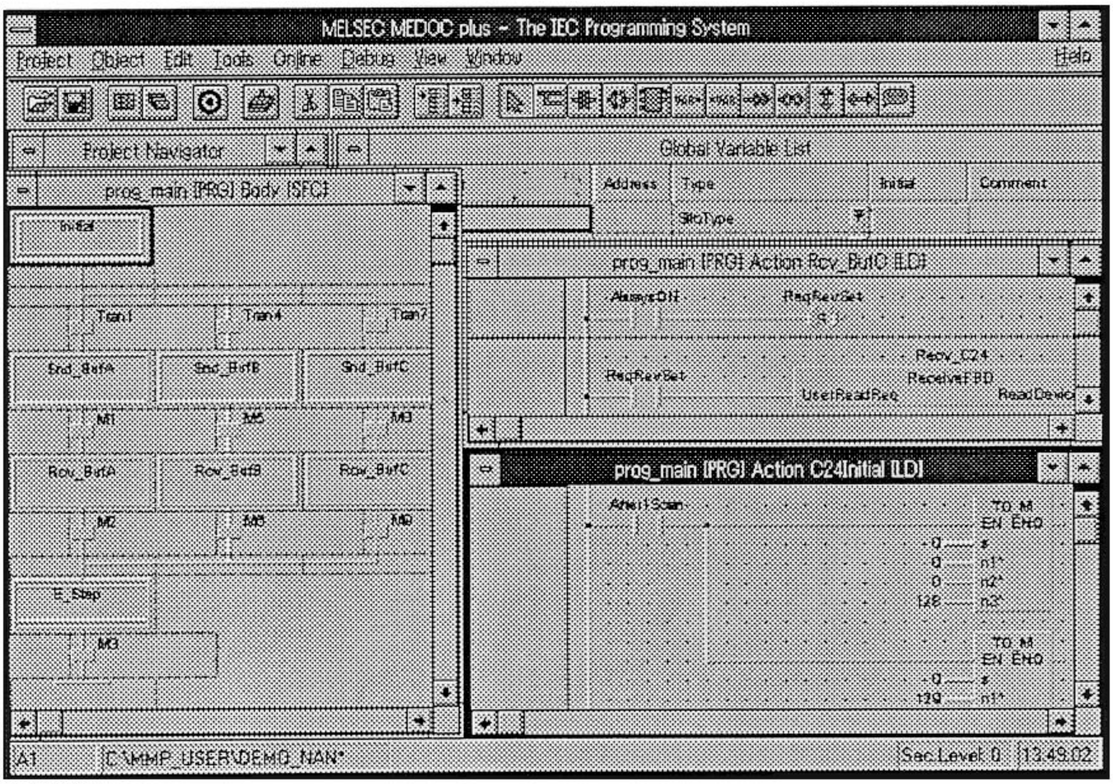

Fig. 4 Typical screen.

developed through the use of function blocks and functions. Fig. 3 shows an example of a function block. MELSEC programmable logic controller (PLC) LD and IL languages will support these features in the future. All MELSEC instructions can be registered as MELSEC function blocks. Software reuse can be promoted by registering frequently used programs (such as a program used to access a special-function module) in a library as a function block.

Easy Operation

The window environment permits concurrent program editing and display of parameter dialog boxes, monitor windows and memory-setting dialog boxes. Customized editors for each language support mouse-based menu selection, cut-and-paste and other Windows environment functions. Fig. 4 shows a typical screen.

Integrated Environment

DDE server functions are currently supported, and future support for OLE2 is planned. These inter-application communication functions enable users to create comprehensive environments that unite multiple applications. The current DDE server functions support two access modes. One allows access to PLC memory and program areas. The second allows monitoring of PLC devices for display and arithmetic purposes.

This sophisticated PLC programming environment provides excellent support for PLC program development under the easily used and well understood Windows graphic user interface. ❑

GOT 800 Series Graphic Operation Terminals

*by Narihiro Akatsuka**

Mitsubishi Electric has developed five graphic operation terminals for programmable logic controller (PLC) user-interface applications. The GOT 800 Series helps boost production efficiency with advanced functionality, various interface capabilities, simple screen design and easy maintenance.

Fig. 1 The A870 terminal.

Product Concept

Operation terminals display the status of I/O points and PLC device information as lamps, switch settings, numerical displays, messages, graphs and graphic objects, and support user input through a touch screen that allows the operator to alter the internal data of the PLC.

The GOT 800 Series is designed to provide a cost-effective, full-function electronic PLC control panel complete with screen debugging and other maintenance features. The series consists

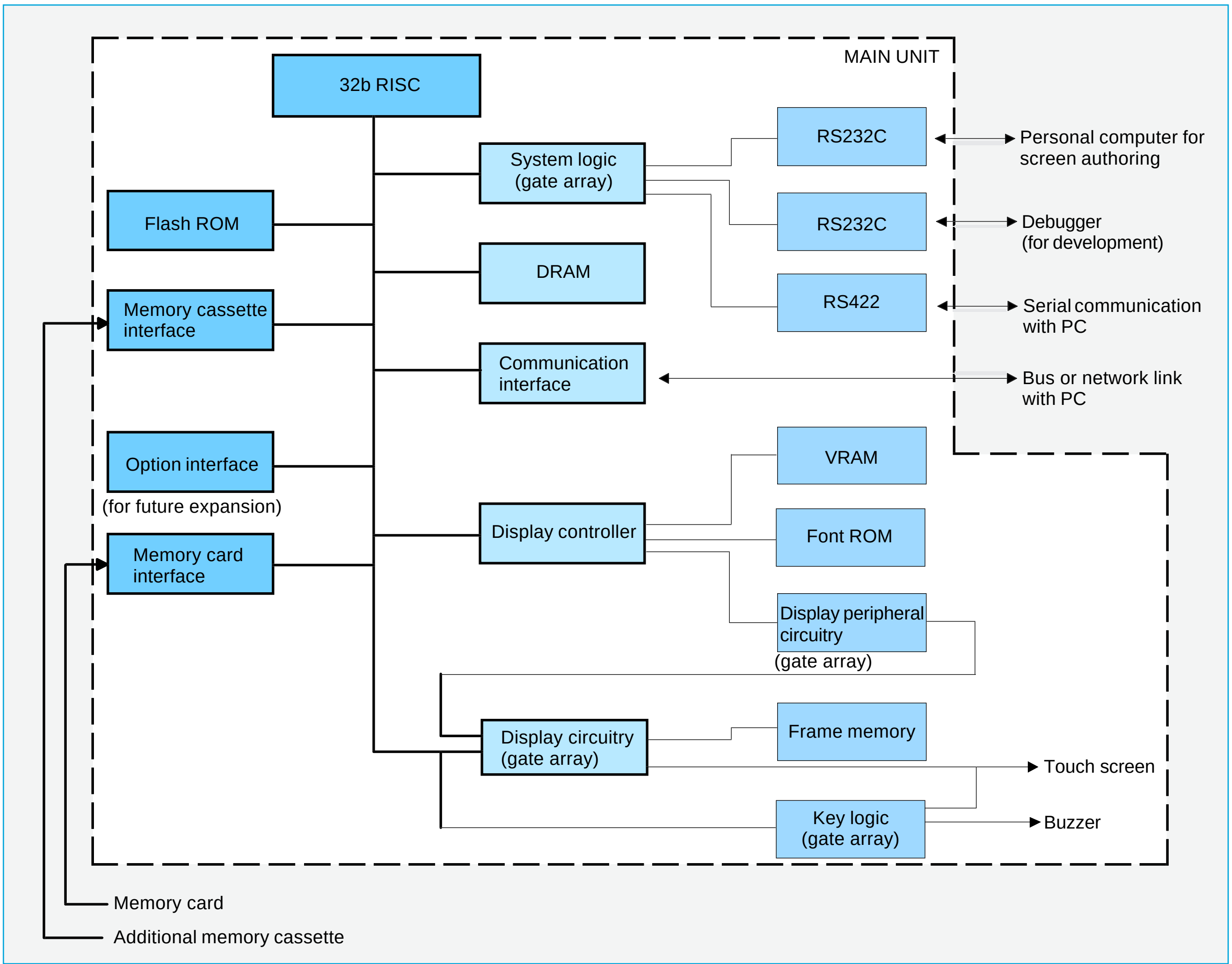

Fig. 2 The A870 hardware configuration.

**Narihiro Akatsuka is with the Nagoya Works.*

of a large-screen model (A870) and a medium-screen model (A850). The A870 features one of three screens: a 640 × 400 dot electroluminescent monochrome screen, a 640 × 480 dot supertwist nematic color LCD or a thin-film-transistor color LCD. The A850 is available with either a 320 × 240 dot monochrome LCD or a supertwist nematic color LCD.

Hardware Configuration

Fig. 2 shows a simplified block diagram of the A870. The A850 is similar, lacking only the memory cassette interface. The main processor, system gate array and internal data buses for flash ROM and DRAM are all 32 bits wide to support high-speed data access.

The main processor is a high-performance 20MHz 32b RISC device. The touch screen provides a 16 × 16 array of cells approximately 5 × 5mm. The terminals can be connected to PLCs in several ways: by a direct bus connection, by a MELSECNET network link or by an RS422 serial cable. They operate on 100/200VAC or 24VDC power supplies, and are manufactured to comply with UL and EN international safety standards.

Software

The terminal software includes a variety of monitoring functions (Table 1) and 3D graphic versions of the familiar lamps, meters and switches of conventional control panels. Alarm functions can be easily configured to display text messages, numeric data and graphs in response to failures, errors or other system events. The user can install any scanned graphic images as background bitmaps or display elements.

The extensive sequence programming previously required to manage screen displays has been all but eliminated by offloading display-related and arithmetic functions to the terminal. Unicode support allows a terminal to display some 26,000 different characters covering major European and Asian languages.

Table 1 Monitor Functions

Lamp/meter display	Lamp images track setting conditions; various meter graphics show numerical values
Numerical data display	PC device values are displayed in decimal or hexadecimal notation; user can specify justification and field width
Comment display	Used to display prepared text messages; selected by bit or word data values
Alarm list display	Comment display when specified device bit turns on; message scroll when numerical data values change
Object display/move	Parameter controlled display of graph, text or image objects; objects track changes in bit or word values; display of image data from external equipment
Trend graph display	Display of word values as a function of time; scrolling supported
Touch key settings	Display of standard keytop graphics or user bit maps; signal on/off, toggle and momentary activation; data write; screen change
Data input	Numerical data input; password-protected input option

Table 2 Maintenance Functions

System monitor	Overall/selected monitoring of CPU devices; set current values of timers, counters and other devices; monitor/modify special-function module buffer memory
Special-function module monitor	Graphically monitor/modify buffer memory for specific special-function modules
Ladder monitor	Monitor ladder program for specified station (with search function); keyword-based PC read/write protection

Debugging Functions

The screen design software runs on Windows 3.1 or Windows 95 operating systems. It includes PLC emulation functions that allow thorough debugging of terminal-to-PLC communication settings so that little or no post-installation debugging is required. System setup time is reduced dramatically as a result.

Maintenance Functions

PLC maintenance functions (Table 2) allow the operator to check PLC program operation when problems occur and quickly identify their origin so that downtime is significantly shortened. System monitor functions enable a terminal to monitor or write to PLC devices without additional equipment. Special-function-module monitor functions provide about 250 screens for monitoring and control of special-function modules. Ladder monitor functions allow sequence programs to be monitored in ladder format.

By taking over most display and maintenance functions, these graphic operation terminals dramatically simplify the task of applying PLCs to process automation. ❑

The FX-50DU High-Performance Programmable Display Terminal

*by Michiaki Isobe and Takeyoshi Kondo**

Programmable display terminals for programmable logic controllers (PLCs) offer control engineers an attractive user interface with both message display and touch-screen input capabilities. This article introduces the features of the FX-50DU programmable display terminal, which is compact, offers a wide range of functions and is easy to use.

Fig. 1 The FX-50DU programmable display terminal.

Basic Specifications

The FX-50DU is designed for user interface applications with MELSEC FX and A series PLCs. Table 1 lists the basic specifications. The display terminal is available with either of two LCD screens: monochrome or eight-color supertwist nematic. A graphics processor supports display of bitmaps and other graphic images. A transparent touch panel over the LCD screen supports direct screen input—an intuitive process that allows the user to indicate choices by touching keys displayed on the screen. The position and size of the keys can be set to any multiple of the touch-screen's unit cells.

The display terminal is linked to a PLC by a simple serial cable. All necessary communications support is provided; no additional user software development is required. Data is exchanged with the PLC automatically based on the screen data contents.

Table 1 General Specifications

LCD display	Monochrome (Model TK) or eight-color (Model TKS) supertwist nematic with 320 × 240 dot resolution
Touch keys	16 × 8 cells
Connectivity	Connection to PC CPU module or external computer
Data interfaces	RS422, RS232C, expansion interface
Screen memory	128KB flash memory, 500 screens max.
Power supply	24VDC
Protective construction	IP65
Dimensions	170 ×130 × 66mm

Screen Creation

Screens are created on a personal computer using special-purpose utility software that requires no special training to operate. To create a screen, the user simply places text, bar graphs and other objects on a blank sheet. Systems of up to 500 screens can be created. Table 2 lists available screen objects. Each object has its own parameter list that specifies images, object behavior, links to PLC data and links to other screens. Table 3 lists the parameters of a typical numerical object. The object displays numerical data from the PLC.

Table 2 Screen Objects

Type	Name
Static	Text, line, rectangle, circuit, bit map
Bit device control	Lamp, buzzer, flip text, flip image
Word device control	Numerical value, bar graph, pie chart, XY graph, text (indirect), image (indirect)
Key functions	Touch key, switch, screen change, modify data, increment data, decrement data
Other	Date/Time

Bitmap images can include standard BMP files created by commercial graphics software. A library of lamps, switches and other commonly used images is provided to support easy creation of clear and attractive screens.

Once the screens are completed, the corresponding data is transferred to the display terminal via serial cable. The data is stored in non-volatile flash memory that requires no battery backup.

**Michiaki Isobe and Takeyoshi Kondo are with the Himeji Works.*

Table 3 Parameters of a Numerical Object

Display position	x,y coordinates
Character size	Expansion factors for character width, height
Data	PC device supplying display data
Digits	No. of display digits, including sign and decimal point
Decimal digits	No. of digits to right of decimal point
Format	Decimal or hexadecimal display
Modify flag	Controls permission for alteration by user input
Upper and lower limits	Allowable input range; values outside this range trigger an error condition

Device Monitor Functions

These functions allow the display terminal to monitor data from timers, counters, I/O and other PLC devices. The user can select monitoring targets from the display terminal without programming, allowing the user to check and adjust PLC devices directly through the terminal.

Alarm Functions

Managing of PLC-controlled installations requires alarms to alert the operator when equipment troubles occur and support for later analysis of event histories by type and frequency of occurrence. The display terminal has a full range of alarm functions that can pop up messages in response to abnormal conditions. The user links the abnormal condition to a PLC bit device and registers a message in the display unit. The display unit monitors bit devices. When an 'on' is detected, a window pops up with the alarm message, and the event type and time are logged in a history file. The event history data can be viewed on the display terminal, transferred to a personal computer for storage and analysis or output directly to a printer.

These functions give users access to a full range of event capabilities through simple display terminal and PLC bit device settings. Compared to display terminals without alarm functions, the programming requirements are minimal.

Other Functions

For production systems, it may be desirable to deny routine users access to maintenance screens. The FX-50DU allows screens to be protected with a four-digit code when the screen is created. Once this is done, users cannot access the protected screen without the code.

The display terminal also has a clock/calendar function that that can turn on eight separate PLC bit devices on particular days and times.

The FX-50DU provides an easy-to-use touchscreen graphic interface for PLCs that can be set up with minimal programming. By handling event monitoring and logging, the display terminal can manage most routine PLC operation and maintenance requirements. ❑

A PLC Programming System Based on Block Diagrams

*by Tsutomu Yoshikawa and Takayuki Nihei**

Inexpensive and reliable, programmable logic controllers (PLCs) are finding applications in measurement as well as factory automation. However, ladder diagrams (LDs), the principal language for PLCs, are based on relay circuits and are inappropriate for process control applications. This article introduces a PLC programming method based on block diagrams, the primary tool for process control design.

Block diagrams express control element blocks as transfer variables and describe control systems as series, parallel and feedback relationships among these variables. The authors have developed a PLC programming environment called a "block programming system" that supports PLC programming and monitoring based on block diagrams.

The system provides a PLC programming environment that supports the entire process control program development cycle from program coding to downloading, monitoring and parameter tuning. Fig. 1 illustrates the system concept. The system implements a programming language based on graphical representations of block diagrams. The high-level nature of the language permits efficient program development. The graphical program listings are highly legible, providing excellent documentation of the program's operation. Fig. 2 shows a typical program editing screen.

System Configuration

Fig. 3 shows the system configuration. The system runs on a personal computer linked to a PLC via a network or serial cable, and can be used to create programs, download them to the PLC, upload them from the PLC and monitor PLC program execution. The completed programs are stored in PLCs in the same way as

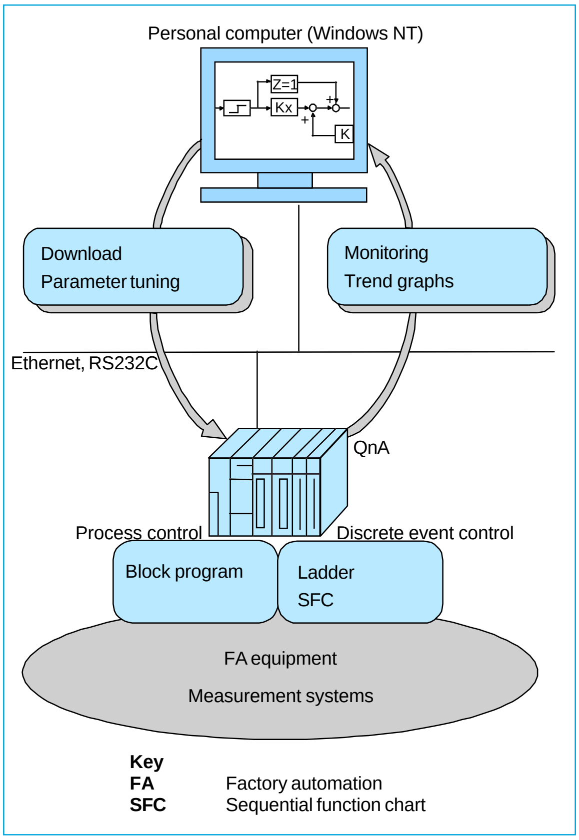

Fig. 1 Block programming system concept.

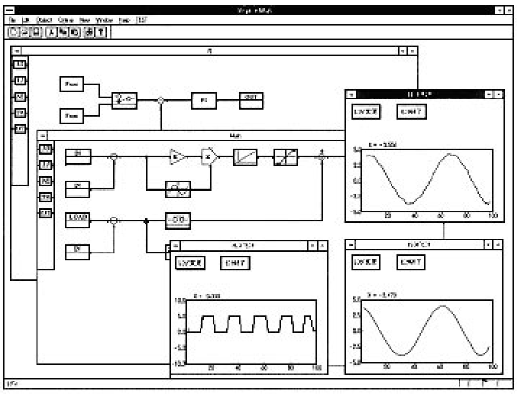

Fig. 2 A program editing screen.

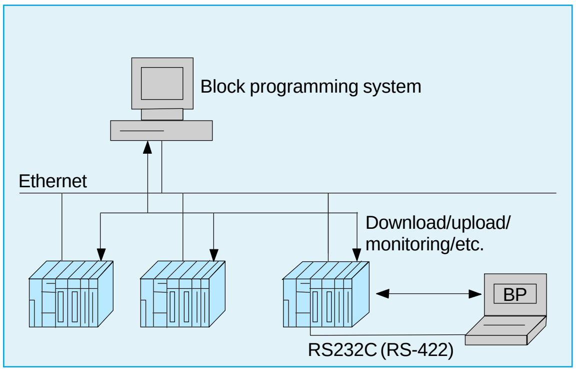

Fig. 3 A system configuration.

*Tsutomu Yoshikawa is with the Industrial Electronics & Systems Laboratory and Takayuki Nihei with the Nagoya Works.

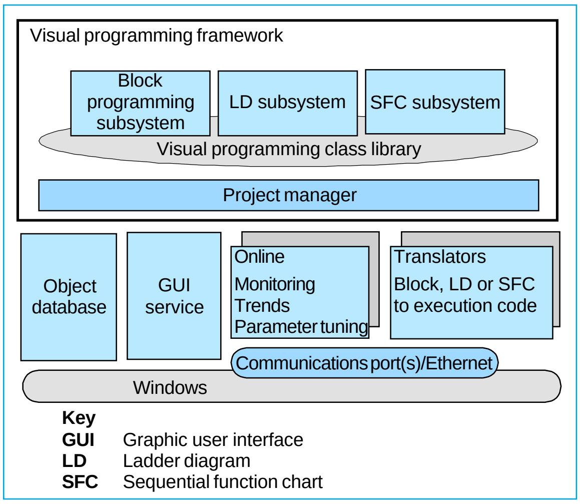

Fig. 4 The software module configuration.

ladder programs, which simplifies field maintenance.

The software modules of the block programming system are shown in Fig.4. The integrated environment for program editing and monitoring embodies both a visual programming class library that expresses the blocks—and the connecting links between them—used in block diagrams, and a visual programming framework that supports unified project management across a number of programming languages. This makes it possible to handle LD, sequential function chart (SFC) and other distributed control languages in the same way as the block programming system, written in the process control language.

The portability of the block programming system is improved by modularization of data management functions and display functions. This is implemented as an object database and graphic user interface (GUI) service. The object database provides for management of basic data types and structures and for basic object handling. Unified management is provided for all internal objects containing protected data in terms of fundamental classes. The GUI service conceals the complexities of the Windows application programming interface (API), providing a simpler API that facilitates user input operations and graphic displays.

Specialized translator modules have been prepared for all machines on which the programs will be implemented so as to provide online functions for monitoring or parameter tuning by generating execution code from the block programming language.

Programming Method

The programming language consists of blocks representing I/O, linear and nonlinear arithmetic, programming interface diagram (PID) control and other functions. The language has enhancements that support I/O statements controlling PLC relay circuits, special-function modules and data sharing with ladder programs. Fig. 5 shows the steps involved in creating programs. A graphical editor is used to generate and edit programs. The mouse is used to select blocks from menus, place them on the screen and interconnect them. Table 1 lists the standard blocks supported by the system and their parameters. Associations for each block are set using dialog boxes.

Programs are created in units of projects, a single project defined as all the code executed by a single PLC. A project consists of three elements: a program, which corresponds to a control loop; blocks, the smallest program units; and tasks, the units of execution.

One project can be implemented as several programs, each of which may contain several subprograms creating a hierarchical structure. Program associations describe execution intervals, limitations and parameters. Tasks can be designed independently from programs in block units, and in units of periodic execution.

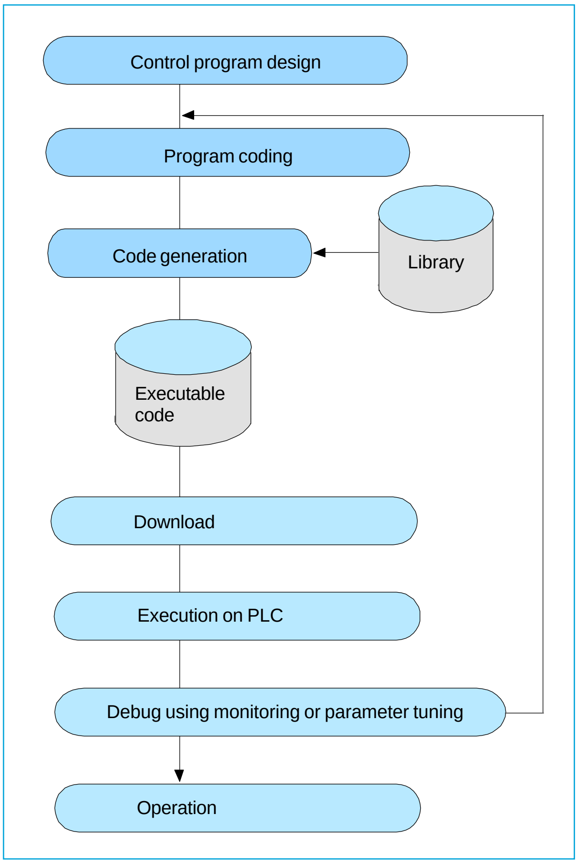

Fig. 5 The development process.

Table 1 Standard Blocks

Type	Block name	Function	Param0	Param1	Param2	Param3
I/O	LOAD	Load internal register	Device name			
	STORE	Store internal register	Device name			
	INPUT	External input (AD)	Unit no.	Buffer address	Channel	Scale
	OUTPUT	External output (DA)	Unit no.	Buffer address	Switch device	Scale
	COUNT	External input (high-speed counter)	Unit no.	Buffer address		
Linear	ADD	Addition				
	SUB	Subtraction				
	GAIN	Gain	K			
	AVERAGE	Moving average	n			
	DIFFERENTIAL	Differential	Kd			
	INTEGRAL	Integral	Ti			
Nonlinear	MUL	Multiply				
	DIV	Divide				
	ABSOLUTE	Absolute value				
	RATE LIMIT	Limit variation rate	Rise	Fall		
	SATURATION	Output value limit	Lower	Upper		
	DEAD ZONE	Output suppress interval	Start	End		
	PATTERN	Pattern	n	Vector		
Control	PI	PI control	Kp	Ti		
	PID CONTROL	PID control	Kp	Ti	Td	
Other	A CONTACT	Contact set A	Bit device			
	B CONTACT	Contact set B	Bit device			
	C CONTACT	Option	Bit device			
	CONSTANT	Constant value	C			
	DELAY	Delay element	n			
	FUNCTION	Function	Type	Interval	Amplitude	
	MODULE	Subblock				

Note: PI, programming interface; PID, programming interface diagram

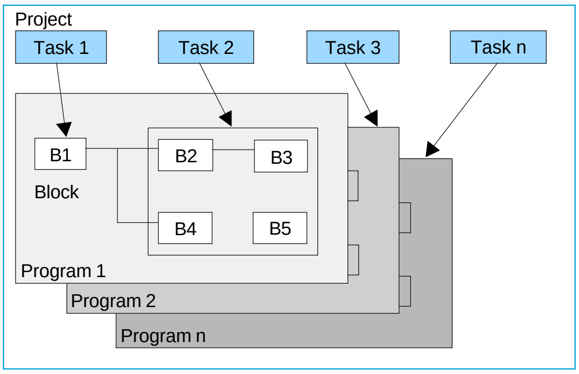

Fig. 6 Program structure.

Code Generation and Execution

A translator converts the control program into executable, discrete-event control code in three steps. First, scheduling generated from the block link and association data is used to determine the execution order. Next, memory devices are allocated. Finally, links to library routines are processed to create executable code.

The executable code is uploaded to the PLC as a single program that is executed periodically. Block programs executed on a MELSEC Q4A PLC can be used in up to eight loops (one PID/loop) with periods of 100~200ms, which is sufficient for simple measurement applications.

Block programs can be executed alongside ladder programs developed for discrete event control. Block programs can also be executed in sync with ladder programs, or asynchronously in open CPU time slices. Data can be passed between ladder and block programs during synchronous execution using load and store blocks, and ladder programs can be used to specify block parameters. This allows parameter settings to be modified on the basis of PLC type or other site-specific criteria.

Monitoring and Parameter Tuning

The program debugging environment employs the same block diagrams used in program generation and editing. A double click on a block link while in the online mode will initiate monitoring, while a double click on a block will initiate parameter tuning.

The monitoring functions can display block I/O data for any specified link. This data can be displayed as a trend graph as well as in numerical form. The parameter tuning functions allow alteration of block parameters during program operation.

The online mode detects error conditions such as PLC abnormalities and arithmetic overflow conditions and displays the block responsible for the error.

By providing a visual programming language and monitoring functions, the block programming system speeds PLC program development. Support for interfacing with ladder programs makes it possible to develop systems that mix discrete event control with process control. ❑

The Application of Concurrent Engineering to the Development of Graphic Operation Terminals for Programmable Logic Controllers

*by Hidemasa Iida & Yasuyuki Suzuki**

Mitsubishi Electric is now utilizing a concurrent engineering method in the development of graphic operation terminals for programmable logic controllers (PLCs). Incorporating tools for rapid prototyping, circuit and thermal analyses and an automatic printed circuitboard (PCB) router, development time for the A850 graphic operation terminal (Fig. 1) was reduced 40% compared to the estimated development time required using conventional procedures.

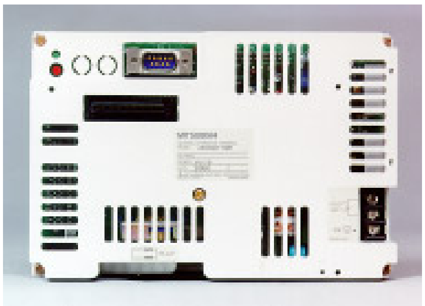

Fig. 1 The A850 graphic operation terminal developed by concurrent engineering.

Background

Conventional hardware development proceeds by a "waterfall" process in which each phase follows, and is dependent upon, its predecessor. Upstream changes are expensive because each successive phase requires perfect data from the previous process. As a result: Each phase of development is long because near-perfect results are required; ASIC and PCB reworking is

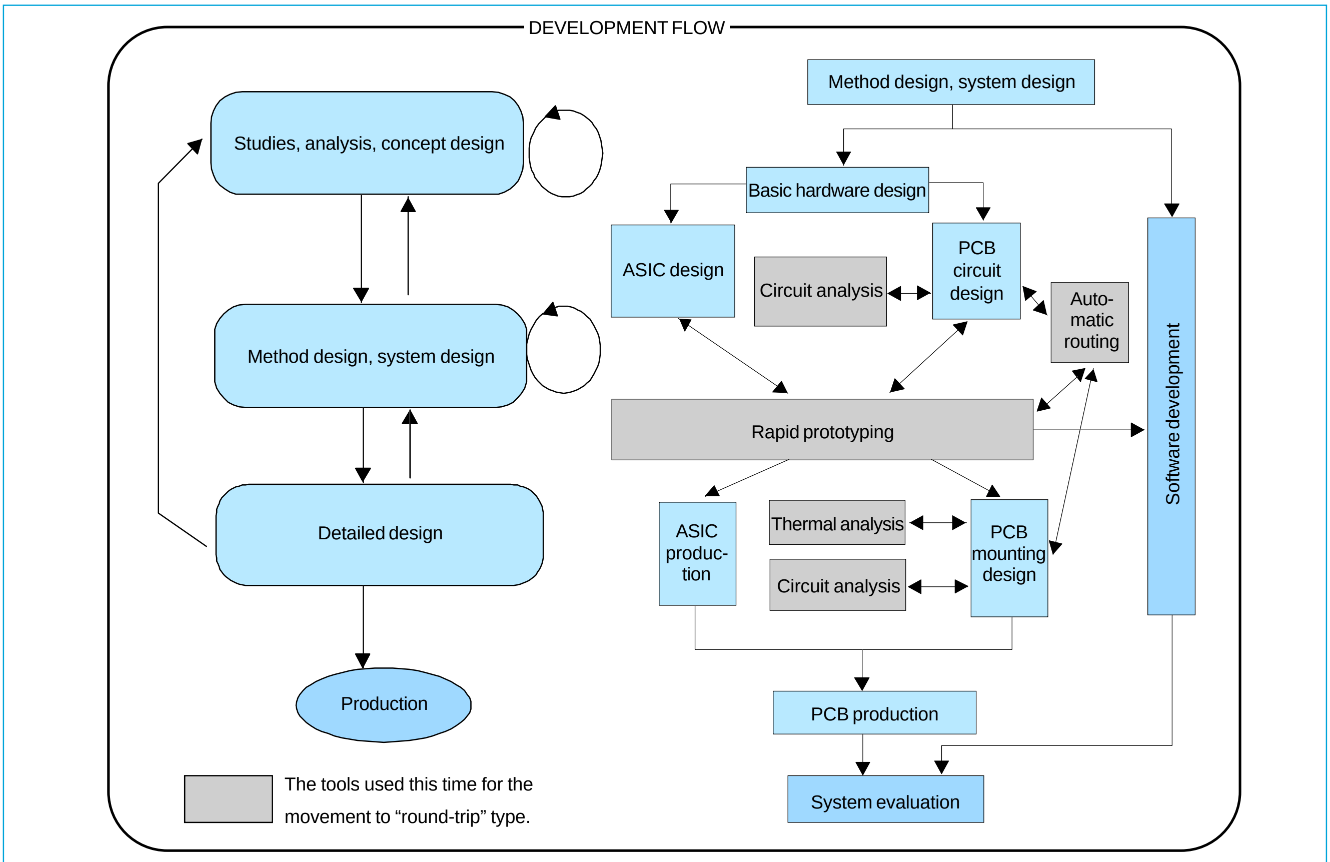

Fig. 2 A round-trip concurrent development method.

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frequently required because qualification is possible only after samples have been manufactured; and software development is delayed because it must wait for ASIC and PCB qualification.

Description

Fig. 2 illustrates a concurrent engineering method that addresses these shortcomings. The rapid prototyping tool allows functional qualification of ASICs and PCBs in software right up until hardware production. The circuit analysis tool simulates PCB characteristics, and conflicts can be easily solved through use of the automatic routing tool.

Fig. 3 shows the design flow of the rapid prototyping tool (APTIX Corporation) we used. The tool takes the product netlist (wiring data) from a workstation and creates the PCB wiring. The tool can embed ASIC and field programmable gate array (FPGA) emulators allowing functional qualification of the entire system.

While the rapid prototyping tool checks system functionality, the circuit analysis tool determines suitability of component mounting locations and circuit patterns in terms of crosstalk, reflections and other electromagnetic considerations. It performs hardware simulation to evaluate circuit characteristics and performance prior to PCB fabrication. Results can then be fed back to the automatic routing tool in realtime and used to correct the printed circuit patterns. Thermal simulations are also performed in software to identify potential power dissipation problems. Power-supply problems, in particular, can be solved prior to fabrication, eliminating a prototype production stage.

Fig. 4 compares the product development times using the traditional waterfall method and the new concurrent method. The latter reduces development time by approximately 40%.

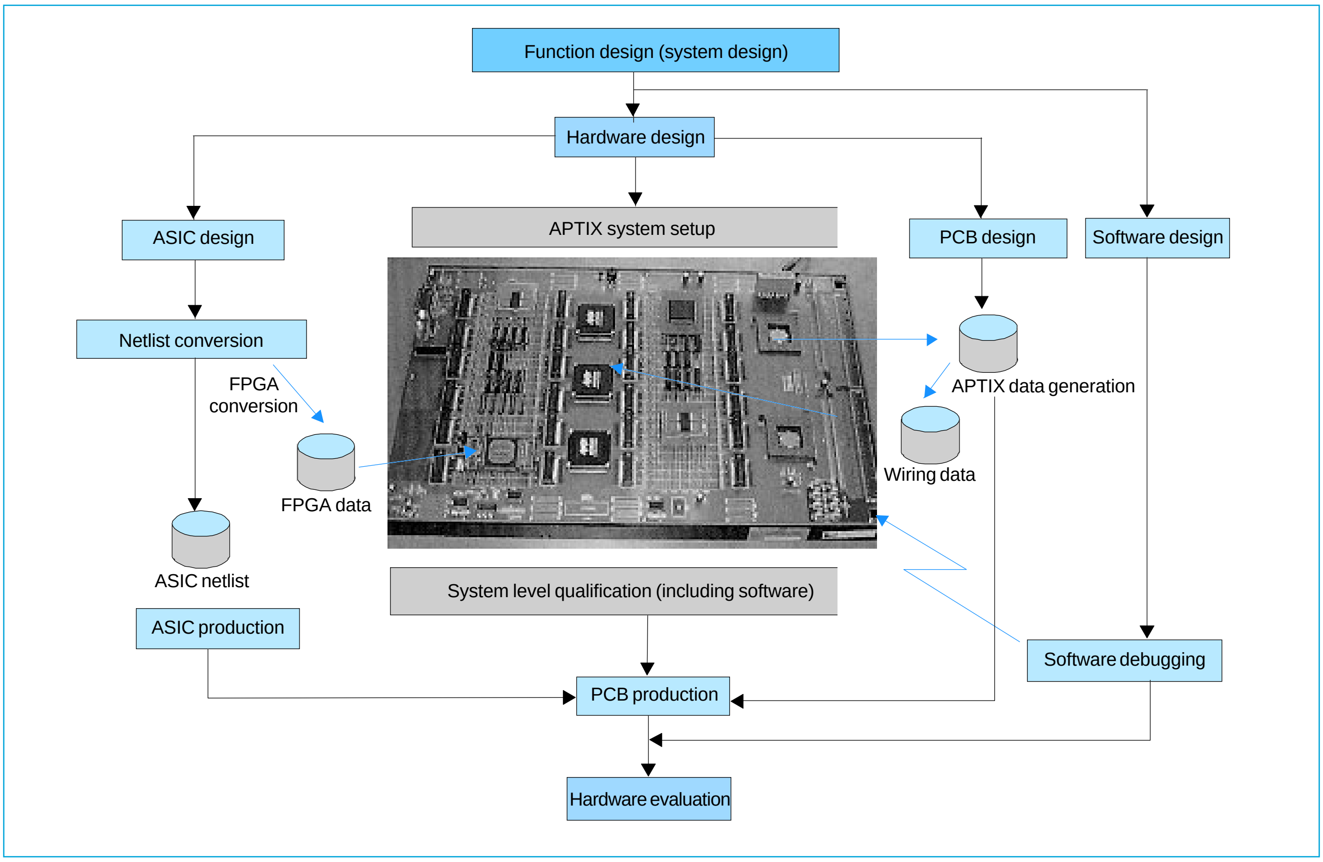

Fig. 3 Rapid prototyping tools and their design flow.

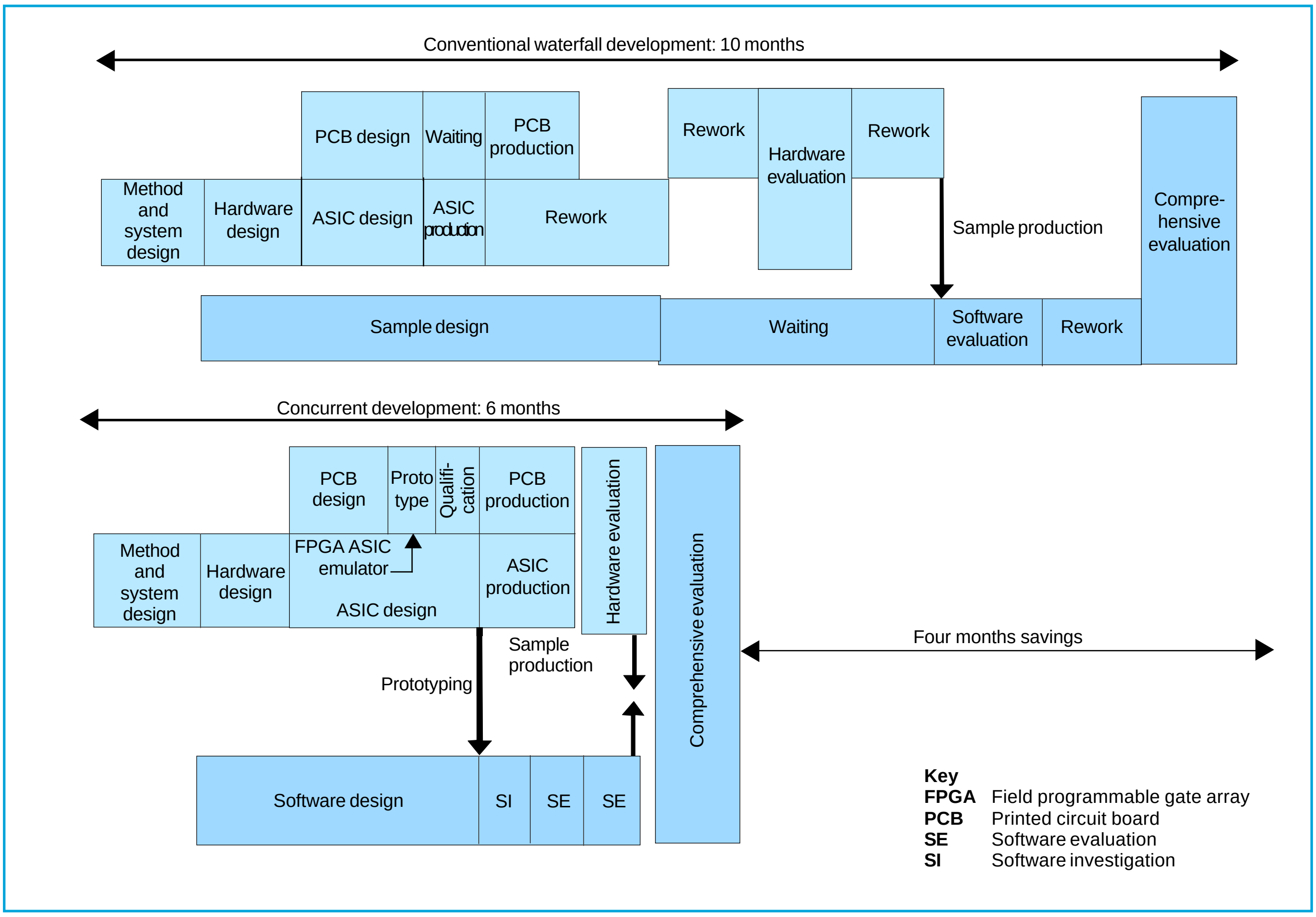

Fig. 4 Comparison of development periods for the A850 graphic operation terminal.

Use of the concurrent engineering approach in the development of electronic products offers a more efficient way to develop programmable controllers and peripherals that meet customer needs for functionality, while dramatically reducing the time required for products to reach the market. ❑

The Trend Toward Open-System Controllers

*by Yoshinori Tsujido**

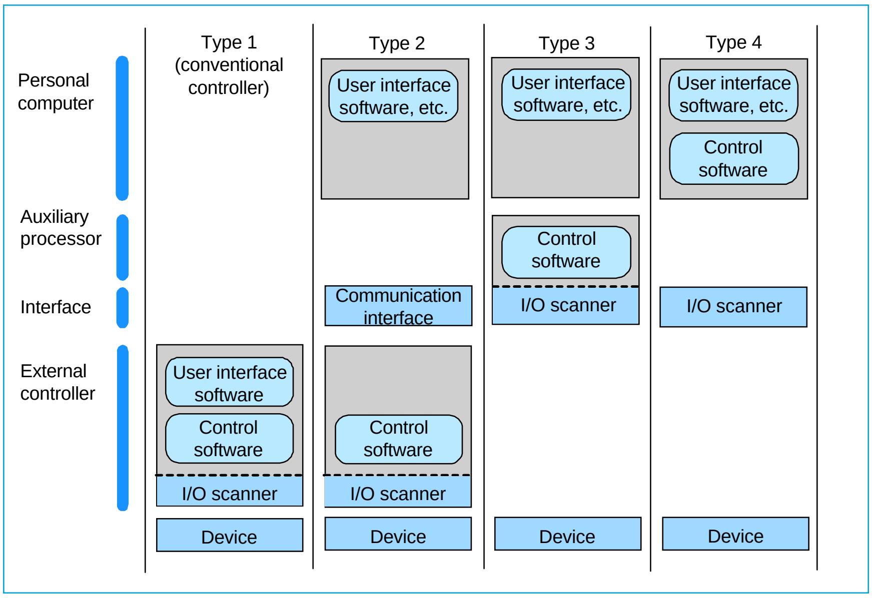

Fig. 1 Conventional controller and personal computer-based controllers.

Multifunction controllers that blur the distinction between sequence and motion processing are being implemented on personal computer platforms. This article reports on trends, features and development themes in these open-system controllers and covers personal computer-based programmable logic controllers (PLCs) and computerized numerical controllers (CNCs).

Background

Multifunction controllers combining sequence control and numerical control functions have recently appeared on the market. They are frequently implemented on personal computer platforms, which has become possible due to advances in microprocessors, peripherals, operating systems and software. Personal computer-based PLCs and CNCs are also growing popular.

Personal computer platforms provide access to abundant software resources, and products developed for non-proprietary hardware have a huge market potential. Personal computer-based products can combine sequence control with motion control and integrate process control functions with office software applications.

Fig. 1 lists types of conventional and personal computer-based controllers. [Type 1 is a conventional PLC.] Types 2, 3 and 4 all utilize personal computers to provide the user interface, with advantages of ease of use and uniform behavior. Type 2 utilizes a personal computer only to provide a user interface. The personal computer in Type 3 utilizes an auxiliary processor to execute the control software. Type 4 utilizes a simple interface with all control functions implemented in software on the personal computer. Type 4 offers maximum flexibility; types 2 and 3 offer some flexibility without sacrificing reliability.

Software PLCs

The functions of a PLC can be implemented as a personal computer software application. Although it lacks the speed of a dedicated processor, this approach offers several advantages: There are both interpreted and compiled PLC applications available to suit various flexibility and speed requirements. The software configuration generally resembles that of Type 4, but some features of types 2 and 3 may also be present. Most products support IEC1131-3 compliant sequential function chart (SFC) and ladder programming, and some support programming by flow chart. Several personal computer implementations of problem-oriented languages have been proposed.

Personal Computer-Based CNCs

Personal computer-based numerical control applications have been implemented using the Type 3 model. Type 4 implementations have been announced, but their range of application is limited since they cannot provide the millisecond-order interrupt response required for high-precision numerical control. Future products are likely to be Type 3 or Type 2 implementations, with an auxiliary processor providing reliable realtime performance. They will be implemented as plug-in cards with interfaces to a variety of personal computers.

Multifunction Controllers

Many equipment developers are incorporating CNC functions in software-based PLC applications. For example, some software-based PLC products embed the elements of motion control language within SFC language. A key consideration is coordinating multifunction con-

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trollers in various distributed control applications.

Integrated Development and Operation Environment

Some development and operation environments are implemented as a single application, but more common are multiple applications that communicate with each other—this is seen as the dominant future direction. Use of a *de facto* application interface standard allows compatibility between office software and third party applications.

Simulation-Based System Development

Personal computers offer possibilities for a simulation-based development environment. This supports stepwise development by allowing yet undeveloped components to be partially simulated. Personal computers can also support various visualization tools.

Personal Computer Controller Issues

Controllers based on personal computers offer user interface advantages and the ability to integrate a variety of software tools, however, there are several disadvantages. The greatest issue is reliability. Personal computers designed for office environments tolerate only a narrow range of temperatures. While hardware failure in an office might result in the loss of individual data files, a similar failure in a factory could result in more severe damage to machines or human life. Moreover, personal computers are not designed for realtime applications and cannot guarantee the millisecond-order interrupt response needed for precise, high-speed control applications. Despite these problems, personal computer-based controllers are highly attractive in a variety of settings, and most reliability and performance issues can be resolved by a hybrid approach combining personal computers with some elements of dedicated controller technology.

The increasing performance of personal computers makes them an attractive platform for implementing PLC and CNC functions. ❑

Field Area Network for Factory Automation

*by Noriyasu Fukatsu**

Demand is growing for field area networks that are "flat," meaning that users need not be aware of the physical layers involved, and "seamless" in that they are capable of operating in a multivendor environment. This report describes a field area network for MELSEC A Series programmable logic controllers (PLCs) that meets system requirements for multivendor compatibility with enhanced user convenience.

Configuration

Fig. 1 shows the network configuration. It consists of a master PLC linked by twisted-pair cable to devices such as remote I/O, analog-to-digital conversion modules, high-speed counting modules, inverters and servos; remote terminals with an RS232C interface; and intelligent devices such as operation terminals.

The user can control a variety of field devices from the master PLC I/O relays and registers as if they were local devices. Intelligent devices can access PLC data and programs, and monitor the state of a variety of field devices. The network also supports communication with the RS232C interfaces of personal computers, and with printers and measuring instruments.

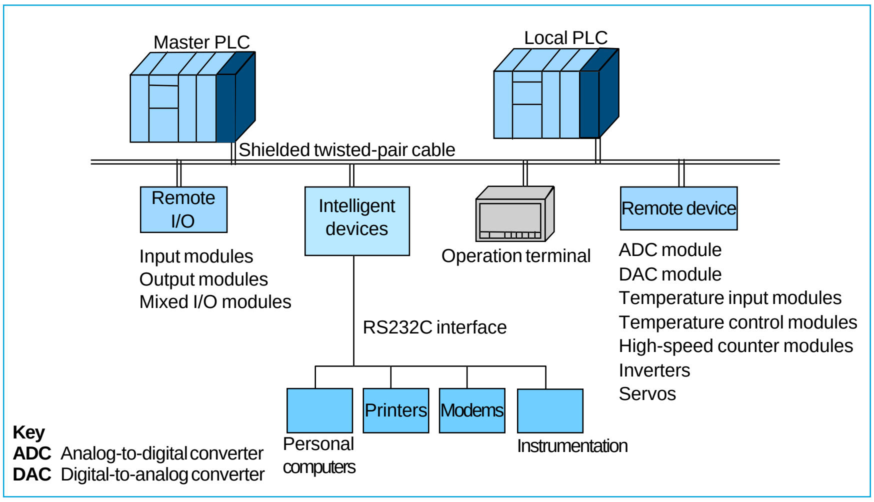

Fig. 1 System configuration.

Specifications

The MELSEC A Series field area network features improved basic transmission performance, with cyclic bit and word transfer abilities enabling remote I/O, high-speed counters, inverters and other remote devices that perform data control to be easily controlled through the relays and registers of the master PLC. Table 1 lists the basic specifications.

Table 1 General Specifications

Transmission speeds	10Mbps, 5Mbps, 2.5Mbps, 625Kbps, 156Kbps
Transmission medium	RS485 bus
Transfer format	HDLC compliant
Max. total length	100m for 10Mbps, 200m for 5Mbps, 500m for 2.5Mbps, 800m for 625Kbps and 1,200m for 156Kbps
Error correction code	CRC
Maximum links	2,048 binary I/O points, 256 word-linked register points

Additional versatility is provided by an automatic refresh function for master PLC relays and registers, and special data access functions that allow easy data access and control of field devices.

Open Architecture

We developed three custom communications protocol LSIs so that the MELSEC A Series field area network can support multivendor open architecture environments. The bit communications LSI supports bit devices for I/O control and operation, and can communicate directly with the PLC without microprocessor intervention. The data communications LSI supports communication between the PLC and devices that handle speed or position data for inverters or servos without explicit communications programming. The message LSI supports communications between the PLC and operations terminals or other intelligent devices. It supports the numerous communication topologies required by distributed systems. By supporting industry standard interfaces and providing a variety of support software, the network provides easy connectivity to many kinds of devices.

The outstanding performance, advanced functionality and multivendor compatibility of the MELSEC A Series field area network offer a significant step forward in user-friendly connectivity options for programmable logic controllers. ❑

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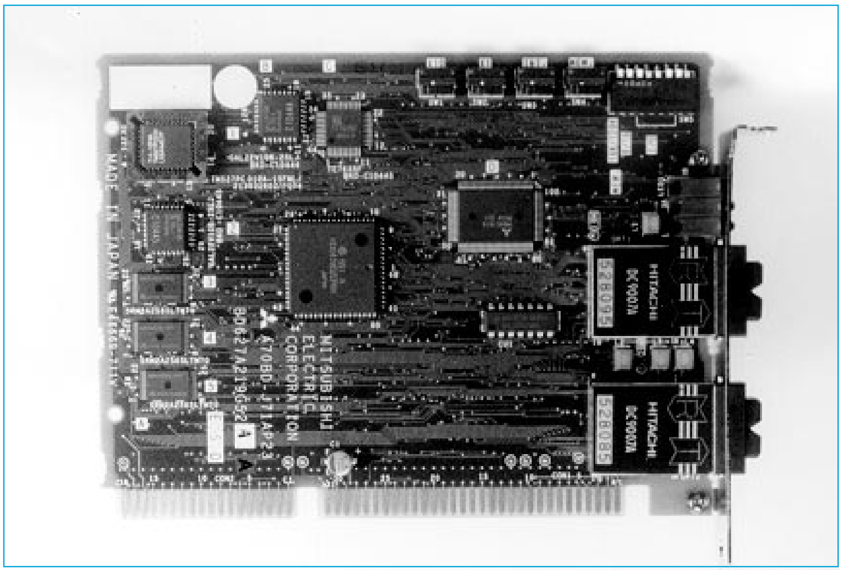
MELSECNET Interface Board for IBM-Compatible Personal Computers

The current trend toward open systems is affecting the factory automation field, leading to a fusion of information and control systems. Most of the next generation of factory systems will shift from PLC-based layered models to new models with PLC-based control and central information processing at each level, and only essential information being exported to information processing systems. Future systems are likely to be "flat" models employing closely tied PLCs and personal computers designed to support direct links between information applications and control system data. A key design issue is achieving this capability while maintaining realtime response in the control system.

Mitsubishi Electric has developed an interface board and software for IBM-compatible personal computers that links them to the corporation's MELSECNET PLC network products. The software includes data-link variables and drivers, and middleware. The design supports flat systems with a guaranteed realtime response of several tens of milliseconds without concern for data volume or number of connected PLCs. The short



A MELSECNET II interface board.

interface board supports the MELSECNET II optical fiber loop, MELSECNET/10 optical fiber loop and coaxial bus networks. Software drivers and data-link variable support are provided for MS-DOS, Windows 3.1 and Windows NT operating systems. Application development is simple since the user can access PLCs without a special access protocol. The interrupt and I/O port addresses can be configured for compatibility with other add-in cards. The interface board appears as a local station under MELSECNET II and as a normal station under MELSECNET/10. ❑

FX_{OS} Series Ultracompact Programmable Logic Controllers

The ultracompact FX_{OS} Series.

ISO 9001

NATIONAL ACCREDITATION OF CERTIFICATION BODIES

Mitsubishi Electric has developed FX_{OS} Series micro programmable logic controllers (PLCs), the world's smallest PLCs and successors to the highly regarded FX_O Series. We first developed micro PLCs in 1981 for incorporation into electronic relay control boards, and cumulative production exceeds two million units. The new series provides the performance and functional enhancements needed to manage current technology, and the more compact dimensions demanded for small form-factor applications.

The mounting area for FX_{OS} Series PLCs has been reduced to 65~70% of the FX_O Series through the use of chip components and double-sided surface mounting technology. The 800-step program storage area is implemented in EEPROM to allow maintenance-free, battery-free operation. Since the programming language is consistent with FX Series PLCs, programs can be developed using efficient development tools for FX Series PLCs.

Ten, 14, 20 or 30 I/O point models are available with AC or DC power supplies, and transistor or relay outputs. Two AC input models are also available.

The FX_{OS} Series is manufactured at an ISO9001-certified production facility, is licensed with UL standards and is certified by the National Association of Certification Bodies (CE). ❑

Virtual Manufacturing and Computer-Aided Production Engineering

A variety of tools have been developed to lower the cost and speed the development of manufacturing systems: petri networks are used for production flow design and qualification, CAD systems for facility design, robot simulators for offline teaching, and programming tools for creating equipment control programs. However, lack of interoperability among these design processes limits the versatility of the development environment.

Production engineering using a virtual factory provides an alternative approach. A virtual factory models the physical characteristics of the production equipment in three dimensions, models the production equipment control logic and uses these models to simulate a functioning factory. The main advantage of the virtual factory over previous development support environments is use of a single integrated model (Fig. 1). This reduces the data input operations otherwise associated with the use of each tool, reduces errors due to data incompatibilities and supports concurrent engineering processes where provisional results of one operation are available for other purposes.

The virtual factory can be used to determine productivity, select equipment locations and verify correct functioning of each station. The model can also be used to supply the factory operation data required to develop monitoring systems.

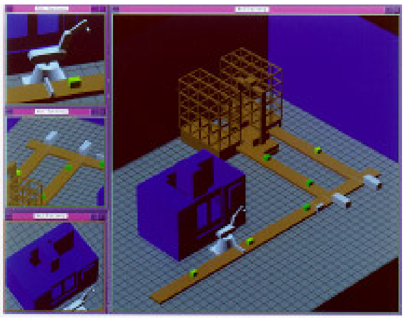


Fig. 2 A virtual factory

Fig. 2 shows a simple factory consisting of three conveyers, a robot, a machining center, an automated storage/retrieval system and two transport machines. This system can be readily modeled as a virtual factory. Objects corresponding to the robot, machining center and other equipment are chosen from the equipment library and placed on the virtual factory floor. Operation logic is then created to describe work flow, and operations of the robot, machining center and other equipment. We can then use this logic to simulate factory operation and evaluate productivity. The same logic data can also be used to generate the control programs required for the physical factory.

The virtual factory model need not serve only as a stand-alone simulator: it can also be an integral part of the factory system. Engineers at Mitsubishi Electric are now exploring a unified environment concept in which a single control algorithm is used to control both the virtual and actual factory equipment. Modifications to the control logic and factory equipment would be tested in software prior to implementing changes on the factory floor. As the quality of the virtual factory model improves, it becomes a mirror image of the physical factory, providing a development environment that bridges the gap between design and implementation. ❑

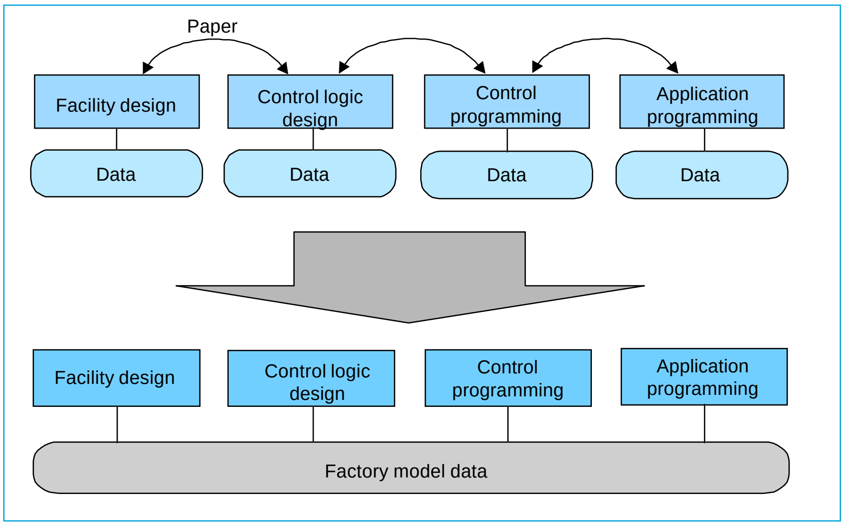


Fig. 1 An engineering system using the factory model.

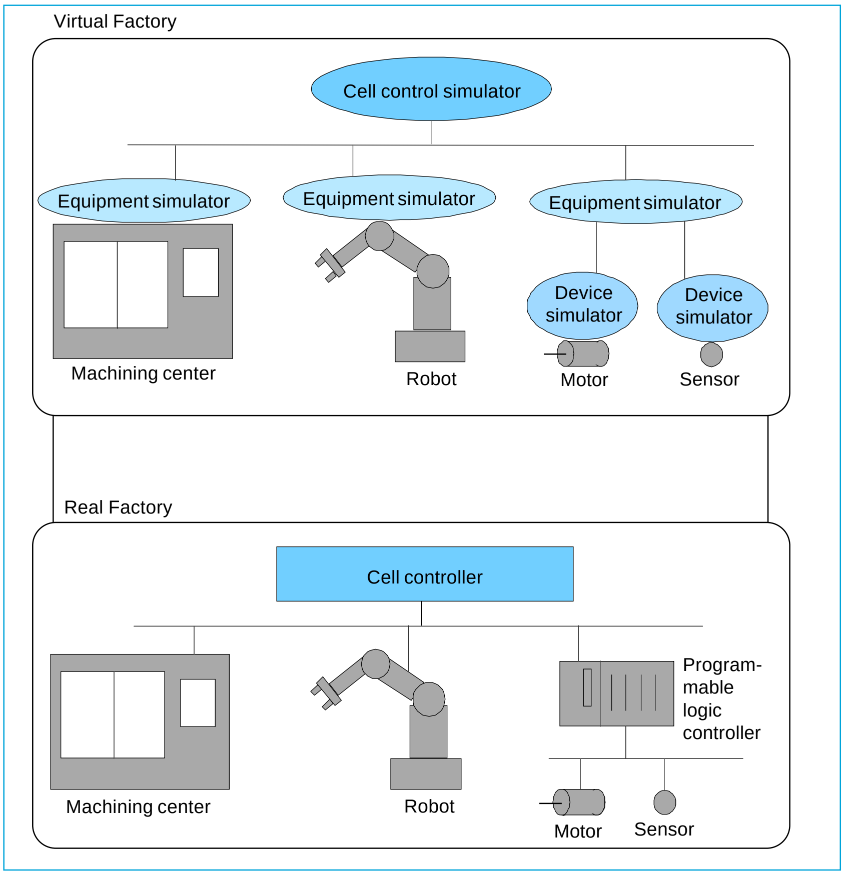


Fig. 3 A mirrored engineering environment.

Mitsubishi apricot FT8000 Series Servers

An apricot FT8000 server.

The apricot FT8000 servers offer a high-performance, high-reliability open-architecture platform designed to support growth in network-centric computing, client-server systems and increased data processing loads.

The top-end Model 800 features eight 200MHz Pentium® Pro processors and a 4MB cache. Model 400 carries four of these processors. The main system bus transfers data at 528MB/s with error correction code or parity protection for data integrity. Two 132MB/s peripheral component interconnect buses are also provided.

The servers feature a symmetrical multiprocessor (SMP) bridge LSI chipset developed to implement a third-level cache for a layered bus. The chipset consists of four devices of three different types with a total of some 400,000 gates. Model 800 employs two CPU boards each carrying an SMP bridge, four processors and third-level cache.

RAID and fast-wide SCSI controllers offer a variety of highly reliable high-capacity magnetic storage options. Up to 228GB of storage is supported using an external cabinet. A RAID5 algorithm executing on dedicated hardware dramatically reduces the load on the CPU board and enhances reliability. Hot-disk swaps are supported with post-replacement data reconstruction.

Modular power supplies are fitted to suit the server configuration, and redundant modules can be installed so that the system is not compromised by failure of a single module. Faulty modules can be replaced without taking the system offline.

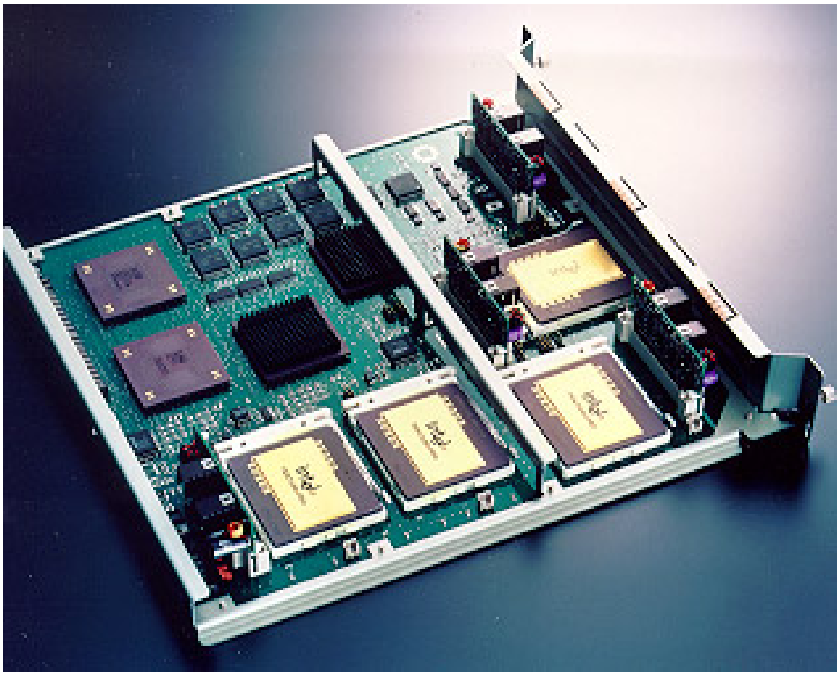
Internal support for an uninterruptible power supply eliminates the use of cables and serial ports that would otherwise impact expansion.

A server monitoring and control unit is provided in the standard configuration. The unit displays the server operation status, monitors environmental conditions, automatically reports faults and has log functions. It also supports remote power switching and remote booting, along with other functions that provide total operation, fault management and security capabilities. ❑

Specifications of the apricot FT8000

Parameter	Designation	Model 400	Model 800
CPU	Type	Pentium Pro 200MHz	
	Number	1/2/4	8
Memory	Cache	1st level 16kB, 2nd level 256kB	
	System cache	—	4MB
	ROM	512kB	
	Main memory	32kB-1GB[512][1]	256MB-1GB
	Video RAM	2MB	
Storage	FDD	3.5inch (1.44MB/720kB)	
	HDD	2GB/4GB (Maximum 228GB[22GB][1])	8GM (Maximum 228GB)
	RAID	RAID-5 (Option)	
	Others	4 x CD-ROM, 4GB Streaming Tape (Option)	
Display monitor		15-inch monitor (Option)	
Keyboard		106 keyboard (Option)	
Mouse		PS/2 type, 2 buttons (Option)	
Interface	RS-232C	1 port: D-sub 9 pin, ASYNC SMC port: D-sub 25 pin, ASYNC	
	Printer	1 port: Centronics, D-sub 25 pin	
	Display	Analog Interface, D-sub shrink 15 pin	
	Keyboard	Mini-DIN, 6 pin	
	Mouse	Mini-DIN 6 pin	
I/O Slots		PCIx2, PCI/EISA x 5[3][1], EISA x 3[1][1]	
Server management		Server mangement controller (SMC)	
Regulation		VCCI-I	
Power supply	AC input	100V AC, 50/60MHz	
	Power	1 CPU:850W, 2/4 CPU: 900 W, 8 CPU:1, 280W (Maximum)	
	UPSs	Integrated UPS (5 min. at maximum configuration)	
Environment		10~35°C, 20~80% RH	
Dimensions (mm)		450 x 830 x 700 (W x H x D)	
Operating Systems		Windows NT Server, UnixWare	

Note 1: Single CPU model
Pentium is a registered trademark of Intel Corporation.
Windows NT is a registered trademark of Microsoft Corporation.
UixWare is a trademark of SCO.



The mounting configuration of Model 400 components.

MITSUBISHI ELECTRIC OVERSEAS NETWORK (Abridged)

Country	Address		Telephone
U.S.A.	Mitsubishi Electric America, Inc.	5665 Plaza Drive, P.O. Box 6007, Cypress, California 90630-0007	714-220-2500
	Mitsubishi Electronics America, Inc.	5665 Plaza Drive, P.O. Box 6007, Cypress, California 90630-0007	714-220-2500
	Mitsubishi Consumer Electronics America, Inc.	2001 E. Carnegie Avenue, Santa Ana, California 92705	714-261-3200
	Mitsubishi Semiconductor America, Inc.	Three Diamond Lane, Durham, North Carolina 27704	919-479-3333
	Horizon Research, Inc.	1432 Main Street, Waltham, Massachusetts 02154	617-466-8300
	Mitsubishi Electric Power Products Inc.	Thorn Hill Industrial Park, 512 Keystone Drive, Warrendale, Pennsylvania 15086	412-772-2555
	Mitsubishi Electric Manufacturing Cincinnati, Inc.	4773 Bethany Road, Mason, Ohio 45040	513-398-2220
	Astronet Corporation	37 Skyline Drive, Suite 4100, Lake Mary, Florida 32746-6214	407-333-4900
	Powerex, Inc.	Hills Street, Youngwood, Pennsylvania 15697	412-925-7272
	Mitsubishi Electric Research Laboratories, Inc.	201 Broadway, Cambridge, Massachusetts 02139	617-621-7500
Canada	Mitsubishi Electric Sales Canada Inc.	4299 14th Avenue, Markham, Ontario L3R 0J2	905-475-7728
	Mitsubishi Electronics Industries Canada Inc.	1000 Wye Valley Road, Midland, Ontario L4R 4L8	705-526-7871
Mexico	Melco de Mexico S.A. de C.V.	Mariano Escobedo No. 69, Tlalnepantla, Edo. de Mexico	5-565-6269
Brazil	MELCO do Brazil, Com. e Rep. Ltda.	Av. Rio Branco, 123, a 1507, 20040, Rio de Janeiro	21-221-8343
	MELCO-TEC Rep. Com. e Assessoria Tecnica Ltda.	Av. Rio Branco, 123, a 1507, 20040, Rio de Janeiro	21-221-8343
Argentina	MELCO Argentina S.R.L.	Florida 890-20º-Piso, C.P. 1005, Buenos Aires	1-312-6982
Colombia	MELCO de Colombia Ltda.	Calle 35 No. 7-25, Oficinas No. 1201/02, Edificio, Caxdac, Apartado Aereo 29653, Bogotá	1-287-9277
U.K.	Mitsubishi Electric U.K. Ltd.	Travellers Lane, Hatfield, Herts. AL10 8XB, England	1707-276100
	Apricot Computers Ltd.	3500 Parkside, Birmingham Business Park, Birmingham, B37 7YS, England	21-717-7171
	Mitsubishi Electric Europe Coordination Center	Centre Point (18th Floor), 103 New Oxford Street, London, WC1A 1EB	71-379-7160
France	Mitsubishi Electric France S.A.	55, Avenue de Colmar, 92563, Rueil Malmaison Cedex	1-47-08-78-00
Netherlands	Mitsubishi Electric Netherlands B.V.	3rd Floor, Parnassustoren, Locatellikade 1, 1076 AZ, Amsterdam	20-6790094
Germany	Mitsubishi Electric Europe GmbH	Gothaer Strasse 8, 40880 Ratingen	2102-4860
	Mitsubishi Semiconductor Europe GmbH	Konrad Zuse Strasse 1, 52477 Alsdorf	2404-990
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Hong Kong	Mitsubishi Electric (H.K.) Ltd.	41st Floor, Manulife Tower, 169 Electric Road, North Point	510-0555
	Ryoden Holdings Ltd.	10th Floor, Manulife Tower, 169 Electric Road, North Point	887-8870
	Ryoden Merchandising Co., Ltd.	32nd Floor, Manulife Tower, 169 Electric Road, North Point	510-0777
Korea	KEFICO Corporation	410, Dangjung-Dong, Kunpo, Kyunggi-Do	343-51-1403
Taiwan	MELCO Taiwan Co., Ltd.	2nd Floor, Chung-Ling Bldg., No. 363, Sec. 2, Fu-Hsing S. Road, Taipei	2-733-2383
	Shihlin Electric & Engineering Corp.	No. 75, Sec. 6, Chung Shan N. Rd., Taipei	2-834-2662
	China Ryoden Co., Ltd.	Chung-Ling Bldg., No. 363, Sec. 2, Fu-Hsing S. Road, Taipei	2-733-3424
Singapore	Mitsubishi Electric Singapore Pte. Ltd.	152 Beach Road #11-06/08, Gateway East, Singapore 189721	295-5055
	Mitsubishi Electric Sales Singapore Pte. Ltd.	307 Alexandra Road #05-01/02, Mitsubishi Electric Building, Singapore 159943	473-2308
	Mitsubishi Electronics Manufacturing Singapore Pte. Ltd.	3000, Marsiling Road, Singapore 739108	269-9711
	Mitsubishi Electric Asia Coordination Center	307 Alexandra Road #02-02, Mitsubishi Electric Building, Singapore 159943	479-9100
Malaysia	Mitsubishi Electric (Malaysia) Sdn. Bhd.	Plo 32, Kawasan Perindustrian Senai, 81400 Senai, Johor	7-5996060
	Antah MELCO Sales & Services Sdn. Bhd.	3 Jalan 13/1, 46860 Petaling Jaya, Selangor, P.O. Box 1036	3-756-8322
	Ryoden (Malaysia) Sdn. Bhd.	2nd Fl., Wisma Yan, Nos. 17 & 19, Jalan Selangor, 46050 Petaling Jaya	3-755-3277
Thailand	Kang Yong Watana Co., Ltd.	15th Floor, Vanit Bldg., 1126/1, New Petchburi Road, Phayathai, Bangkok 10400	2-255-8550
	Kang Yong Electric Co., Ltd.	67 Moo 11, Bangna-Trad Highway, Km. 20 Bang Plee, Samutprakarn 10540	2-312-8151
	MELCO Manufacturing (Thailand) Co., Ltd.	86 Moo 4, Km. 23 Bangna-Trad, Bangplee, Semudparkarn 10540	2-312-8350~3
	Mitsubishi Elevator Asia Co., Ltd.	Bangpakong Industrial Estate, 700/86~92, Moo 6 Tambon Don Hua Roh, Muang District Chonburi 20000	38-213-170
	Mitsubishi Electric Asia Coordination Center (Thailand)	17th Floor, Bangna Tower, 2/3 Moo 14, Bangna-Trad Highway 6.5 Km, Bangkawe, Bang Plee, Samutprakarn 10540	2-312-0155~7
Philippines	International Elevator & Equipment, Inc.	Km. 23 West Service Road, South Superhighway, Cupang, Muntinlupa, Metro Manila	2-842-3161~5
Australia	Mitsubishi Electric Australia Pty. Ltd.	348 Victoria Road, Postal Bag No. 2, Rydalmere, N.S.W. 2116	2-684-7200
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