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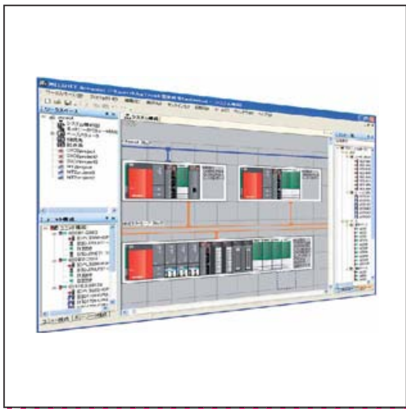
MITSUBISHI ELECTRIC

ADVANCE

Mitsubishi FA Integrated Platform



MITSUBISHI ELECTRIC

Changes for the Better

Sep. 2007 / Vol. 119

MITSUBISHI ELECTRIC ADVANCE

Mitsubishi FA Integrated Platform

Cover Story

We have developed the integrated platform as a new FA integration solution for optimizing production sites. (1) shows the GOT1000 series graphic operation terminal which provides a human-machine interface, (2) shows the engineering environment for efficiency in the phases of equipment development, operation, and maintenance, (3) shows the control systems for types of devices, including high-speed programmable controllers (QnU series), motion controllers, CNCs (C70 series) for production lines and robot controllers, (4) shows a general-purpose servo amplifier and servo motor for controlling machines in combination with the motion controller, and (5) shows an NC amplifier and spindle motor for controlling machine tools in combination with the CNC for production lines.

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Technical Reports

Overview

Author: *Hideyasu Nonaka**

Manufacturing companies are increasingly being required to raise the added value of their manufacturing plants to win the fierce global competition. The companies must overcome all challenges such as high productivity targets to meet expanding product demand in the market and shorter delivery times requested by clients; reduction of total system cost including development, start-up, operation, and maintenance of manufacturing facilities as well as man-hour management; and improved quality by establishing a system that neither produces nor delivers defective products. To meet these requirements, manufacturers must develop and implement new manufacturing systems that go beyond the extent of conventional systems. This will require a group of factory automation (FA) components to reduce the tact time of facilities with superior high-speed, high-precision control function; improved working efficiency with greater operability in the engineering environment; and a data management system for high-speed sharing between facilities of huge volumes of production-line and quality control data.

As a general supplier of FA systems, Mitsubishi Electric Corporation supplies various types of control devices and also has proposed e-F@ctory to link all related information for improved management. We have looked at the component devices of e-F@ctory from the systems perspective and have developed an integrated platform of controllers to enhance the performance of the entire system, improve ease of use, and reduce the total cost. This paper describes the concept and the device groups of the integrated platform. We will continue to develop e-F@ctory to meet the needs of our customers.

**Factory Automation Systems Group*

FA Integrated Solution: e-F@ctory and the Integrated Platform

Authors: *Kimio Saito** and *Yoshifumi Mita**

1. Introduction

Production plants in fields such as the semiconductor, liquid crystal, and auto industries need to be able to produce variable volumes of diverse products, respond quickly to shorter product cycles, and raise production efficiency.

Mitsubishi Electric has evolved the concept of e-F@ctory for optimizing the entire plant facilities as illustrated in Fig. 1 and has introduced MES interface products that link the host information system and production sites for enhanced visualization of the production sites. This report describes the integrated platform that links the production sites in line with the information linkage technology mentioned above.

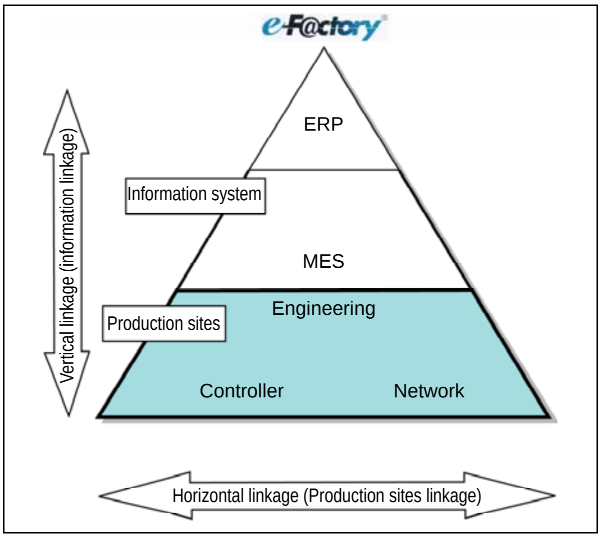

Fig. 1 e-F@ctory and the integrated platform

2. Linkage between Production Sites: the Integrated Platform

Production sites are facing tough demands for higher productivity yet lower development cost arising from the construction or modification of production lines, production-line start-up cost, and maintenance and operation cost. To achieve these cost reductions, it is necessary to reinforce the linkage between the FA components incorporated in the production sites. We have developed and released the integrated platform, which is based on a new concept for reinforced linkage. The integrated platform is composed of the controller platform, the engineering platform, and the network function.

3. Controllers for the Integrated Platform

Controllers designed for the integrated platform of controllers offer improved performance of the bus between CPUs, CPUs themselves, and the network used in conventional MELSEC-Q series products.

Figure 2 shows the controllers newly developed for the integrated platform.

(1) Multiple CPU high-speed base unit
(2) High-speed programmable controller
(3) High-speed motion controller
(4) Numerical controller (CNC) for the production line
(5) Robot controller
(6) Controller network unit (MELSECNET/G)

3.1 Controller platform

The controller platform has the following two features.

(1) High-speed data transmission between multiple CPUs

The multiple CPU high-speed bus shown in Fig. 3 features a transmission speed that is 8 times that of the bus used in the conventional MELSEC-Q series. The bus can be used with any of about 100 units (such as I/O, intelligent functions, and network functions) of the conventional MELSEC-Q series without changing their specifications.

(2) Data transmission synchronized with the operation cycle of the motion controller

With the multiple CPU high-speed data transmission synchronized with the operation cycle of the motion controller, optimum data transmission between CPUs is achieved for enhanced overall performance of the control system (for example, a system consisting of the programmable controller CPU and the motion controller CPU). This applies to the CNC for the production line and the robot controller.

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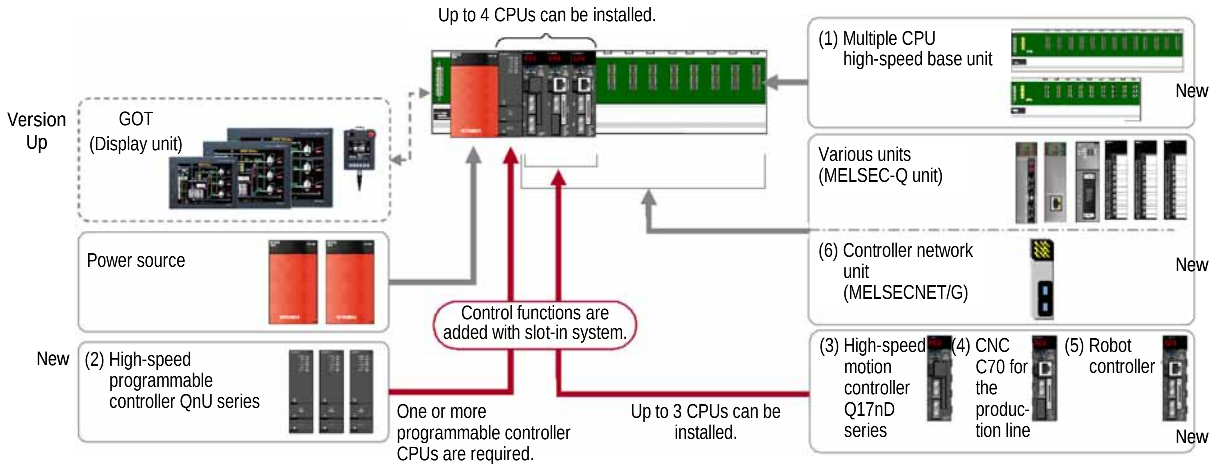

Fig. 2 Controllers newly developed for the integrated platform

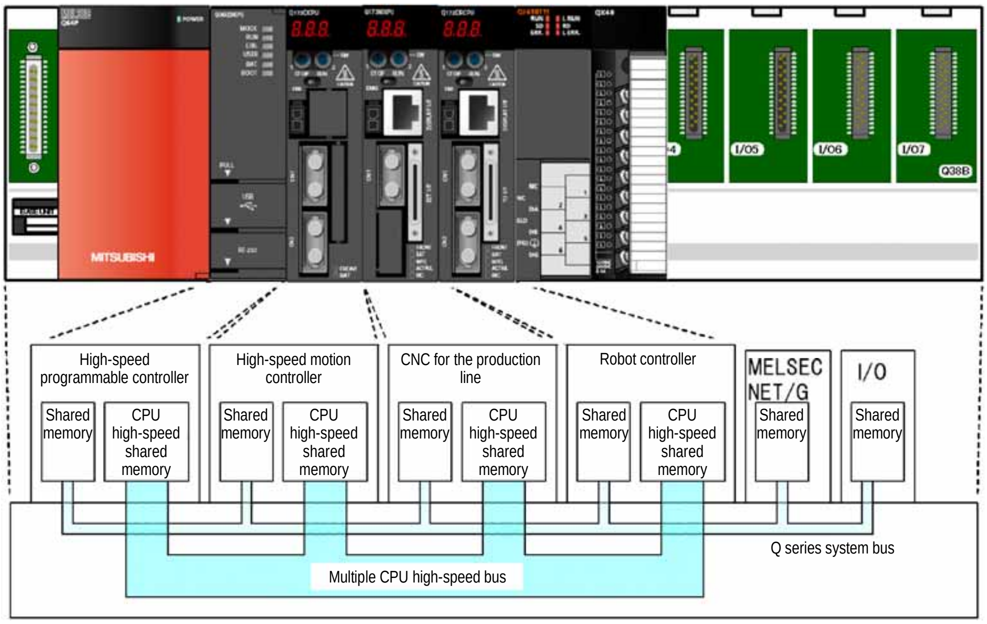

Fig. 3 Controller bus configuration

3.2 High-speed CPUs and controller network

To improve the performance of the entire control system, we have simultaneously released high-speed CPUs and the controller network for the integrated platform.

- The high-speed programmable controller QnU series features a high PCMIX value, an indicator of sequence control performance, which is approximately 6 times that of the conventional model due to faster basic instruction processing, floating-point operation, and memory access.
- The processing capacities of the high-speed motion controller Q17nDCPU and CNC for the production line have been approximately doubled compared with those of the conventional models as they are installed in newly developed hardware having new architectures.
- The controller network MELSECNET/G is equipped with communication technology conforming to the IEEE802.3Z (1000BASE-SX) Standard in the physical layer to increase the communication speed to 1 Gbps and the number of link registers to 8 times larger than that in MELSECNET/H.

4. Engineering Environment for the integrated platform

Engineering work for the conventional control system required software programming and debugging for each device. However, as control systems become increasingly complicated, it has become important to raise engineering efficiency by improving the linkage between software programs.

We are developing an engineering environment specifically for the integrated platform to improve the linkage between programs and so make engineering work more efficient.

The features of the engineering environment currently under development are introduced below.

4.1 Engineering platform

The engineering platform has the following three features.

(1) Integration of development environment

Such functions as programming, monitoring, and diagnosis, are called up from the System Configuration Management Tool shown in Fig. 4 to make it easy to design the control system and understand the work status. In addition, a function for sharing design information is provided.

(2) Sharing design information between development phases

The component devices of the control system are grouped so that, as shown in Fig. 4, the design information is shared between phases such as development, maintenance, and operation, thus boosting the efficiency of user-oriented activities.

4.2 Engineering common function

In the engineering environment for the integrated platform, effective functions are offered to each development phase. Typical functions are described below.

(1) System configuration management function

The system configuration management function allows the user to define the hardware configuration and network configuration graphically by using a mouse for editing and managing the system configuration charts as shown in Fig. 5. In addition, by operating the mouse on the system configuration chart, the user can call up various types of functions.

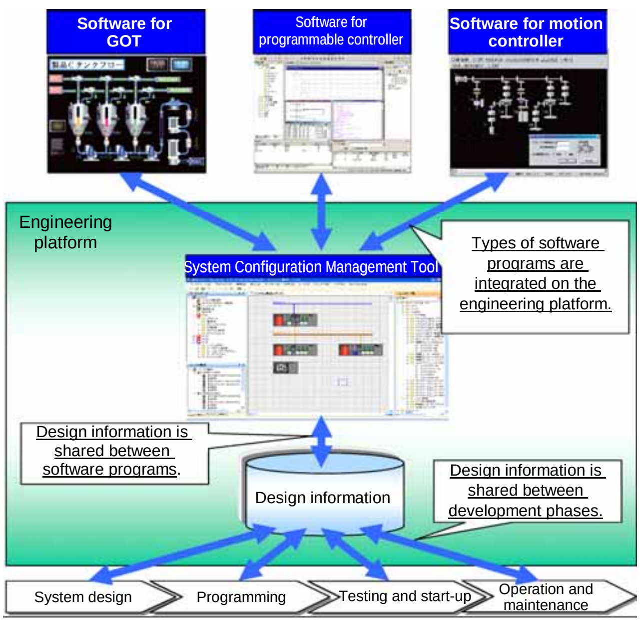

Fig. 4 Engineering environment for the integrated platform

(2) Label programming function

The label programming function allows the user to name devices (label definition) and program the labels to improve the readability of the program.

(3) System diagnosis function

The system diagnosis function allows the user to diagnose the entire system, including activation of the types of monitors on the programmable controllers and motion controllers in accordance with the system configuration chart.

(4) System back-up and restore function

The system back-up and restore function allows the user easily to read out and/or save the program parameters or other data stored in the component devices of the control system.

In addition, the user can write the program parameters or other data stored in the system together into a desired device, which helps to reduce maintenance time when replacing a device.

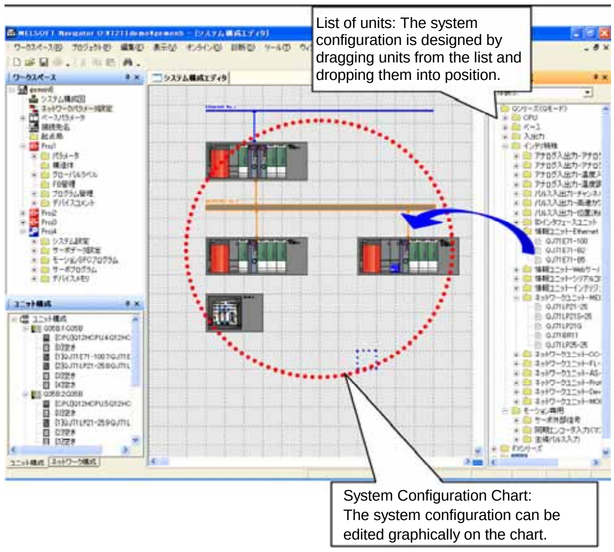

Fig. 5 System configuration management function

5. Conclusion

Following the information linkage at production sites, we discussed the integrated platform and related products for linking FA component products at production sites. We will improve the product range and performance of the common functions for the integrated platform to improve the controller and engineering environment. This will increase the productivity of production sites, reduce the engineering cost, and rationalize the development environment in innovative ways for users.

High-Speed Programmable Controllers “QnU Series”

Authors: *Hiroshi Ishida** and *Yasuhiko Chiba**

1. Introduction

The market environment of the manufacturing industry has been changing along with the trend toward increasing complexity and highly advanced technology in manufacturing facilities. To ensure flexible adaptation under these circumstances, programmable controllers require improved basic performance, system performance, environmental tolerance, and lower power consumption. We have developed the “QnU Series” of high-speed programmable controllers as the central controller supporting the integrated platform.

2. Outline of QnU Series

The QnU Series was developed based on the “MELSEC-Q Series” released in 1999. Figure 1 shows a simplified block diagram of the multiple CPU system of the QnU Series. With the sequence operation processing function and the operation performance for large volumes of data significantly improved, control processing is much faster and complex control can be performed with ease, thus raising the added value of the system. In addition, the settings for CPU unit processing can be optimized in accordance with applications, including control and monitoring purposes. Furthermore, the data transmission speed in multiple CPU systems is also increased so that the controllers can be flexibly applied to various types of manufacturing facilities, while providing higher reliability and lower power consumption of the CPU units.

3. Higher Added Value of Manufacturing Facilities

To realize higher added value of manufacturing facilities, such as increased speed, improved machining accuracy, and monitoring of high-speed sensor signals in manufacturing lines, it is necessary to improve the basic instruction processing time of the programmable controllers used in the manufacturing facilities and to improve the ease of using large volumes of data.

Using an architecture that allows high-speed operations, QnU Series programmable controllers offer much faster sequence operation processing. For example, the sequence execution time per instruction has been improved to 9.5 ns (3.5 times the conventional level), which is the highest level in the industry. Table 1 shows the list of improved performance levels for typical instruction operations. As a result of this high-speed operation, the PC MIX value has reached approxi-

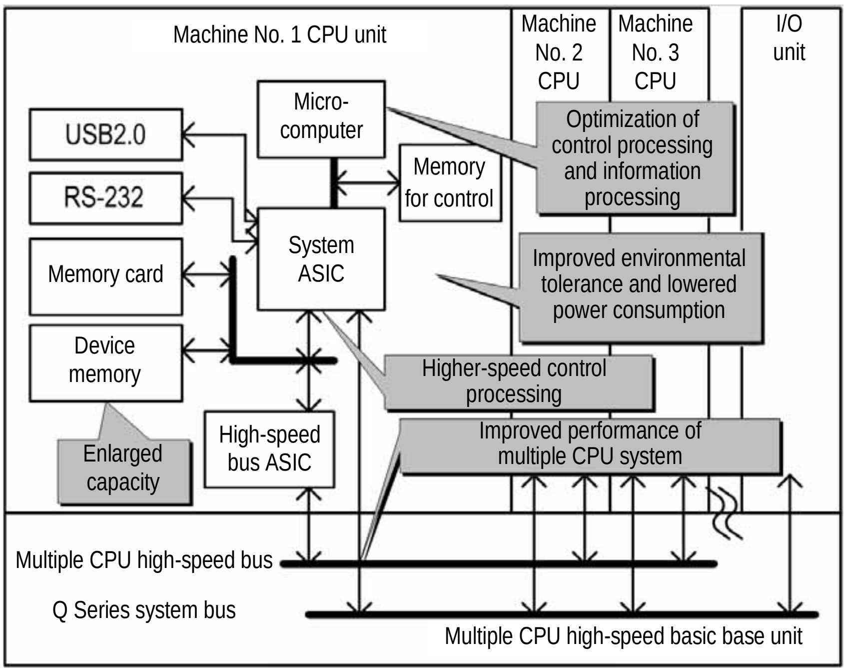

Fig. 1 Outline block diagram of QnU Series multiple CPU structure

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Table 1 Instruction processing performance of QnU Series

Instruction type	Instruction	QnU Series	Q Series
Contact instruction	LD X0	9.5 ns	34 ns
Output instruction	OUT Y0	9.5 ns	68 ns
Data transfer instruction (Serial number access format)	MOV ZR0 D0	76 ns	2966 ns
Floating-point operation instruction	E+ D0 D1	57 ns	782 ns
Index register operation instruction	INC Z0	9.5 ns	2800 ns
BIN 32-bit division operation instruction	D/ D0 D2	161.5 ns	6018 ns

mately 60 instructions/μs. (PC MIX value is the number of basic instructions executed in 1 μs divided by the average number of instructions such as data processing instructions or the like. The larger the value, the faster the execution speed.) This means that the QnU Series is about 5.8 times faster than that of the Q Series, thus greatly reducing tact time in manufacturing facilities.

The operation processing time for the index register was improved by a maximum factor of 300, which gives sufficient allowance for structuring programs to encourage reuse of programs and improved quality.

The capacity of the programmable controller CPU module built-in memory has been enlarged, and a file register of up to 384 K words and a 1-MB ROM that stores user data and device comments are included as standard. Also, the file register access speed by serial number access format is increased by a factor of about 40. The index modification range in the serial number access format is expanded to enable access to the entire file register region by using index modification. As a result, large volumes of data can be easily handled.

4. Applicability to Types of Manufacturing Facilities

The time ratio of sequence operation processing (control processing) and service processing (information processing) such as monitoring from an external device can be set with ease. Figure 2 shows a chart of scan execution using the programmable controller CPU. With the time ratio set, it is possible to set the optimum ratio of processing in accordance with the various types of manufacturing facilities, thus expanding the application range of programmable controllers.

In addition to the conventional Q Series system bus, a multiple CPU high-speed bus system was constructed for the integrated platform. Via this high-speed bus, data is transmitted periodically at a high speed of 14 K words/0.88 ms (8 times the conventional speed). Even when huge volumes of data are transmitted with the motion controllers and multiple CPU system configured, quick response and synchronization with the operation cycle are achieved, which also expands the application range of the multiple CPU system.

5. Improvement of Environmental Tolerance

Programmable controllers are often used in harsh electromagnetic environments, including manufacturing sites. The requirements stipulated in the EMC (Electromagnetic Compatibility) Directive, with which programmable controllers must comply, have been reinforced. The noise immunity of the QnU Series has been strengthened based on the results of analysis, with its characteristic high performance unchanged.

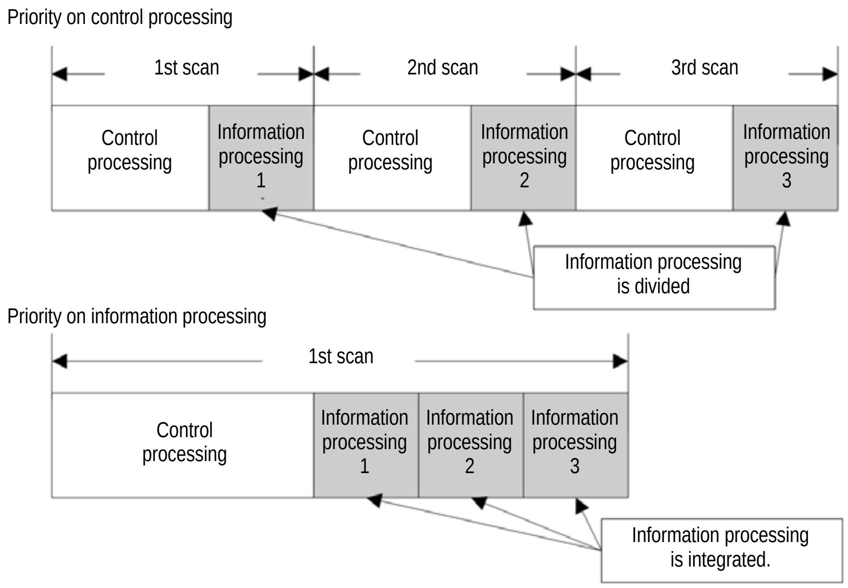

Fig. 2 Chart of scan execution for priority on control processing and information processing

In addition, there is a function for checking the integrity of the data in the memory that stores the programs for executing a sequence program, whether rewritten or changed, due to electric noise or failure.

6. Lower Power Consumption

With the reduction in number of elements used in memory ICs, the power consumption of the CPU module has been lowered by 40%.

The back-up storage locations have been limited to the range necessary to reduce the back-up current and prolong battery life. In addition, a function that restricts the back-up data to clock data prolongs the battery life by approximately 2.5 times.

We will further improve the performance, functions, and ease of use of the QnU Series as the product lineup expands.

High-Speed Motion Controller “Q17nD Series”

Authors: *Takahiro Kamada** and *Yuuko Tomita**

1. Introduction

Today’s global market requires not only better CPUs to boost the functionality, performance and cost efficiency of components, but also higher throughput of entire systems. We have therefore developed a high-performance motion controller with multiple CPU high-speed transmission (Fig. 1).

2. Features of Motion Controller “Q17nDCPU”

We have developed a multiple CPU high-speed bus for data transmission between the motion controller and programmable controller to realize maximum data transmission of 14 kW at intervals of 0.88 ms. With a new architecture for the motion controller hardware, the improved performance allows up to 6 axes to be controlled at an operation cycle of 0.44 ms.

3. Multiple CPU High-Speed Transmission

3.1 Outline of multiple CPU high-speed transmission

Multiple CPU high-speed transmission refers to a data transmission function executed between multiple CPUs at a fixed cycle (0.88 ms; “multiple CPU high-speed transmission cycle” hereafter).

In the data transmission of a conventional Q Series motion controller, the device data on the motion controller side is set in the shared CPU memory at the main cycle intervals of the motion controller, then fed to the programmable controller by the END processing in the sequence program. On the other hand, with the newly developed multiple CPU high-speed bus, the data is transmitted to the programmable controller at the multiple CPU high-speed transmission cycle and read out by the sequence program, by setting the device data on the motion controller side to the shared multiple CPU memory (Fig. 2).

As a result, the device data is updated at high speed without the influence of the motion main cycle or the scan time of the sequence program.

Existing system (Auto refresh)
(1) Device ON
Device reflection time
Device reflection time
(8) Device ON

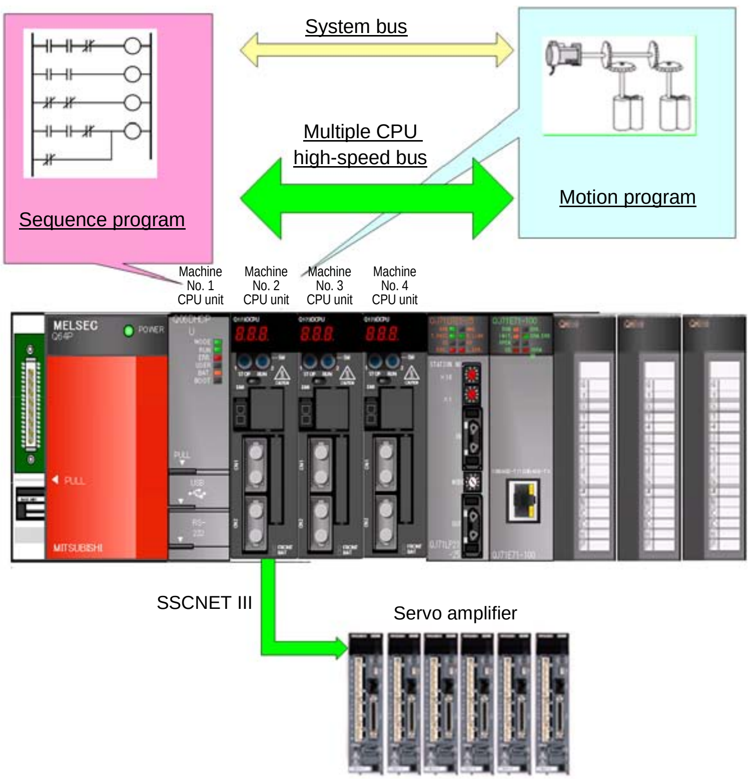

Fig. 1 Overall system configuration

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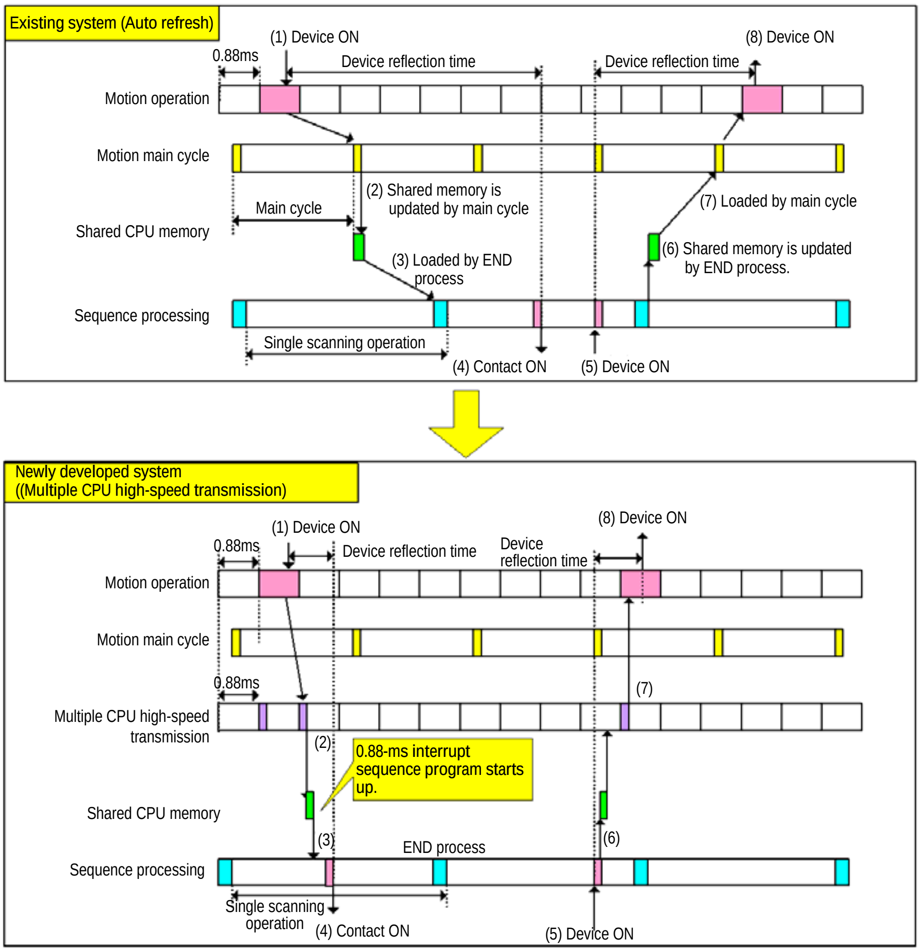

Fig. 2 Data transmission (Schematic diagram)

3.2 Technologies employed in multiple CPU high-speed transmission and their features

(1) The conventional Q Series motion controller uses only the system bus for data transmission between all units. Consequently, as the number of units increases while large volumes of data are periodically transmitted between CPUs, the required data transmission time inconveniently increases. Therefore, we have provided a multiple CPU high-speed bus exclusively for transmission between the CPUs, which enables high-speed data transmission regardless of the number of CPU units or the volume of data.

With this multiple CPU high-speed bus, large volumes of data, a maximum of 14 kW, are refreshed at high speed for each multiple CPU high-speed transmission cycle to allow high-speed data sharing between the CPUs, increasing the data volume to almost 3.5 times the conventional transmission.

Since the multiple CPU high-speed transmission is synchronized with the operation cycle of the monitor controller, data transmission involves no inefficient latency. In addition, data transmission on the programmable controller is also synchronized; synchronized data transmission is secured between the programmable controller and the motion controller. Furthermore, since the communication with the servo amplifier is synchronized with the operation cycle of the motion controller, synchronized data transmission is achieved throughout between the programmable controller, motion controller, and servo amplifier. Thus, the data transmission has no latency and can process the data at high speed, resulting in a remarkable reduction in tact time.

(2) Refresh device range settings are now increased from 4 types to 32 types for more flexible setting of the command and monitoring devices between the CPUs. As a result, the user can assign devices as desired, increasing the degree of freedom in programming.

(3) A free area is newly provided in the shared CPU memory (Fig. 3). In this area, the user can specify the same devices in the sequence program, motion sequential function chart (SFC) program and servo program and easily understand the interrelationship between the programs, thus improving the program readability of the system.

(4) Sequence instructions for the motion controller

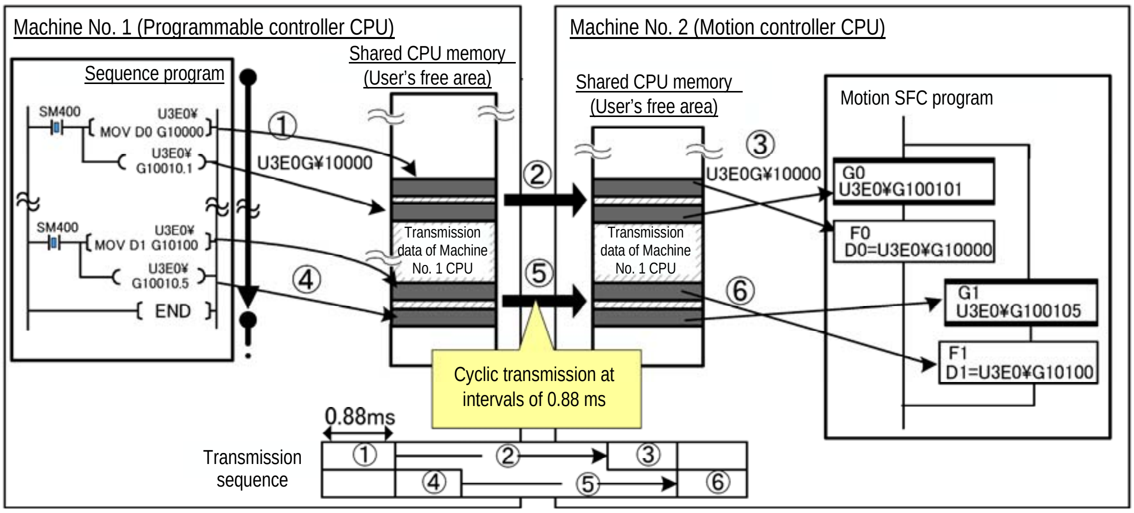

Fig. 3 Shared CPU memory

only are modified so that "complete device" or "device for storing complete status" can be omitted. This improvement simplifies sequence program execution while motion controller instructions are being used.

On the other hand, the conventional Q Series motion controller can perform sequence instructions for the motion controller only once during a single scanning operation. With this new series, multiple sequence instructions for the motion controller can be executed at the same time (a maximum of 32 times per single scanning operation).

(5) Interrupt sequence programs synchronized to the operation cycle of the motion controller can be described; sequence processing synchronized with the motion control is now available. As a result, the high-speed servo control function uses information received from the units under the control of the programmable controller (high-speed counter module and analog-digital converter module) and the information can also be used in various applications mainly related to the sequence.

4. High-Speed and High-Performance Operation with Motion Control

The hardware architecture of the Motion Controller Q17nDCPU has been significantly improved compared to the conventional ones; performance is almost double and an operation cycle of 0.44 ms/6 axes has been realized (Table 1).

Table 1 List of operation cycles

Q173DCPU	Q172DCPU
0.44 ms / 1–6 axes 0.88 ms / 7–18 axes 1.77 ms / 19–32 axes	0.44 ms / 1–6 axes 0.88 ms / 7–8 axes

The processing speed of motion SFC instructions has also been increased to almost three times that of the conventional series on a 32-bit addition basis.

This development enhances the overall performance of Mitsubishi FA products. As a total FA equipment supplier, we will continue developing products by focusing on the importance of total optimization.

CNC C70 for Production Line

Authors: *Mutoshi Fukutani** and *Mitsushiro Fujishima**

1. Introduction

Mitsubishi Electric Corporation has introduced a new CNC, the MITSUBISHI CNC C70, which supports the integrated platform and enables high-speed data refresh by incorporating a high-speed bus into MELSEC Q Series's main base.

The C70 is highly compatible with the diverse range of Mitsubishi FA product lines that boost the efficiency and performance of production systems. This excellent compatibility as well as its dramatically enhanced processing capacity make the C70 the most suitable CNC for production lines in the auto industry.

2. Background of C70 Development

Overall cost reduction is a top priority for automobile engine manufacturers when constructing lines for components such as cylinder heads, cylinder blocks, crankshafts and gearbox casings. To meet their needs, coordination with adjacent processes is critical, in addition to minimizing individual processing time. Therefore, a CNC for line control must offer not only numerical control but also sophisticated sequence control. Although these demands have been met with the C6/C64 Series so far, the control speed and connectivity with other FA products need to be improved further.

In response, Mitsubishi has launched the CNC C70 which supports the new integrated platform, by incorporating a high-speed bus into MELSEC Q Series's main base to achieve faster data refresh among CPUs.

In line with Mitsubishi Integrated FA Solution "e-F@ctory" concept for optimizing total factory processes, the C70 is designed to work with a range of FA products that raise the efficiency and performance of manufacturing systems and to incorporate far greater processing capabilities. These features make the C70 ideal for line control.

3. C70 Overview

As the C70 is a CNC to be mounted on Mitsubishi PLC MELSEC's platform, the product concept is entirely different from that of existing CNCs.

The C70 consists of multiple CPUs, including a PLC CPU for sequence control and a CNC CPU for numerical control. Peripheral units of the MELSEC-Q Series, such as an I/O (Input/Output) and network modules, can work directly with the C70. This unification of CNC with PLC helps compatibility with a variety of networks as well as Mitsubishi Integrated FA Solution.

Compatibility with MELSEC has been improved by adopting the GOT1000 Series display unit. In addition, a screen creation package, GT Designer2, facilitates machine operation panel functions. This tool enables both machine panel and NC screen functions to be handled with a single display unit.

Figure 1 shows the C70's system configuration.

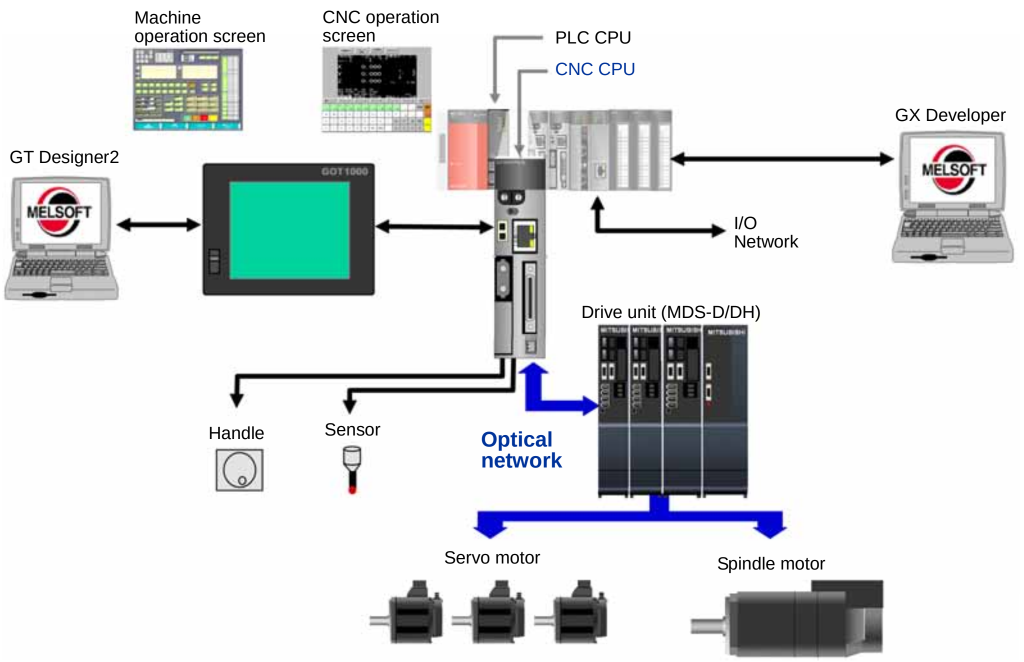

Fig. 1 C70 system configuration

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4. Enhanced Compatibility with PLC

A newly developed, high-speed PLC CPU functions as the C70's sequence controller, delivering world-leading sequence performance, and which can be used together with diverse MELSEC Q Series units. Three types of PLC CPU are available in the lineup, which can be selected to meet the user's scale of control system, such as program size and performance level.

Users can easily construct the best solution for their production facilities by combining these CPUs with other units (see Fig. 2).

A programming package for MELSEC PLC, GX Developer, is available for creating PLC programs, which can offer the same programming environment as MELSEC Q Series.

5. Display Module

To reduce space while enhancing the operability of facilities, automakers need a touch panel that can serve as both a machine operation screen and as a CNC operation screen. The GOT1000 Series as the C70's display module satisfies this need.

The GOT1000 Series line ranges from a compact 3.7" size up to a wide 15" size at XGA resolution.

The CNC monitor (Fig. 3), which functions as a CNC operation screen, can be installed in 10.4", 12.1" and 15" type GT15 monitors with SVGA or higher resolution, which will work as the machine's main operation panel. Other smaller monitors can be used as sub operation panels.

A GOT, which functions as the main operation panel, is directly connected to the dedicated interface on the CNC CPU module (via Ethernet), ensuring rapid CNC screen display regardless of the PLC CPU throughput.

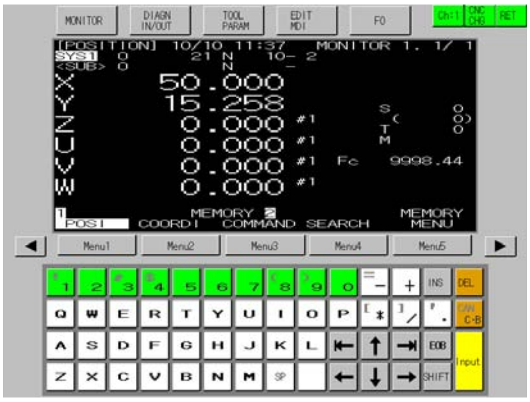

Fig. 3 CNC monitor screen

6. Smaller Size

Designed to fit in a slot of the MELSEC main base, the C70's CNC CPU module is among the world's smallest, with palm-size dimensions of just 98 mm in height, 27.4 mm in width and 119.3 mm in depth. Almost all CNC functions except for the power supply and sequence control are packed within these dimensions. Moreover, CNC capability has been more than doubled compared with the previous CNC. This performance uplift as well as downsizing have resulted from some of our new developments, such as a high-speed RISC CPU with built-in second cache memory, a new high-speed, high-integration ASIC that embodies Mitsubishi's cutting-edge computer technologies, DDR memory control, high-speed access to peripheral buses using built-in ASIC's 4-layer read/write queues, and efficient use of DMA.

Despite this downsizing and performance increase, overheating is not a concern. All the primary chips run at a low core voltage (between 1.2 and 2.5 V) and the circuit consumes little power due to its environmentally friendly design.

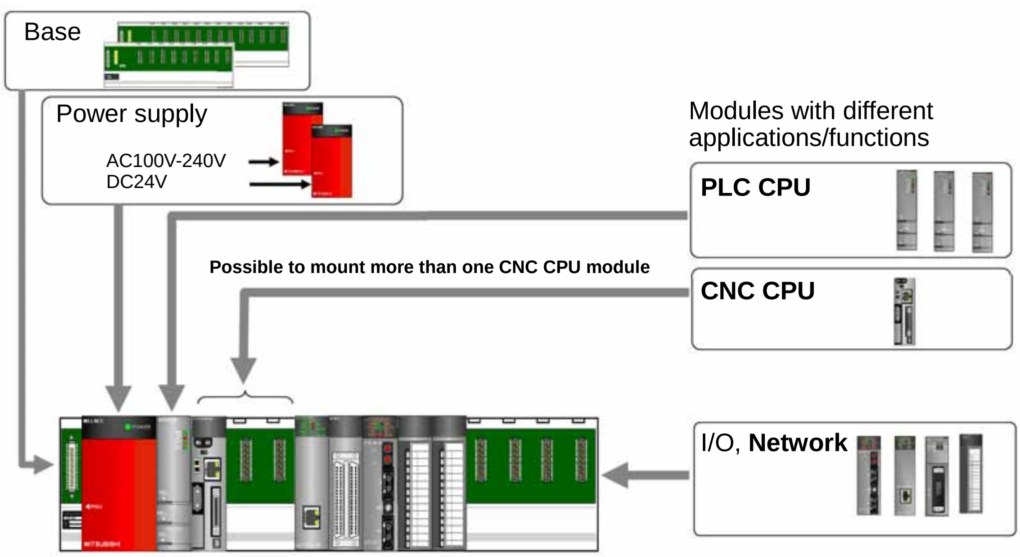

Fig. 2 CNC CPU combined with PLC CPU

7. Shorter Tact Time

A machine tool is equipped with various auxiliary devices, as well as servo axes that act as its fundamental mechanism. As the motions of these devices are controlled by ladder programs, better ladder performance can directly reduce the tact time.

Combined with a high-speed PLC CPU and incorporating a high-speed multi-CPU bus into the base unit, the C70 has much greater capability. For instance, the ladder scan time is now 20 to 30 times faster and M code processing is 3 to 5 times faster than the previous C6/C64 Series, thus reducing tact time.

Furthermore, its capability of processing machining program blocks has been doubled compared with the C6/C64 Series.

8. Safety Observation Function

In response to growing demands for safety, we have incorporated a safety signal observation function into the C70, in addition to the existing speed observation function supported by the Mitsubishi CNC 700 Series.

This existing speed observation function ensures safe machine operation even while the machine's protection door is kept open.

To use this function, the door's state signals have to be input to both the CNC CPU module and drive module. Then each module monitors the signals through two different routes. When the door is open, the machine is allowed to operate at a predetermined safe speed. Similarly, motor speed is observed by a drive module and CNC CPU module through two different routes. If either module detects a motor rotating at a speed exceeding the predetermined safe speed, the motor will be immediately commanded to decelerate, and will stop and enter the power-shutdown state.

When the door's state signals input via two different routes do not match each other, the motor will decelerate, stop and enter the power-shutdown state. In this way, the speed observation function ensures a safe machine setup even without closing the door.

Moreover, a new safety signal observation function allows both the CNC CPU module and PLC CPU module to monitor safety signals such as a light curtain signal that are input/output to/from both modules via two different routes, in addition to the door's state signals.

With this new function, CNC CPU and PLC CPU can monitor the signals via two different routes. As soon as either CPU detects any signal mismatch, the motor will decelerate, stop and enter the power-shutdown state.

The safety signal observation function allows this type of safety system configuration to be provided without costly safe relays, whereas previously it was possible only with special hardware. This significantly reduces machine cost.

In conclusion, the C70 allows devices to be used flexibly according to each environment. The C70 has tremendous potential to be used on not only automobile engine manufacturing lines but other sites where CNC has not yet been installed.

Engineering Environment for Programmable Controllers: "GX Developer2"

Author: *Masahiro Hirata**

1. Introduction

An appropriate engineering environment for efficient software development is required for today's larger, more complex user systems in FA systems. We have developed "GX Developer2" as engineering environment for programmable controllers. GX Developer2 is designed to be compatible with the integrated platform, allowing linkage and data sharing with the engineering environment of other FA products. This boosts work efficiency through each system construction phase (system design, program development, debugging and start-up, and operation and maintenance) and reduces man-hours in the development stage.

2. Features

2.1 Improved programming efficiency

By fully utilizing users' software assets and operating the library function, centering on the function block (FB) as well as the linkage function with other types of MELSOFT products, users' programming efficiency can be remarkably improved.

- The Library Management Function makes it easier to use software assets, for more effective program development.
- Sharing of labels with other MELSOFT products makes it easier to link data with other setting tools, for more effective program development.

2.2 Improved debugging efficiency

Provided with a simulation function (Virtual Programmable Controller Function) for running a sequence program on a personal computer, debugging can be performed on the personal computer with ease, without the need to load the sequence program on an actual programmable controller. System quality can be established before making adjustments at users' sites, thus remarkably shortening the on-site adjustment time.

(1) Integrated tools for more efficient debugging

A simulation tool, which was an independent item in the conventional series, is now integrated into GX Developer2 as a component for fast changeover between the sequence program edit and simulation screens. The user can immediately modify the problems found in debugging and efficiently confirm the results of modification by repeating the simulation.

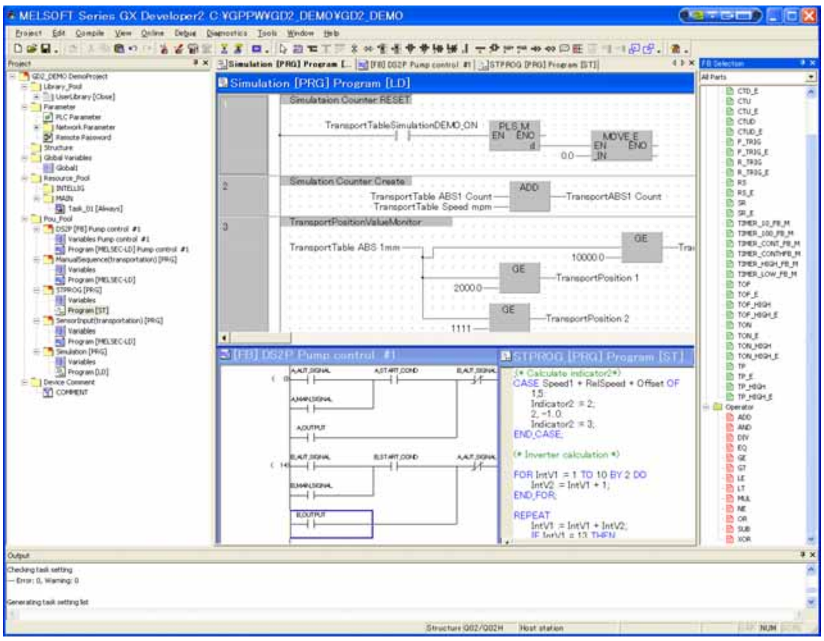

Fig. 1 GX Developer2

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gram component to be reused and copy it to the target

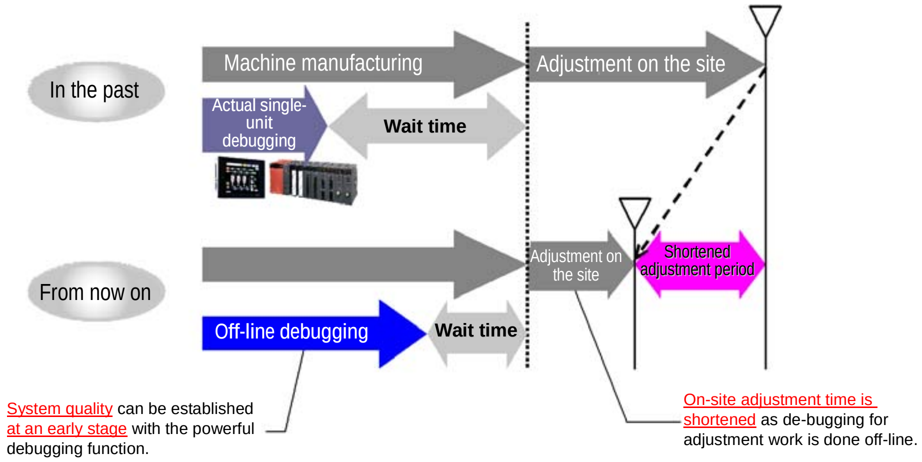

Fig. 2 Shortening of system adjustment time by using simulation function

(2) Multiple controller simulation for improved debugging efficiency

With the conventional series, only one simulation function at a time was executed on a personal computer. For larger user systems, a new debugging environment allows simultaneous function activation of up to four programmable controllers for simulation. By simulating multiple GX Developer2 projects at once, networked systems can be efficiently debugged.

2.3 Reinforced security for operation and maintenance

The user authentication function has been reinforced for data access in the operation and maintenance phases in order to prevent project access by unauthorized users and to prevent leakage of authorized users' know-how.

- The user authentication function can protect the project data.
- Access to data can be controlled based on authorized user levels.

3. Problem and Solution

3.1 Improved reusability of programs through the library function

With the conventional series, when reusing program components such as structures or FB, the user had to find a particular project that contained the program component to be reused and copy it to the target project (Fig. 4). This made it difficult to locate the project containing the desired program components for reuse (Fig. 3).

Our solution in GX Developer2 is to store structures and FBs that can be used as program components in a library separated from the project. This separation allows program components to be managed by function, so the user can easily obtain and use the desired program components from the library (Fig. 4).

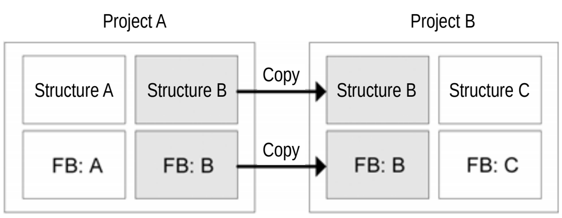

Fig. 3 Recycling method of program component by project copy

3.2 Improved debugging efficiency

3.2.1 Simultaneous simulation of multiple programmable controllers

With the conventional series, only one programmable controller was debugged by a single simulation operation. It was necessary to repeat the simulation when debugging multiple programmable controllers connected via a network.

However, with GX Developer2, parallel simulations can be performed by changing the transmission between applications from the conventional shared mem-

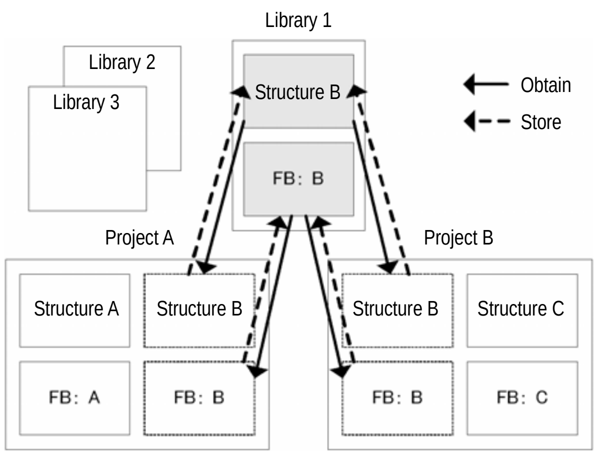

Fig. 4 Recycling method of program component by library

ory operation to TCP/IP transmission and activating the function of multiple programmable controllers simultaneously on a single personal computer.

3.2.2 Increased response speed during simulation

Simultaneous execution of the monitor function and simulation function of GX Developer2 on a single personal computer faces problems with execution speed of the simulation function and responsivity of the user interface. For example, when priority is given to the simulation function to secure a certain level of execution speed, the simulation function occupies much CPU time of the PC, thus lowering the monitor performance on GX Developer2.

Our solution design as shown in Fig. 5 secures the wait time (B) that is equal to the time (A) spent for executing simulation to allow other applications to run. For example, even if multiple simulations are executed simultaneously, the user interface response speed is not affected.

3.3 Reinforced security for operation and maintenance

In the severely competitive semiconductor and liquid crystal device industries, it is crucial to prevent leakage of know-how. In addition, programs must be protected from accidental alteration by operators unauthorized to edit them.

GX Developer2, equipped with user authentication and access control functions, offers off-line project security.

4. Conclusion

We have developed “GX Developer2” as engineering environment for programmable controllers. We will increase the functions to improve programming efficiency for version upgrades in the future.

References

(1) Zenei Kamiya and Nobuyuki Ban: Integrated Programming Environment for Programmable Controllers, Mitsubishi Electric Corporation Technical Report, Vol. 74, No. 07, 2000

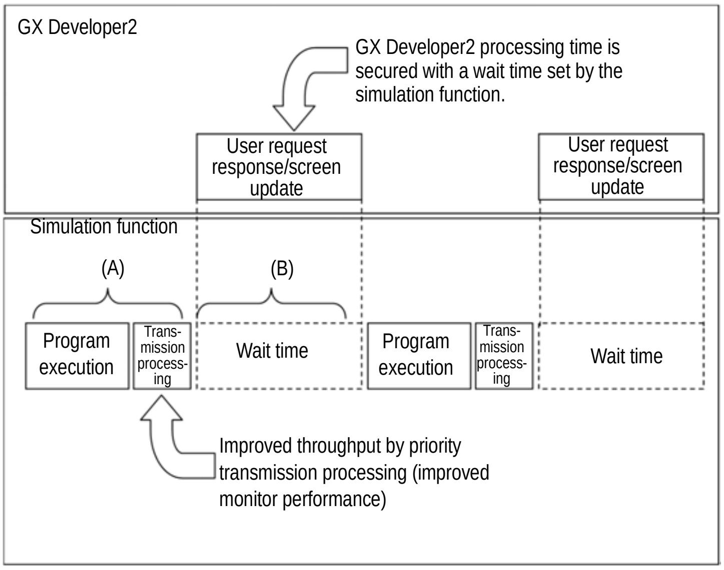

Fig. 5 Adjustment of simulation function run-time

Engineering Environment for Motion Controllers

Author: *Hidehiko Matsumoto**

1. Introduction

Various industrial machines employing servo systems contain many combinations of different FA components such as programmable controllers, motion controllers, servo mechanisms, and display units. To improve the performance and multifunctionality of those machines, an increasing number of man-hours is spent on programming, parameter setting, start-up, and debugging the FA components built into the machines. An engineering environment to reduce this time is now an important factor when selecting FA components.

We have developed "MT Developer2", an engineering environment for motion controllers that complies with the integrated platform of controllers. This improves the overall software development efficiency by combining the engineering environment for programmable controllers or engineering environment for display units.

This report describes the features of the MT Developer2 motion controller programming software compliant with the integrated platform of controllers, and introduces the challenges and solutions faced during development as well as future development prospects.

2. Features

The MT Developer2 motion controller programming software provides an engineering environment that complies with the integrated platform of controllers, and has the following features.

(1) Improved program development efficiency

1) Improved program creating efficiency

- The motion program offers label programming to simplify standardization of user programs.
- CAM data is created by importing the data from CSV-format files for greater freedom in CAM data creation.

2) Shorter man-hours

As the engineering environment complies with the integrated platform of controllers, the sequence program and motion program are created seamlessly through the unified user interface.

(2) Reinforced program management function

Unauthorized access to the project is prevented by a stronger user authentication function, thus protecting users' know-how against leakage.

(3) Improved debugging efficiency

With highly improved operability of the digital oscilloscope, which can sample the data from the motion controller and servo amplifier and also display them in waveforms, debugging efficiency is greatly improved.

3. Challenges and Solutions

3.1 Programming using labels

The motion controller has various devices for storing user data, such as word data and bit data, which can be used in the motion SFC program and servo program. In conventional methods, creation of these programs required using device names that had been designated previously. With MT Developer2, the devices are labeled to allow user-designated labels when programming (Fig. 1).

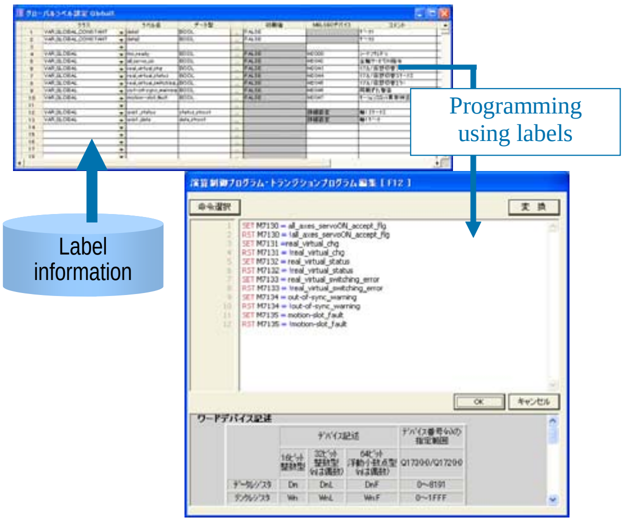

Fig. 1 Programming using labels

As a result, program creation is more efficient and the program is more readable.

3.2 Increased efficiency of cam data creation

In the conventional methods, dedicated software included in MT Developer had to be used to create cam data. However, with MT Developer2, CSV-format data can be imported for CAM data creation (Fig. 2), and the CAM data created by the software can be exported.

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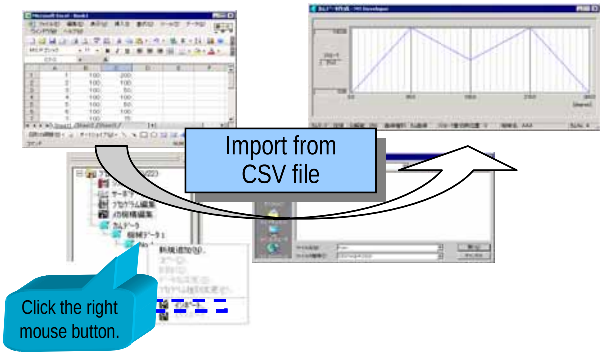

Fig. 2 Import of CAM data

As a result, CAM patterns created by the user can be used, and CAM data can be set more easily and flexibly than by the CAM data creation software of MT Developer.

3.3 Unified user interface

The motion controller is used in combination with the programmable controller; the users need to operate the programming software of the two devices respectively. The unified user interface makes program development more efficient (Fig. 3).

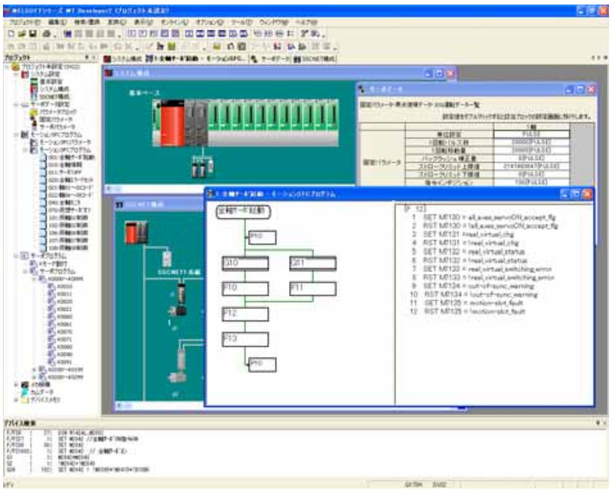

Fig. 3 Unified user interface

With MT Developer2, the user interface is identical with that of the programming software for MELSEC programmable controller "GX Developer2", for seamless programming.

The data link between applications allows jumping from the sequence program to the motion program and vice versa, thus improving the efficiency of user programming.

3.4 Security

In conventional methods, there was no limit on the use of project data, and so the master project data was sometimes accidentally changed by inexperienced operators, or confidential data could be leaked.

MT Developer2 incorporates the same user authentication and access control as in GX Developer2; only those users with access authority can perform such operations as displaying and editing the program, thus ensuring off-line project security.

3.5 Digital oscilloscope function

The digital oscilloscope, which can sample the data from the motion controller and servo amplifier and also display them in waveforms, provides handy functions for starting up and debugging FA devices (Fig. 4).

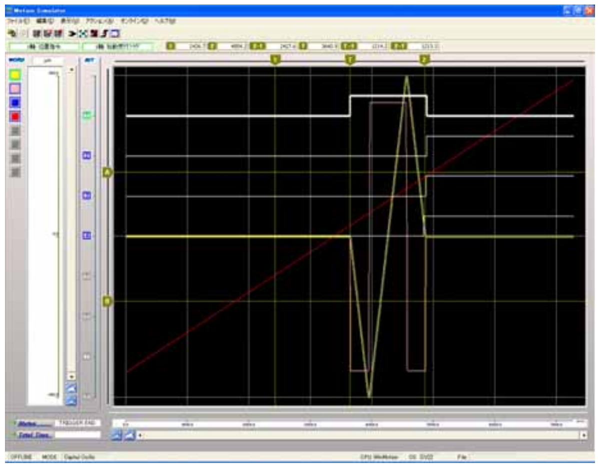

Fig. 4 Digital oscilloscope

The digital oscilloscope in MT Developer2 has conventional functions with remarkably enhanced operability of expanding or reducing the graph display scale as well as data processing. As a result, users can start up and debug their devices more efficiently.

4. Conclusion

We will further improve the efficiency of software development and overall system performance by reinforcing the integrated linkage function of the engineering environment, which complies with the integrated platform of controllers for motion controllers, can be used seamlessly with various programming software for motion controllers, programmable controllers, display units, and the like, and is designed to speed up device development by users.

GOT 1000 Series and Engineering Environment, GT Designer2

Author: *Tetsuyuki Usami**

1. Introduction

Mitsubishi Graphic Operation Terminals, GOT 1000 Series, was first introduced in July 2004. Since then, we have expanded both product lineup and functionality for further market penetration.

This article introduces the new models and functionalities of the GOT 1000 Series and the implemented technology in them.

2. GOT 1000 Series and Engineering Environment

The GOT 1000 Series consists of three models: GT15 (full-spec model that covers wide-ranging applications from networking to stand-alone operation); GT11 (standard model fully equipped with basic functionalities for stand-alone use); and GT10 (basic model with GOT functions condensed into palmtop size).

After the GOT 1000 Series was launched in 2004, the product lineup and functionalities have been expanded.

As the engineering environment for the GOT 1000 Series, the drawing software package GT Designer2 supports all GOT 1000 models and is expected to help reduce rising engineering costs. When the GOT 1000 was released, GT Designer2 was updated to support all models and functions of the GOT series. Since then, further improvements have been made by adding new functions and enhancing operability for improved performance.

The following sections introduce the expanded models and functionalities of the GOT 1000 Series and GT Designer2.

3. Expanded Functions of GT Designer2

3.1 Features of GT Designer2

GT Designer2 was launched in 2002 as the drawing software package for the GOT 900 Series to reduce the time for creating screens. GT Designer2 is easy to use even for beginners, with many functions for reducing the time to create screens, and Windows-based operations.

3.2 Expanded functions after the GOT 1000 compatible version (Version 2 and later)

GT Designer2 was upgraded to GOT 1000 compatible Version 2, where various functions were enhanced as listed in Table 1. Corresponding to the highly functional GOT 1000's ability to handle a greater amount of information, the enhanced functions make it much easier for users to create screens, thus improving efficiency.

Table 1 Expanded functions of GT Designer2

Name of Function	Description of Expanded Function
Window preview	Preview of the window screen is available.
Multiple data enlargement/ reduction	Multiple data can be enlarged or reduced at once.
Wizard	A newly created project can be interactively initialized.
Data consistency check	Data in the personal computer can be checked with the data in the GOT main unit.
Screen image list	Screen images can be checked on a thumbnail list; and editing functions such as copy and delete are available.
3D CAD data compatible	IGES format graphic data can be read in.
Automatic size adjustment of direct input characters	When changing a switch size, directly entered characters are automatically adjusted.
Library color selection	Library images can be displayed by color.
Touch area fit-in	Touch area (valid area) can be optimized to fit within the frame of the switch image.
Data transfer tool	Data upload/download tool without any support from GT Designer2.

3.3 Compatibility with the integrated platform

To make GT Designer2 compatible with the integrated platform, the following functions have been added:

(1) Graphical system setup function
(2) Label reference function
(3) Security function (User authentication)

Details of (1) and (2) are described below.

(1) Graphical system setup function

The system management software is now able to allocate the GOT in the same way as the programmable controller. When an allocated GOT is selected (double clicked), the system management software starts GT Designer2, which then configures detailed settings such as the type of GOT and communication

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settings. Settings made by GT Designer2, i.e. GOT type, communication settings, etc., are reflected in the system management software.

(2) Label reference function

In the previous version of GT Designer2, items displayed on the monitor, e.g., numeric data and lamps, were specified by the device notation, making it difficult to identify the data type of displayed items. In addition, when the device assignment was changed across the system, the changed device and data needed to be checked on all screens, which was inefficient and time-consuming. The new label reference function makes it possible to specify monitor display items by their labels (names) instead of the device notation.

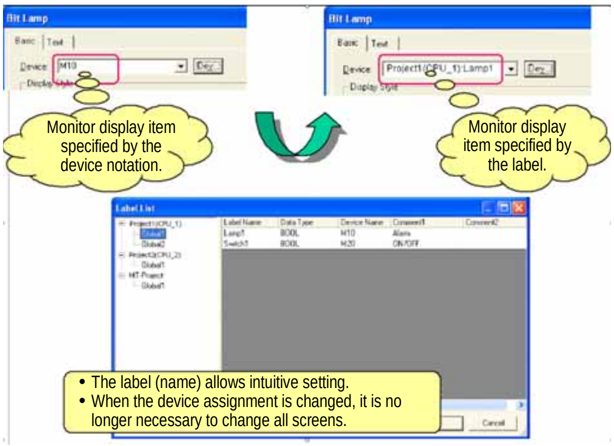

Fig. 1 Label reference function

4. Expanded Models and Functions of the GOT 1000 Series

The product lineup of the GOT 1000 Series has continually grown. The main models added in 2007 are listed in Table 2.

Table 2 Expanded models of GOT 1000 Series

Model	Outline
GT15, 5.7-inch VGA model	With a 5.7 inch VGA LCD, this model realizes large information display and compact size.
GT11, 5.7-inch model specifically for bus connection	Connection mode is specifically for bus connection to pursue cost effectiveness.
GT10, 4.5-inch model	GT10 basic model following the 3.7 inch model.
CF card unit	Add-on unit for the CF card interface.
External input/output interface unit	Optional unit for connecting I/O devices such as an operation panel and lamps.
Sound output unit	Optional unit for sound output

Functionalities have also been expanded as shown in Table 3, with the main ones described below.

(1) Compatibility with high-speed programmable controller and high-speed motion controller

Connectivity of GOT 1000 has been enhanced for both the high-speed programmable controller and the high-speed motion controller, which are compatible with the integrated platform. The GOT 1000 now supports various connection modes (bus, serial and Ethernet) as well as maintenance monitoring functions such as system monitor and ladder monitor functions.

Table 3 Expanded functions of GOT 1000

Name of Function	Description of Expanded Function
Backup and restoration function	Backs up the sequence programs, etc. in the GOT main unit with one touch.
Operator authentication function	Sets up each operator's authority level for access to the operation and display screens.
Expansion of advanced recipes	Number of advanced recipes has been increased to 2000 records.
Ladder monitor	Supports local device monitoring, and enables storing of sequence program comment data onto a CF card.
MES interface function	Buffers triggered actions, and expands accessible databases.
Stroke font	Thai and Chinese (simplified and traditional characters) have been added.
Transparent bitmap figures	Transparent color is available for bitmap figures.

(2) Backup and restoration function

To ensure proper system operation and maintenance, sequence programs, etc. must be periodically backed up in case of system failure, and replacement or program reinstallation must be promptly carried out when the programmable controller fails. To overcome this challenge, a "Backup and Restoration Function" has been newly developed.

The backup and restoration function enables the sequence programs to be backed up in the GOT 1000 with one touch. In addition, should the programmable controller fail, restoration from the GOT can be achieved with one touch without using a personal computer. This function ensures simple and quick backup and restoration.

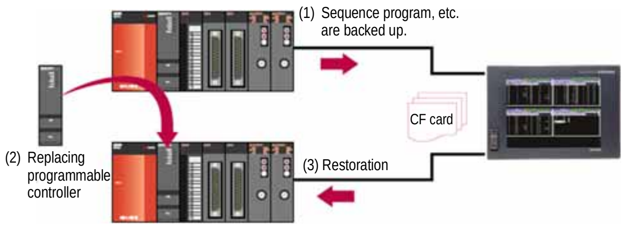

Fig. 2 Backup/restoration function

(3) Operator authentication function

To strengthen security, an "Operator authentication function" has been developed to manage the operation authority for GOT 1000. This function authenticates the operator name and password, and manages each operator's authority for access to the display and operation screens. In addition, together with the operation log function, it is also possible to record which operator performed what operations.

The operator authentication function thus boosts security and helps trace the cause of operation errors.

We will continue pursuing graphic operation terminals for efficient operations and shorter downtime by enhancing the operator interface, device connectivity and accessibility to the information systems as well as improving the basic functions.

Controller Network MELSECNET/G

Author: *Tomoyuki Fujita**

Article Introduction

Controller network MELSECNET/G is a network system for distributed control devices, and can transmit and receive large amounts of data in real time. MELSECNET/G features (1) high-speed and high-capacity cyclic transmission; (2) a highly reliable network with dual transmission lines; (3) troubleshooting support in the event of cable failure or faulty wiring; and (4) easy troubleshooting with visible network diagnostics.

1. Introduction

MELSECNET is a control network system that interconnects distributed controllers such as programmable controllers and personal computers. Using high-speed and high-capacity link devices, MELSECNET transmits and receives machine operation data between the distributed controllers in real time.

In the newer production lines for semiconductors, LCD devices, etc., machinery has become increasingly sophisticated and a growing volume of data is transmitted and received across the network for control, recipe and monitoring purposes. In addition, as the performance of machinery becomes more sophisticated, shorter communication response time is required. Such technical demands necessitate a network system that meets the users' needs such as a larger amount of communication data handled by the controller network and higher transmission rate.

In response, we have developed the controller network system MELSECNET/G as the next-generation MELSECNET, offering more link device points and a higher transmission rate. The combination of MELSECNET/G and controllers compatible with the integrated platform reduces tact time in the production line as well as raises communication performance.

2. Specifications of Communication

Table 1 shows the communication specifications of MELSECNET/G.

3. Features of MELSECNET/G

In addition to higher-speed and higher-capacity communication performance, controller network users also require that a system fault, e.g., station down and cable failure, does not lead to an overall system failure, and that prompt troubleshooting can be done in the event of such a fault. MELSECNET/G features the following functions that satisfy these requirements.

Table 1 Communication specifications

Item	Specification
Maximum link points per network	Link relay: 32 K bits Link register: 128 K words
Maximum link points per station	Link relay: 16 K bits Link register: 16 K words
Communication speed	1 Gbps
Connectable stations per network	120 stations
Connection cable	IEEE 802, 3Z (1000 BASE-SX) Optical fiber cable (multimode fiber cable)
Interstation distance	Up to 550 m
Maximum number of networks	239
Type of transmission line	Duplex loop
Transmission method	Token ring method
Synchronization system	Flag synchronization (Frame synchronization)
Encoding method	8B/10B
Packet format	Ethernet II
Error control method	HCS (CRC32 of header) DCS (CRC32 of data) FCS (Conforming to Ethernet)

3.1 Higher performance network system

Cyclic transmission serves as the base of MELSECNET, where data is periodically communicated between all stations on the network at a specific interval. Data communication using this function can be established only by setting the appropriate parameters, and thus system configuration is simple.

The cyclic transmission of MELSECNET/G allows the communication link points (number of data items) up to 32 K bits for the link relays (bit information) and 128 K words for the link registers (word information). Compared to MELSECNET/H, the number of link points is doubled for the link relays and eight times more for the link registers.

The data transmission rate crucially affects the users' main concern: improvement of tact time and production yield in their production line using a distributed control system. With the transmission rate of 1 Gbps by MELSECNET/G, assuming a system of 32 stations and each station transmits 2K-word link register data, the system delivers a 5 msec or shorter link scan time (the cycle time required for all stations to sequentially transmit data), some 14 times faster than that of MELSECNET/H.

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3.2 Highly reliable network system

MELSECNET/G provides a duplex transmission line through a loopback function using 2 core cables. As illustrated in Fig. 1, when the cable is connected only to the IN or OUT port, the loopback function performs both data reception and transmission from/to other stations at the port connected with the cable. This function isolates a faulty section due to cable breakage or a faulty station and continues to perform the cyclic transmission between normal stations.

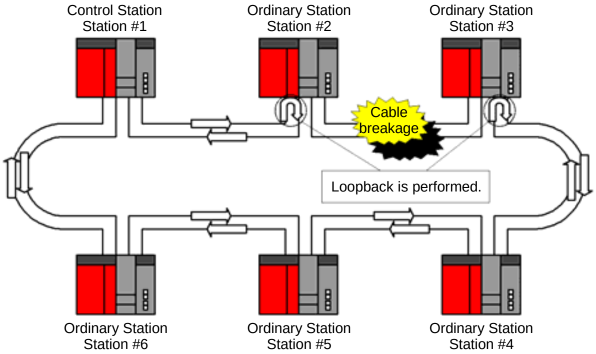

Fig. 1 Loopback function

3.3 Easy troubleshooting in the event of failure

3.3.1 Troubleshooting support in the event of cable failure

In the conventional network, if a faulty data frame caused by breakage of an optical fiber cable or failure of a communication connector, for example, is sent out to the network line, a transmission error is detected at all stations on the network (due to the increase in CRC errors and/or short frames), making it difficult to locate the failure and prolonging system recovery. In contrast, MELSECNET/G uses, in addition to the frame check sequence (FCS) conforming to Ethernet, a header check sequence (HCS) embedded in the frame header and a data check sequence (DCS) attached to the data, whereby the station that received the faulty frame can be identified. This function speeds up troubleshooting for cable failures and reduces maintenance time.

3.3.2 Troubleshooting support when installing cables

MELSECNET/G requires cable connections between the OUT port of other stations and its own IN port, and between its own OUT port and the IN port of other stations.

As shown in Fig. 2, when the cables are wired in the MELSECNET/G system, two stations at the end of the cables perform auto-negotiations for the connecting ports. If a faulty connection, either IN-IN or OUT-OUT, is detected, these stations do not join the network. This function avoids a delay in system setup caused by faulty wiring.

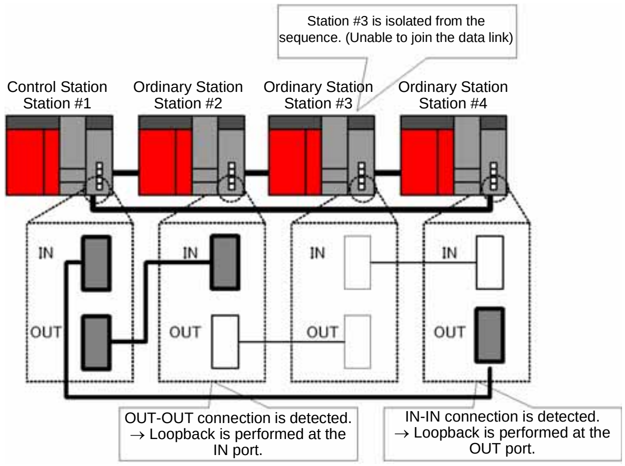

Fig. 2 Cable insertion error detection function

3.3.3 Convenient operability of network diagnostics

Conventional network diagnostics by GX Developer provides the operating conditions of all stations on the network as a bit sequence arranged in the order of station number. Therefore, in the event of a failure caused by cable breakage, etc., in order to determine the fault location it is necessary to determine the sequential order of all stations on the network using a system configuration diagram or the like. In contrast, MELSECNET/G collects the cable connection status for all stations when the network is being re-established and constructs the information on the sequential order of all stations on the network. As a result, as shown in Fig. 3, the network diagnostics of MELSECNET/G visibly indicates the sequential order and operating conditions of each station on the network. This function enables rapid troubleshooting of network failures and reduces maintenance time.

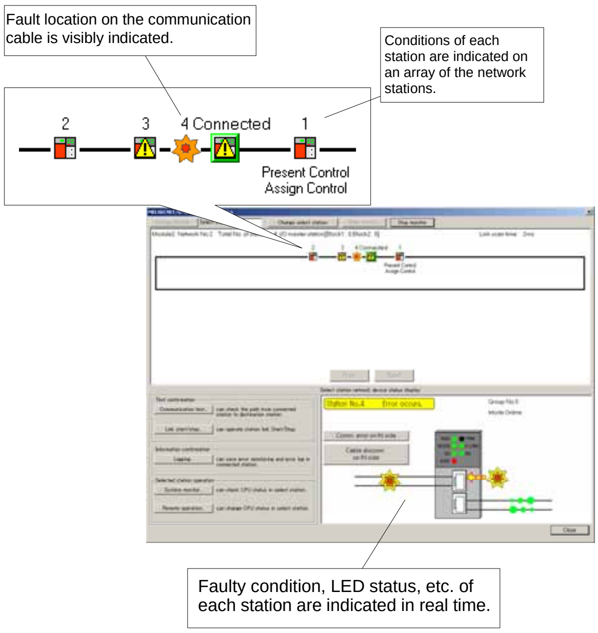

Fig. 3 MELSECNET/G network diagnosis

4. Summary

We have developed MELSECNET/G network products: MELSEC-Q compatible interface unit and personal computer interface board. We will continue to expand the lineup and functionality of MELSECNET/G network products.

References

(1) Masanori Kachi, Shigeru Yoshida: Network System of MELSEC-Q Series, Mitsubishi Electric Corporation Technical Reports, Vol. 74, No. 07 (2000)

MELSEC Process Control System

Author: *Yuji Ichioka**

1. Introduction

It has been about 30 years since the Distributed Control System (DCS) was first introduced in the process automation field, and most initial systems now need to be renewed. For customer projects related to system replacement or new construction, we receive increasingly urgent requests for downsizing and cost reduction. In response, we have developed component products and enhanced their functionalities for a process control system constructed on a platform based on the general-purpose programmable controller MELSEC-Q Series.

2. Key Products for MELSEC Process Automation

To realize a programmable controller-based full-scale process control system, we have developed the following key products: process CPUs, channel-isolated analog modules, programming and monitoring tools of PX Developer, and redundant systems.

The features of these products are introduced below.

3. Process CPU

The process CPU module is based on the high-performance programmable controller CPU of the MELSEC-Q Series and features 52 special instructions built in for process control. Some of these instructions are: basic PID (proportional, integral and differential) control, 2-degrees-of-freedom PID control, sample PI control, alarm detection, auto-tuning, and various correction operations. The process CPU is consequently able to perform both sequential control and loop control simultaneously. It can also execute PID control loops at about 400 µs/loop, achieving a fast control cycle of 10 ms.

4. Channel-Isolated Analog Module

For process automation, analog modules are frequently used for fluid and temperature control, etc. In the process control field, for the wiring to the sensors (flow meters, pressure gauges, etc.) and actuators (control valves, etc.), a channel fault caused by noise in the wire must not affect other channels. Also, measurement must not be disturbed if a potential difference arises between channels. To meet these requirements, we have developed channel-isolated analog modules for MELSEC process control.

The channel-isolated analog modules sufficiently offer useful functions for process automation such as analog input signal filters (first-order lag and average), wire-breaking detection, upper/lower-bound value output on being burned-out, tight-shut-off output, process alarm detection, and rate alarm detection.

5. Programming Tools of PX Developer

Programmable controllers generally use the LD (ladder diagram) programming language. However, for continuous processing of analog variable values such as the loop control, it is not easy to describe the algo-

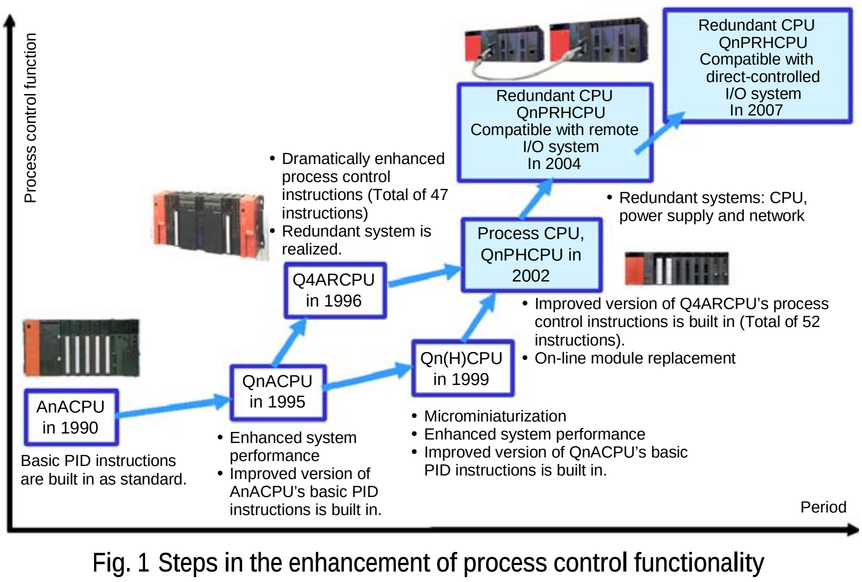

Fig. 1 Steps in the enhancement of process control functionality

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rithms using a ladder diagram. To help users describe the loop control, the MELSEC process control system adopts function block diagram (FBD) language conforming to the IEC 61131-3 standards. For even greater usability, the language specifications are partially extended to accept tag-based process control programming, which is used in process control engineering.

Various function blocks (FBs) are also provided as convenient programming tools, including an FB that encapsulates the special instructions built into the process CPU for process control, and a module FB that easily inputs or outputs external digital and analog signals. Simply by dragging and dropping these FBs to the sheet, wiring them, and setting parameters, programming can be easily accomplished for sophisticated process control algorithms comparable to those by conventional DCS (Fig. 2).

6. Monitoring Tools of PX Developer

For easy adjustment of the loop control parameters by comparing them to the response of the target system for process control (e.g., proportional, integral and differential parameters for PID control), the PX Developer is bundled with monitoring tools in addition to programming tools. The monitoring tools include standard screens (faceplates, tuning panels, control panels, trend graphs, alarm list and event list), which are frequently used for process control monitoring and operation. These tools allow users to immediately start adjusting the loop control for system startup.

7. Redundant System Configuration of MELSEC-Q Series

For continuous operation of the process control system even in the event of an unexpected failure, users often request redundancy of key system components, so we have provided a redundant system for MELSEC process control.

The redundant system for the MELSEC-Q Series is configured such that a CPU module (redundant CPU), a power supply module and a network communication module are attached to the two independent base units, and the two CPU modules are connected by tracking cables. The I/O system can be configured either in remote I/O or direct-controlled I/O configuration. The remote I/O configuration allows distributed arrangement using MELSECNET/H or CC-Link networking, while in the direct-controlled configuration, the I/O system is directly connected to the two redundant CPU modules by the internal data bus using a special extension base unit to provide high-speed response time (Fig. 3).

The redundant CPU modules are configured in the hot-standby style, where one of the two CPU modules performs control (control system), while the other remains in standby mode (standby system). If the control system is unable to continue operation due to failure of the CPU, power supply or network, the control is automatically switched to the standby system, which takes over and continues operation of the entire system. The two CPU modules continuously exchange data (data tracking) in preparation for system switching. The data tracking achieves a high data transfer rate of 22 ms/100K words, which allows for operation using a high-speed and large-scale control system.

We are developing products for the MELSEC process control system to realize sophisticated programmable controller-based process control systems. Leveraging our know-how acquired through the experience of factory automation, we strive for higher functionality and performance as well as providing “easy-to-use” products for the process control field.

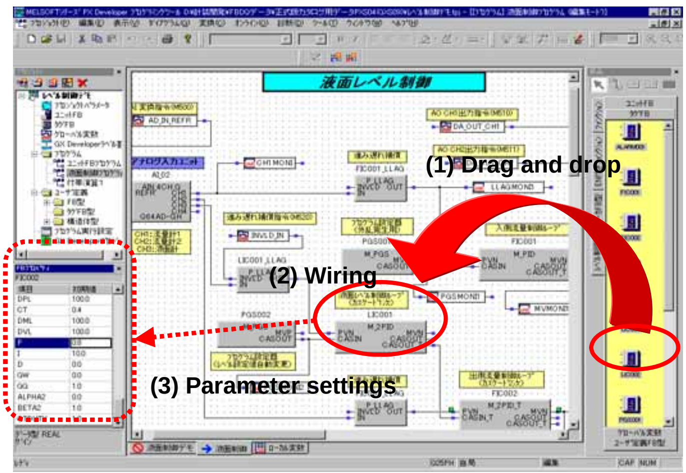

Fig. 2 Example of the operation of PX Developer programming tools

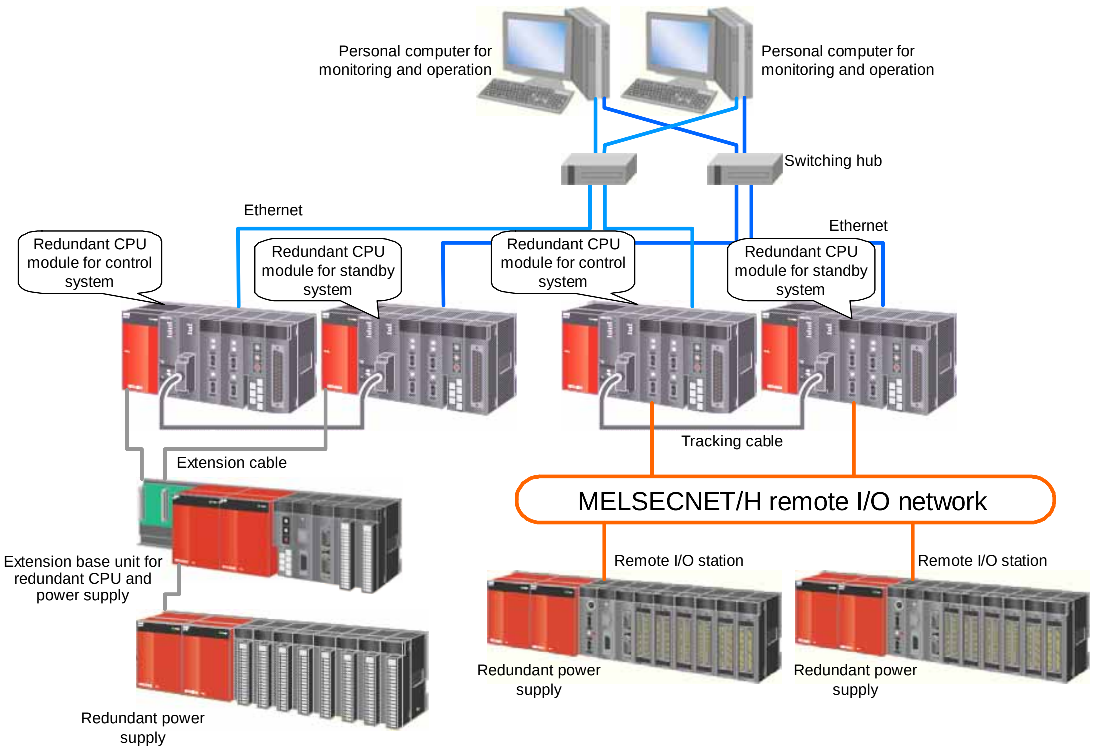

Fig. 3 Redundant systems for CPU, power supply and networking

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