New Generation Integrated Control System MICREX-IX

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1. Introduction

In recent years, there have been intense demands for "downsizing" and "open systems" in the field of information processing. Formerly located in a special room computers are now placed on or next to workers' desks. In the field of process control, plant modernization has been rapidly taking place.

One of the key technologies for the control system is EIC: integration for electrical control (E), instrumentation (I), and computers (C).

Fuji Electric was the first to put on the market the EIC integrated control system DCS (Distributed Control System) "MICREX" (**Fig. 1**). Introduced into many plants as well as equipment, it has helped users support the industry.

To match recent market innovations, the company in October 1992 began selling the fourth-generation "integrated control system MICREX-IX"*1 in which past experiences and up-to-date technologies are concentrated. This paper outlines this system.

2. Development Philosophy

Since 1987, the basic concept of MICREX has been EIC integration, succession of architectural property usable over the long term, and system development. MICREX-IX has already exceeded this basic development philosophy.

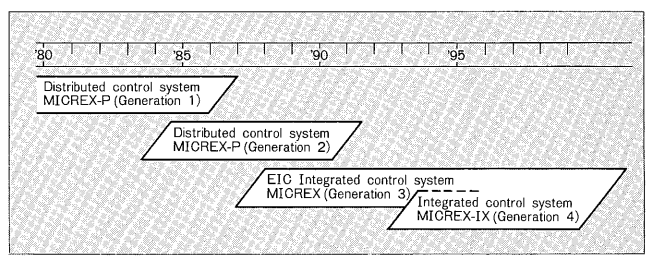
(1) Enhancement of EIC integration

An electrical and an instrumentation controller were combined, thereby developing an EI integrated control station capable of controlling both electrical (E) and instrumentation (I) systems.

(2) System development and succession

Like the former MICREX, MULTIBUS II*2 is used to update hardware. The high-speed dataway DPCS-F of 10M bits/s is replaced, taking into consideration its connection with conventional systems. The Functional Control Language FCL used in control stations replaces past software.

Fig. 1 Changes in MICREX systems



(3) Pursuit of facilitated operation

Hardware including resolution, display color, and display functions of operator stations has been improved, along with such functions as a touchscreen, windows, plant panels and operation support functions.

(4) Closer linking with computers

A "computer linking function" is installed in operator and database stations; thus, familiarity with the computer has been increased and single windows have been reinforced.

(5) Improvement in engineering

Fuji Electric has developed the software support system FPROCES (Fuji Programmable Controller and Process Controller Engineering Support System) which integrates tools for software design, drawing, testing, and maintenance. FPROCES operates on a personal computer installed with MS-DOS*3 and MS-Windows*4, allowing for comfortable engineering in a unified work environment using windows, icons, and a mouse.

Work efficiency is improved by the use of a multi-window environment, which can display two or more windows at the same time.

(6) Compatibility with field buses

System architecture adaptable to field buses under present IEC standardization is adopted. In the network configuration of process input-output (PIO) for a control station, future development is taken into consideration. The system can also be connected to the optical fiber field instrumentation system FFI, which has a long track record.

*1: The IX of MICREX-IX stands for integrated and extended control systems for the next generation.

*2: MULTIBUS is a registered trademark of Intel Corp.

*3: MS-DOS is a registered trademark of Microsoft Corp.

*4: MS-Windows is a registered trademark of Microsoft Corp.

(7) Use of AI (artificial intelligence) and fuzzy technology

The operator receives powerful support through a link with a computer installed with AI software. The control station can be equipped with fuzzy software in order execute advanced fuzzy control.

(8) Rationalization of maintenance

The diagnosis and maintenance of intelligent transmitters "FCX" (field instruments) and the "optical fiber field instrumentation system FFI" is possible at the operator station or the integrated engineering workstation.

3. System Configuration

MICREX-IX consists of an Integrated Operator Station IOS-2500, an Integrated Database Station IDS-2500, and an EI Integrated Control Station ICS-2500, all connected by the dataway DPCS-F (**Fig. 2**).

In addition, there is an Integrated Engineering Workstation IES-2500 which serves as a software support system.

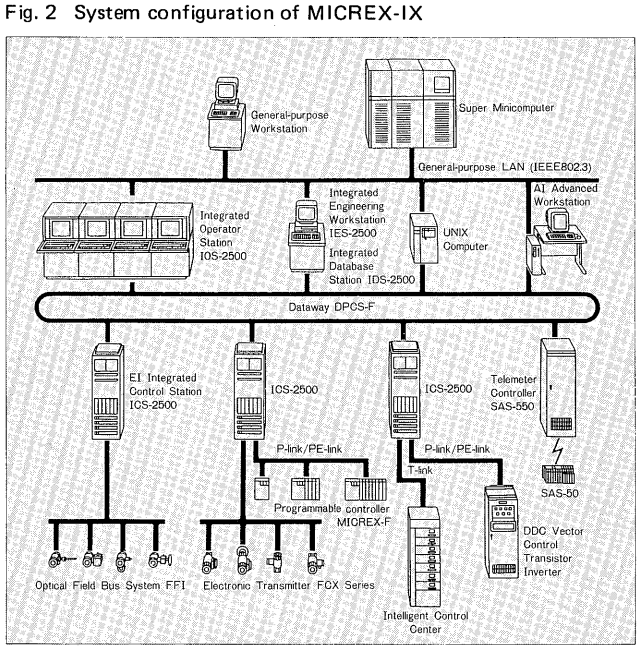
DPCS-F is a high-speed LAN of 10M bits/s for control and compatibility with former MICREX systems.

IEEE802.3 can be connected to IOS-2500 and IDS-2500. This LAN is Ethernet*5, which links computers, workstations, and personal computers.

Adequate types of computers are lined up for the system. DS/90 7000 series is a server and workstation that realizes open, distributed computing with standard UNIX*6/SVR4 and RISC processor "SPARC"*7 or "Super SPARC."*8

*5: Ethernet is a registered trademark of Xerox Corp.
*6: The UNIX operating system is developed and licensed by UNIX System Laboratories, Inc.
*7: SPARC is a trademark of SPARC International.

Fig. 2 System configuration of MICREX-IX



AI-AWS is an advanced AI workstation installed with fuzzy control and various AI packages for real-time, on-line control.

Two kinds of processor links, P-link and PE-link, with a transmission speed of 5M bits/s can be connected to the ICS-2500. With these processor links, ICS-2500 stations can be connected to each other, thus controlling lower level systems.

In addition, ICS-2500 can be connected with a motor drive for electrical control, an intelligent control center, a programmable logic controller, or various FA components.

A connection between the optical Fiber Field Instrumentation system FFI and ICS-2500 results in a superior instrumentation system for an hazardous zone, a location with a high level of noise, or an area frequently hit by lightning.

4. Human Interface

4.1 Hardware

The Integrated Operator Station IOS-2500 (**Fig. 3**) is an interface with a comfortable operational environment based on human engineering.

With a CRT resolution of 1,120 x 750 dots, high resolution pictures can be displayed. A large picture made up of 2,048 x 1,024 dots can be drawn up and displayed by scrolling.

IOS-2500 is provided with special operator console desk on which a 21-inch CRT is installed with an infrared touch screen, a flat dustproof keyboard, and an IOS control unit.

The desk is small, 600mm in width and 1,150mm in height, so that the operator can view the conventional graphic panel, the large display and the site itself.

Up to four CRTs can be connected to one IOS-2500 station, and 32 CRTs can be used by in the whole system.

In addition, a remote CRT arrangement and an external large display connection can be used to set a CRT apart from the IOS control unit. At most, one color hard

*8: Super SPARC is a trademark licensed to Texas Instruments by SPARC International.

Fig. 3 Integrated Operator Station IOS-2500

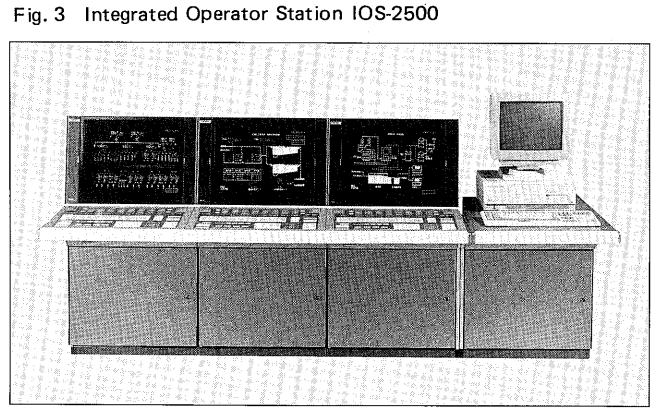


Fig. 4 Windows in a plant panel of IOS-2500

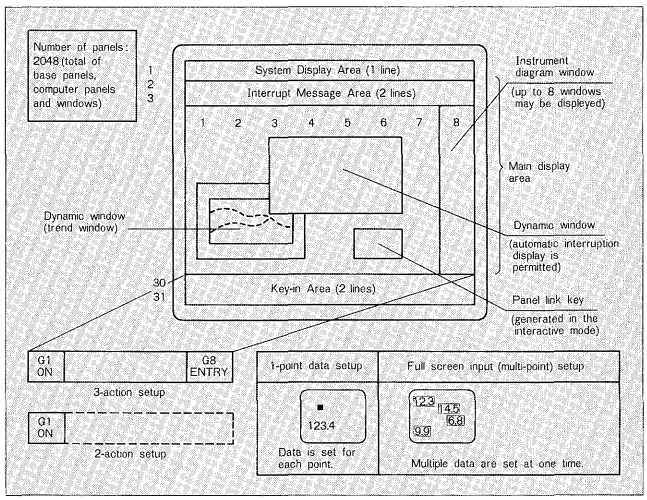
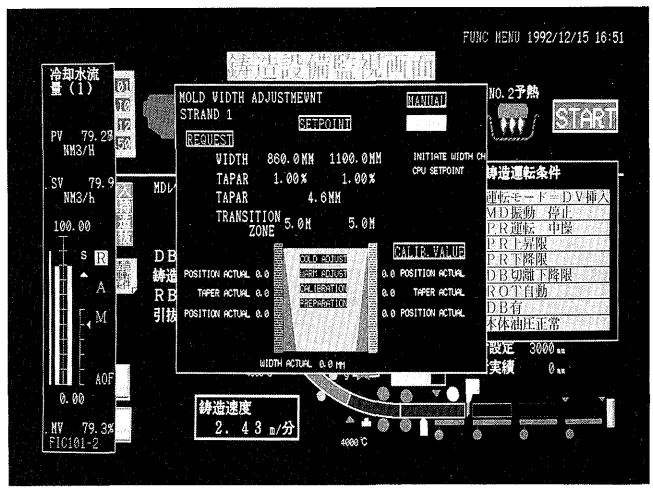


Fig. 5 Example of a dynamic window



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copy unit can be connected to 16 CRTs.

4.2 Operating functions

IOS-2500 has "service" functions to handle various kinds of plant information such as operation monitoring and logging, maintenance, and linking with production planning and other divisions.

(1) Multiwindow function

IOS-2500 can display various kinds of information on the screen, called a "panel," and can perform changes in setting and device operations. A multiwindow function (**Fig. 4**) is installed to provide other information that can be superimposed on the screen. This multiwindow function enables effective use of the limited CRT display area, providing the operator with necessary information.

(2) Touch operation

The touch operation of the IOS-2500 utilizes a field tested and highly reliable "EXIT mode," a system which responds when a finger no longer touches the screen. With this system, even when the screen is mistakenly touched or a wrong operation is selected, re-selection or cancellation is possible by moving the finger to a "safety" zone and then taking it off the screen.

(3) System display area

The first line of the screen acts as a control panel that gives a rough status of the control system and process, and then calls up a required screen or window. This area collectively displays in words various information, such as the status of MICREX-IX alarms, etc. By touching a specific subject, a related panel or window can be called to the screen.

(4) Interruption message area

IOS-2500 has an automatic interruption that displays alarm and "event" message on the second and third lines of the CRT screen. This informs the operator of the status of the alarms, etc. without changing the screen.

(5) Plant panel

This is a user graphic display that plays a most active part in plant monitoring and operation. Up to 1,024 displays can be used in the system.

The plant panel displays data from the EI integrated control station and computers, and can be used for setting up data and device operation.

One screen of the plant panel can display up to 1,024 characters of display data and setting up data, 32 of which can be display in a high-speed "refresh" mode.

Items for setting up the data and device operation can all be selected by touch.

(6) Dynamic window

A dynamic window (**Fig. 5**) is a user window with the same function as a plant panel, and two windows can be superimposed on a plant panel at once.

If trends, device operation guides, process particulars, etc. are prepared as dynamic windows, various kinds of information can be made available.

(7) Instrument diagram window

This window displays the status of "internal instruments" for the instrumentation control function of the EI integrated control station, allowing modes and set points to be changed as well as adjusting output. In the instrument diagram, two kinds of warning tags, "caution" and "operation inhibited" can be installed.

4.3 Database function

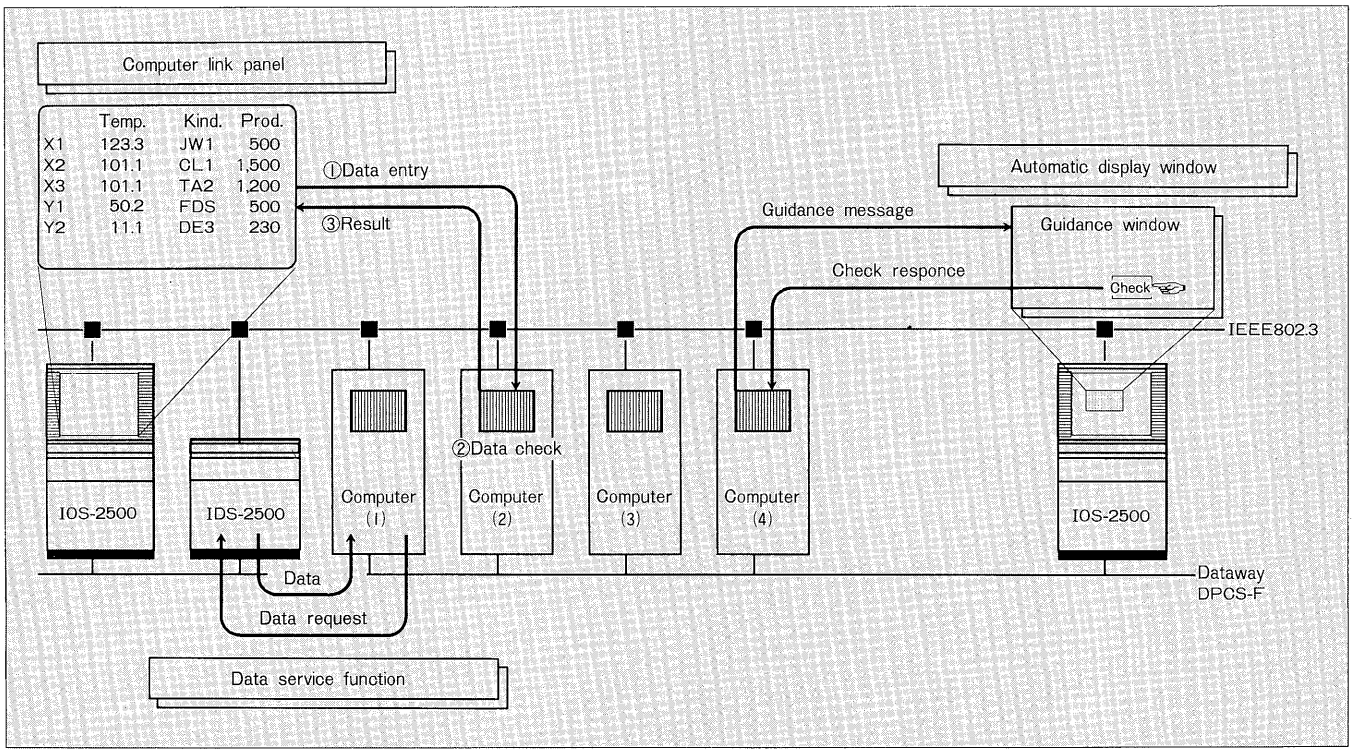
The Integrated Database Station IDS-2500, which controls the database for the entire MICREX-IX, manages various historical data, alarms, the time, and programs.

From all stations along DPCS-F, IDS-2500 receives RAS and alarm information, trend and reporting data, information on change in data setting at the operator station, and information on plant equipment and device operation, storing necessary information on the hard disk. This information can be sent to another station on request.

On detecting any alarm or message, IDS-2500 informs the Integrated Operator Station IOS-2500.

Since IDS-2500 records historical information according to the system clock, all information is adjusted according to the time.

Fig. 6 Computer linkage function



5. Computer Linkage Function

In order to reinforce its link with the computers, MICREX-IX is now provided with a "computer linkage function" (**Fig. 6**).

5.1 Guidance window

Various messages such as "caution" or "lack of instruction" are sent to the operator from the computers through an automatic window superimposed on the Integrated Operator Station IOS-2500 screen.

5.2 Computer link panel

Updating data display, checking input data, etc. are all executed by computers, with the IOS-2500 computer link panel acting as a terminal.

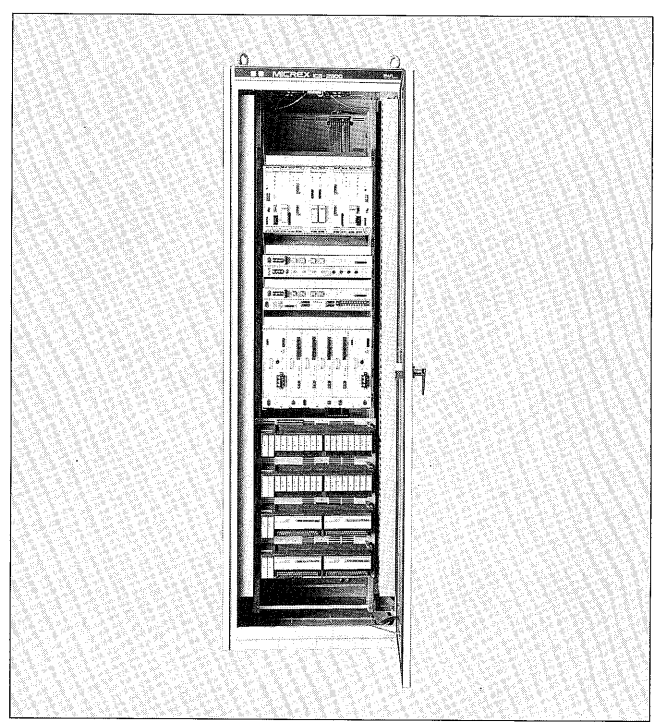
5.3 Data service function

This function provides process and historical data, such as trends and reporting data, collected by the Integrated Database Station IDS-2500 upon request by a computer.

When computers write their alarm and operation log information into the IDS-2500 file in accordance with the MICREX-IX data format, alarms and operation logs can be brought under centralized management.

Further, with a computerized production schedule, it is possible to send "recipe parameters" and setting data to controllers as well as to execute computer-aided, advanced or AI control.

Fig. 7 EI Integrated Control Station ICS-2500



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6. EI Integrated Control Station

6.1 Hardware

The hardware of the EI Integrated Control Station ICS-2500 (**Figs. 7** and **8**) is installed in a cabinet. It has

Fig. 8 Typical system configuration of ICS-2500

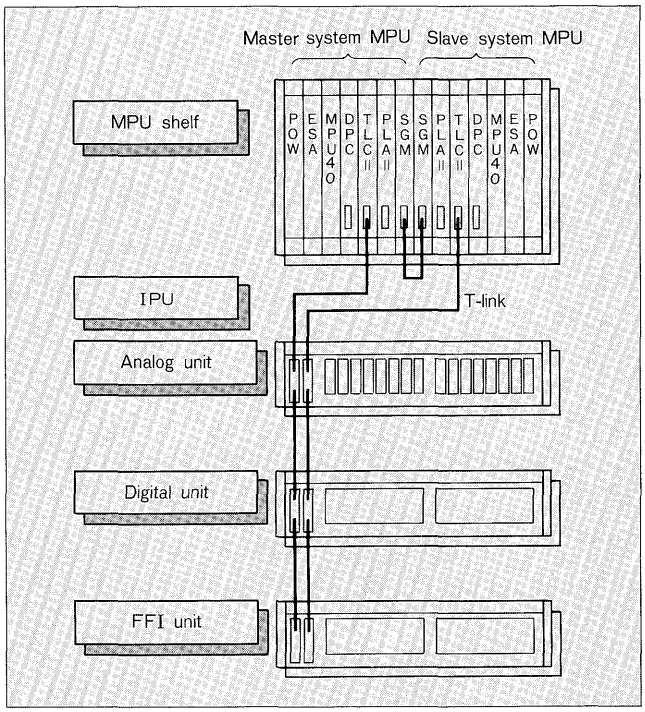

Fig. 9 Analog IPU

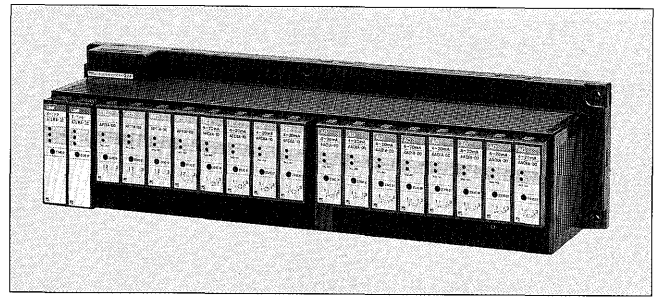

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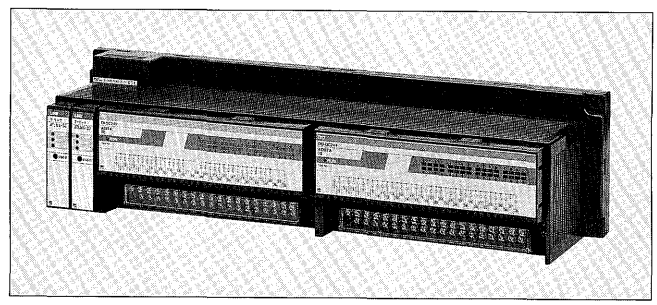
Fig. 10 Digital IPU



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a one-shelf, double construction and uses a new type of PIO capable of direct digital transmission with the converter, resulting in a simple, compact hardware construction as compared with former controllers.

Adoption of a new, high-performance "front power supply" enables elimination of "supply current waveform distortion", rush current suppression, two-system or double power supply, and parallel multiplex operation.

(1) MPU (Microprocessor Unit) shelf

Basic parts such as MPU and momory boards as well as transmission boards are installed on the MPU shelf.

Formerly, doubled MPU required a two-shelf space; however, high density mounting technology has reduced the number of boards, and a doubling of space on one shelf has been made possible.

A high-speed, high performance, 32-bit processor that can execute sequential instructions at a minimum of 0.125 μs is used for the MPU.

The duplication system uses a "warm standby system," whereby, the basic parts of the master and slave systems independently execute processing. The processing result of the basic part of the master system and the input-output data of the PIO are always transmitted to the basic part of the slave system through SGM boards provided with a data equalizing function for duplication; thus, both systems are kept up to date.

(2) Processing Input-Output Unit (PIO)

ICS-2500, when used as an electrical (E) control station, is equipped with a high-speed PIO on a 19- or 24-inch MPU shelf, executing line control, high-speed positioning control, and motor control.

ICS-2500 can also have a remote PIO configuration connected with a 500 kbits/s terminal link "T-link." Usually, an electric cable is used for a T-link; however, in a place with a high level of noise, immunity can be improve by using an optical fiber cable passed through an optic adapter.

An intelligent, distributed PIO "IPU" (Intelligent Process Input-Output Unit) connected through a T-link has been developed for use by the ICS-2500.

The IPU has a unified, compact, and simple construction that can be efficiently installed in a cabinet as well as in field panels or equipment. A T-link transmission line connected to a duplex MPU can be doubled.

The IPU consists of modules corresponding to converters or relay terminals and units mounted with modules. The modules include analog (**Fig. 9**), digital (**Fig. 10**), and FFI modules.

The analog module is constructed of a former signal converter and an AI or AO board, with one module handling one terminal of analog input or output signals. An analog unit can mount up to 16 terminals for inputs and outputs combined. Because an AI or AO board is eliminated and the MPU can directly execute digital transmission with the converter, conversion error has decreased in comparison with the former PIO and size has reduced to approximately 60% of the former size.

The analog module has a "software-free range", so that it can flexibly handle an on-site change in the thermocouple signal range and resistance thermometer signals.

In addition, pulse input and pulse output are available.

The digital module is constructed of a former DI or DO board, input-output circuits of a relay or transistor, and external connection terminals. A digital unit can mount two modules for a combined input and output, with each module having 32 or 16 terminals.

Fig. 11 Hierarchical structure of ICS-2500 software

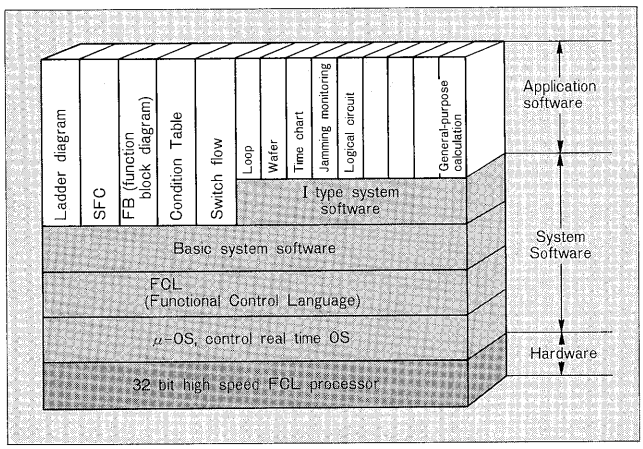
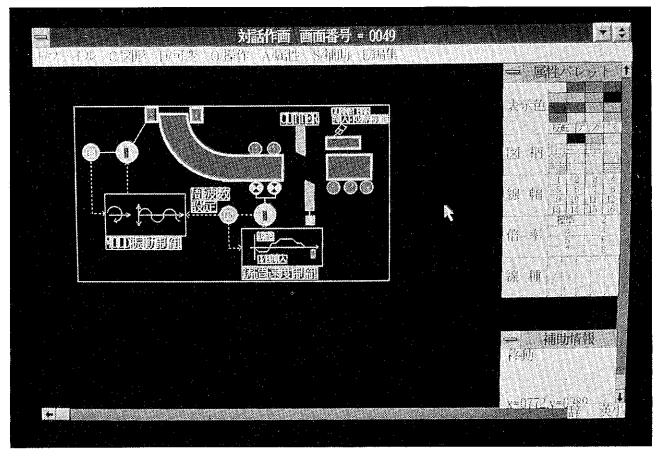


Fig. 12 Example of interactive graphic generation



The FFI module is an interface for the optical fiber field instrumentation system FFI, and the FFI unit can mount two modules. The FFI module can be duplicated to meet the duplication of optical fiber cables in the FFI system.

6.2 EI control function

In ICS-2500, a performance ratio of E-control and I-control processors can be freely set due to EI "free generation."

Further, ladder circuits for electrical control and internal instruments for instrumentation control can be operated in synchronization, enhancing control.

Using the Functional Control Language FCL as its control language, ICS-2500 can describe various programs such as a ladder diagram, a FB diagram, and an SFC. System software, I-type system software to realize instrumentation control software, and various software packages are all described with FCL (**Fig. 11**).

When the I-type system software is installed, ICS-2500 serves as an "EI free type" or an "I type." In this case, an I-control function is comprised of a "time chart sequence", internal instruments for loop control functions, annunciators, analog upper/lower setters, switches, jamming monitoring, logical calculation, transfer, and counters.

When the I-type system software is not installed, ICS-2500 serves as an "E-type;" that is, a high-speed programmable controller (PLC) for electrical control.

7. Engineering Function

7.1 Outline of FPROCES

Engineering with MICREX-IX is performed on a personal computer having the integrated engineering support software FPROCES installed. This personal computer installed with FPROCES is referred to as the "Integrated Engineering Workstation IES-2500."

FPROCES runs in both the MS-DOS and MS-Windows environments. IBM-PC is used for English word processing.

FPROCES is classified by its functions; for example, "FPROCES-C" supports control functions and "FPROCES-M" supports operator station definitions as well as screen and logging definitions.

In addition, FPROCES is an integrated support tool that can perform diagnosis of the EI Integrated Control Station ICS-2500 and remote maintenance of intelligent PIO (IPU) and intelligent field instruments FFI and FCX.

7.2 Operator station support system (FPROCES-M)

Using FPROCES-M, "standard panel generation," which includes MICREX-IX system configuration and functions, tag allocation and alarm definitions, various screen layouts, and "plant panel generation" for the user's own graphic screens, can all be performed (**Fig. 12**).

Standard panel generation is simplified by adopting a Fill-In-The-Form (FIF) system for input of tag number, service comments and entries of definition items.

Plant panel generation features a CAD image graphic generating function using a mouse. It has various functions, including moving, copying, and updating graphs. Moreover, a generated plant panel can be displayed on the IES-2500 with a simulating function and checked for correct operation.

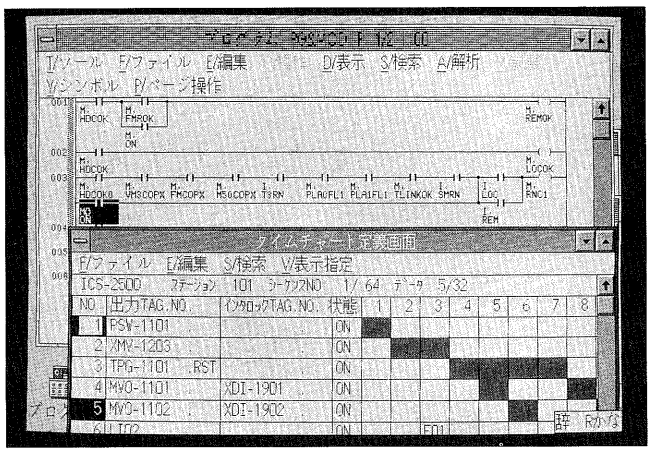
7.3 Control station support system (FPROCES-C)

Design work to be done first with FPROCES-C is selection of one type of EI Integrated Control Station ICS-2500; that is, to select an "E-type" for electrical control, an "I-type" for instrumentation control, or an "EI free type" for both electrical and instrumentation control.

In particular, the "EI free type" enables "EI free generation," which optimizes the load of the control station MPU through the definition of "application program grouping" and operation timing.

FPROCES-C can support programming languages for ladder diagrams, FB diagrams, SFC, decision tables, loop diagrams, and "time chart sequence" corresponding to the issuing control station (**Fig. 13**). It is possible to properly use programming languages in order to meet controlled contents and suit the user's taste.

Fig. 13 Example of FPROCES-C display



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7.4 Application of AI

Because MICREX-IX has a more advanced link with computers, various developments are made possible. These developments include an "AI Advanced Workstation AI-AWS" with an installed AI package and a high-grade operation support system which is linked with a computer.

Intelligent alarms and fault diagnosis predict failure, "AI guidance" is linked with fault prediction and fault diagnosis, and "AI scheduling" directs production plans timely and flexibly.

Such information is automatically displayed by AI windows to the operator and gives precise operation support. As a reduction in labor and improvement in operating efficiency has been recently demanded, systems installed with AI functions will be the operator's powerful partner, or "AI navigator."

8. Conclusion

In addition to security management and operation monitoring with the use of CRTs and grouping controlled equipment, MICREX-IX operator stations operate and maintain a control system which grows larger and more complicated every day.

"Remote maintenance," which provides fault analysis and preventive diagnosis to a MICREX system through a public circuit, is undergoing field tests and is expected to start service shortly.

Many orders for the MICREX-IX systems have been placed, and delivery started in April 1993.

From now on, keeping "system integration, evolution and succession" in mind, we will undertake the integration of conventional systems, combination of information systems, utilization of high-grade AI functions, and preparation of solutions for each field.

With the help and encouragement of our users, we will strive for the development of control systems as we approach the 21st century.