UDC 621.316.7

DISTRIBUTED DIGITAL PROCESS CONTROL SYSTEMS –DEVELOPMENT OF MICREX-P/FFI SYSTEM–

Nobuhiko Ando
Yasushi Morioka
Hiroshi Matsuka
Ken Kakizakai

1 INTRODUCTION

In recent industrial fields, distributed control systems have been extensively introduced. Presently process control systems are usually planned keeping in mind the distributed control conception. Demand for distributed control systems of higher function, higher performance, and higher reliability has been increasing.

In 1975 Fuji Electric developed and put on the market MICREX-P (16 loops) and MICREX-W (32 loops) as CRT-operation-oriented rack-mounted multi-loop distributed DDC systems. Since 1979 Fuji Electric has offered Programmable Compact Controller F (CC-F) and Compact Controller E (CC-E) as a panel-mounted single-loop digital controller and a function-selective controller, respectively.

In 1983 the MICREX-P system was greatly upped in function level: the loop controller part was ultimately distributed to single loops, and the CRT operation was diversified into small-scale to large-scale series. In 1985 Fuji Electric published Optical Fiber Field Instrumentation System (FFI System) in combination with the MICREX-P.

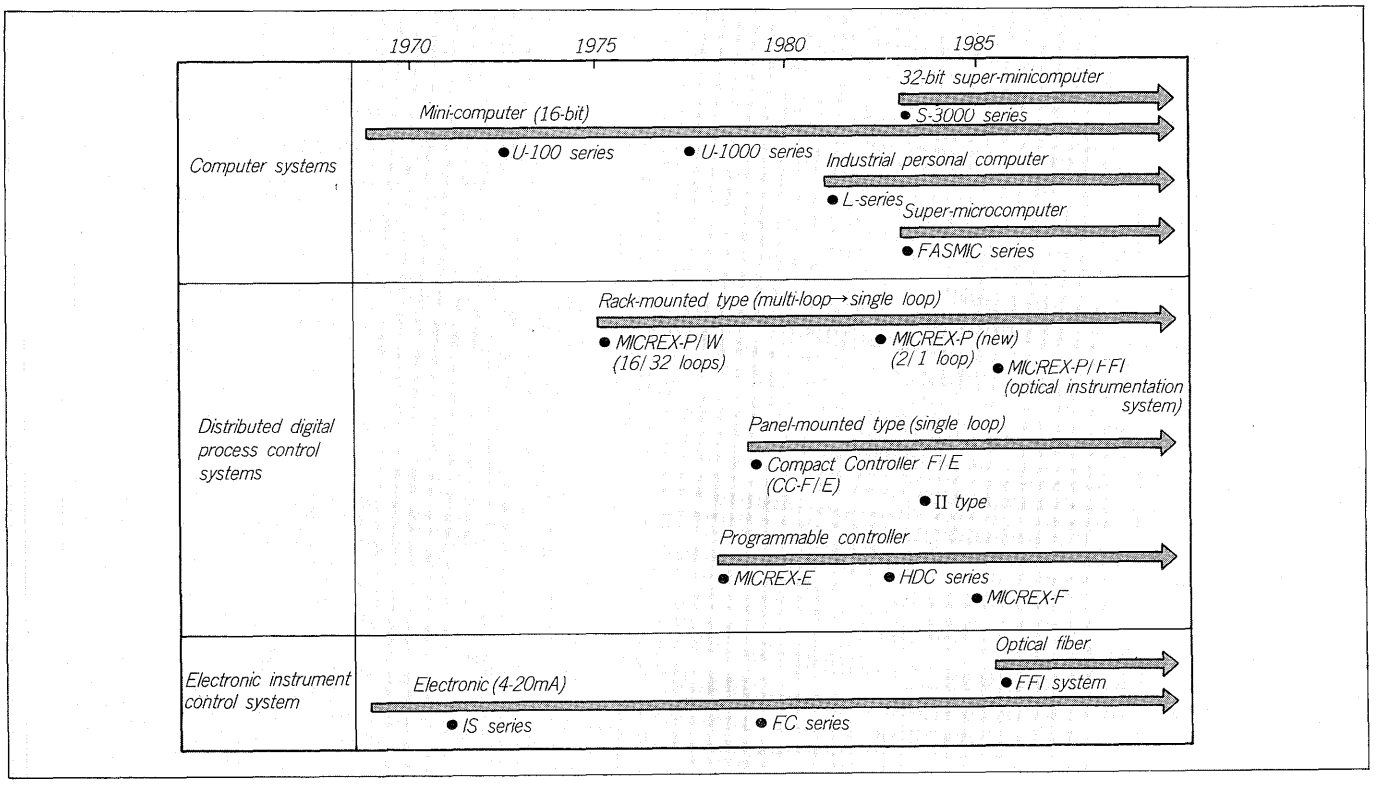
Fig. 1 shows the development of Fuji Electric's process control systems.

2 DEVELOPMENT OF MICREX-P

The MICREX-P system consists of:

(1) 'Process Station PSC-100' furnished with a number of control functions realizing the single-loop ultimate risk distribution;

Fig. 1 Development of process control systems



(2) Man-machine interface 'CRT Operator Station OCS-1100/200/150'-large/medium/small scaleemploying colorful graphic CRT;
(3) Looped high-speed high-reliability 'Micro Dataway DPCS-E' connecting the process station and the interface.

The MICREX-P system has been developed with the state-of-the-art technology as described below:

(a) 'CRT Operator Station OCS-100-Series' for supervising and operating medium/small scale processes has been diversified.
The OCS-150-a 14-inch color graphics small console with easy-to-use interactive plotting functions and report printing functions-and the OCS-200-a 20-inch desk-top compact unit for medium-scale operation-have been added to the OCS-100 series. The operator station can be diversified by employing these units.

(b) 'FFI System', which is an optical-fiber field instrumentation system, has been furnished with supervision/operation, control, and maintenance supporting functions.
The 'FFI System' is now capable of remote maintenance, including detection of field instrument abnormality, checking of connections between instruments and controllers, checking of field instrument specifications, and setting/revision of instrument parameters. The MICREX-P/FFI System has been thus developed as a totally rationalized system including field instruments.

Fig. 2 shows the system structure of the MICREX-P. Out of the recently developed or improved systems, we would like to introduce below the OCS-150 for a small-scale system, the OCS-200 for a medium-scale system, and the MICREX-P/FFI, which is an optical fiber instrumentation system realized by combining the MICREX-P and the FFI system.

3 CRT OPERATOR STATION: OCS-150/200

The OCS-150 and the OCS-200 are user-friendly units, developed on the basis of the complete standard operating functions of the OCS-100 and additional 'Free-line' functions. The 'Free-line' interactive plotting functions permit the operator to plot plant flow diagrams easily and freely by operating the keyboard, watching the CRT display, without knowledge of a special programming language such as the BASIC. The trend panel is furnished with smooth scrolling functions and digitally indicates trend values and time values. With the report printing functions, the trend panel can output hourly, daily, monthly reports. With the alarm/operation printing function, the panel also outputs abnormality information at hardware trouble, and records of setup and operations performed by the operator.

The OCS-200 is a model upper than the OCS-150. The OCS-200, though it is of desk-top type, is equipped with an easy-to-see 20-inch CRT. With a 10 M-byte hard disc built

Fig. 2 MICREX-P system structure

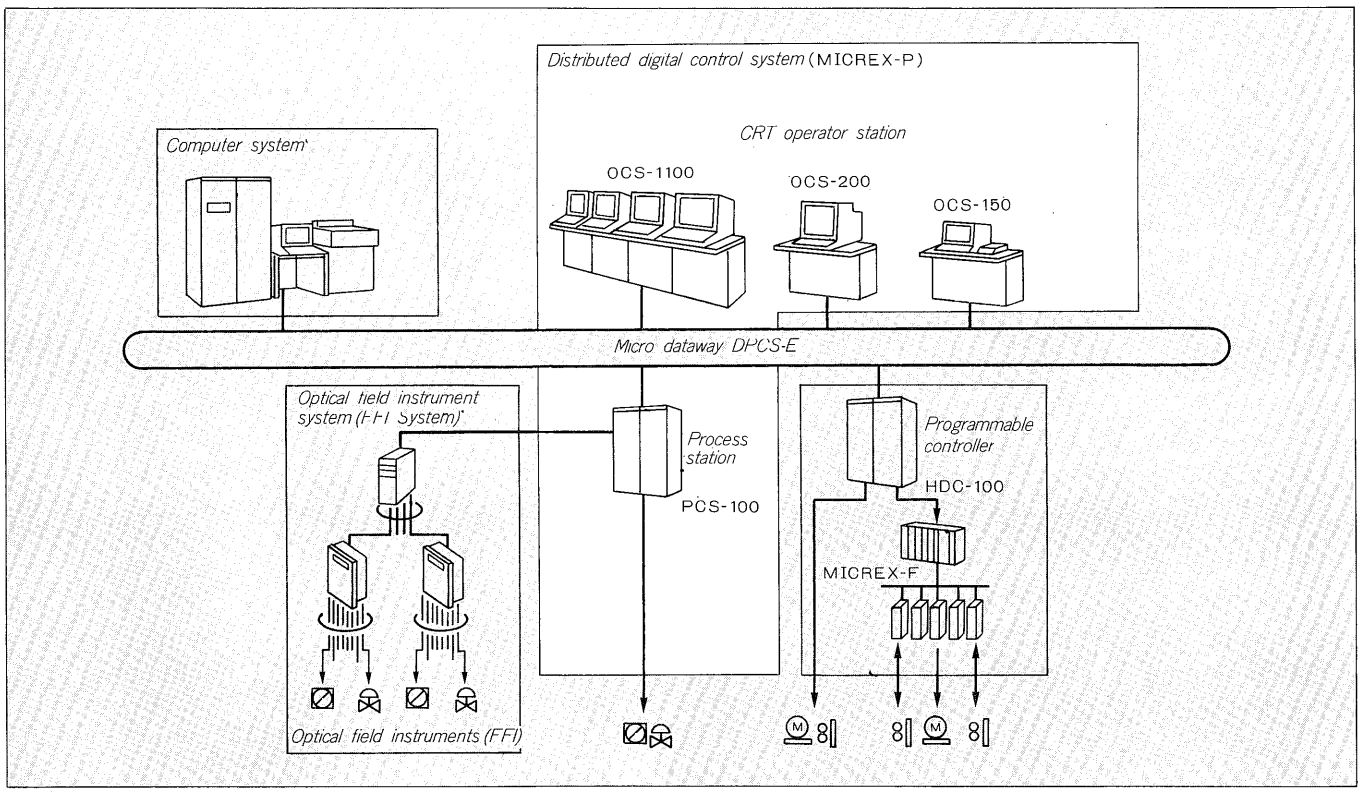


Fig. 3 Rubber-band functions at OCS-200 Free-line

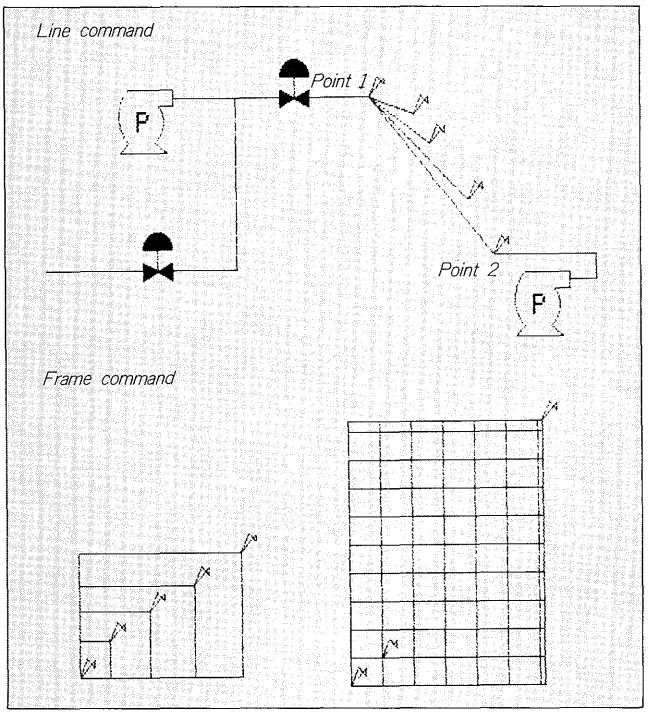
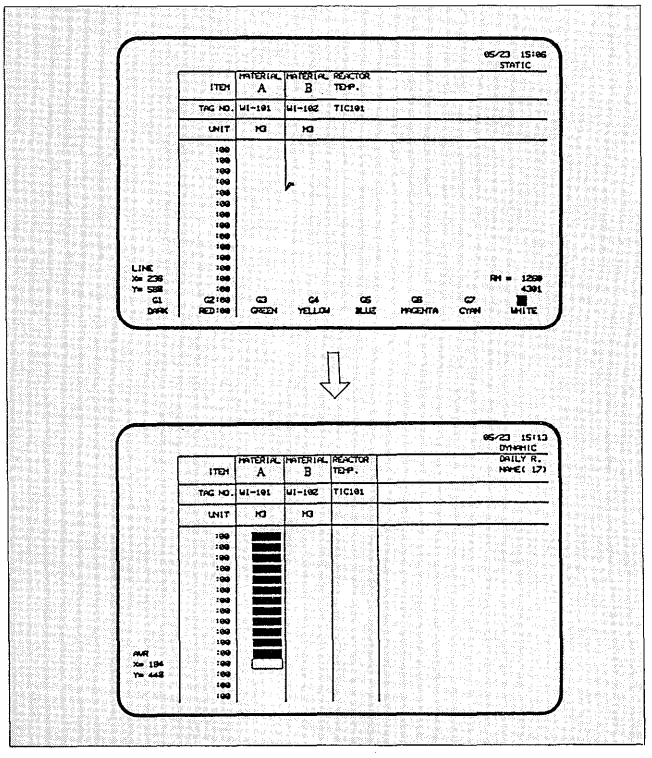


Fig. 4 Format tabulating function at OCS-200 'Free-log'

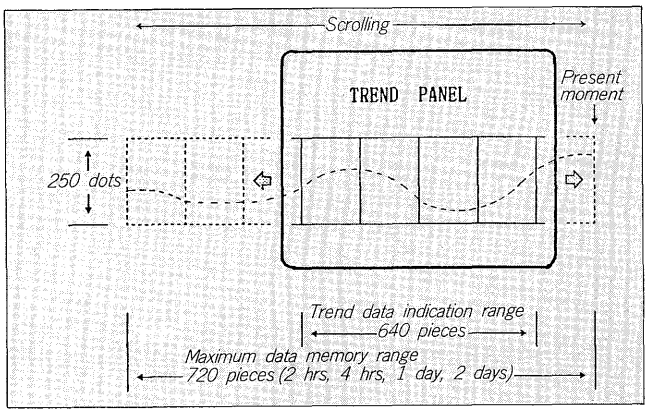


in, the OCS-200 has the following functions:

(1) Kanji display (JIS 1st level) on individual panel for standard operation;

(2) Interactive plotting with the bar band functions, which is efficient for plotting squares;

Fig. 5 OCS-150/200 trend panel with smooth scrolling



(3) 'Free-log' function, permitting report printing in free formats, and connection of two kanji printers.

Fig. 3, *Fig. 4* and *Fig. 5* show part of particular functions of the OCS-150/200, an example of the format tabulation with the 'Free-log', and an example of the trend panel with smooth scrolling. *Table 1* compares the functions.

4 MICREX-P/FFI SYSTEM

4.1 Summary

The 'FFI system' is a state-of-art instrumentation system developed by Fuji Electric. This field instrumentation system, employing most advanced sensor technology and optical fiber digital system for field instrument intelligence and data transmission, has realized high accuracy, high reliability, and automated maintenance. Published on newspapers in September 1985 and exhibited in the '85 JEMIMA, the 'FFI' has been sttracting attention and inquiries from domestic and overseas clients.

As process sensors, Fuji Electric has already offered successfully to world clients electrostatic capacity type 'Electronic Transmitter FC Series' employing a special technique called 'floating cell'. On the basis of the technology of such field instruments as sensors and actuators, the 'FFI' has been developed as a third-generation instrumentation system, of optical fiber type, to succeed the pneumatic and the electronic (DC 4-20mA) systems. Thus, the today's technical renovation with the digital instrumentation, which was applied mainly to the control room instruments, has been extended to the field instruments and further improved.

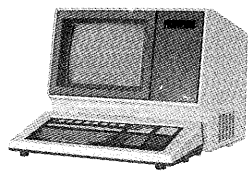
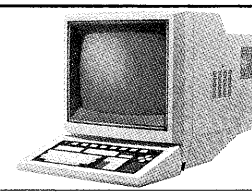
The main technical features are:

(1) Improved functions, accuracy, and remote mainteance with intelligent sensors using a microprocessor;

(2) Anti-explosion and noise resistance, and compatibility with a digital instrumentation system because of the digital transmission through optical fibers.

The sensors are low-powered, driven with built-in lithium batteries, and connected with one-line optical fibers. For transmission with the central station, eight field instruments are multiplexed into a pair of fibers through an

Table 1 OCS-150/200 function comparison table

		OCS-150	OCS-200
External view			
Basic portion	Structure	Desk top	
	CPU	16 bit microprocessor	
	Main memory	768 k byte	
	Auxiliary memory	Floppy disc (1M byte x 2)	Floppy disc (1M byte) Hard disc (10M byte)
CRT display portion	Monitor	14 inch	20 inch
	Display color	8 colors (red, green, blue, yellow, cyanic, magenta, white, and black)	
	No. of displayed characters	Maximum 2,000 characters (80 places x 25 lines)	
	Kinds of characters	250 (figures, latin, kana, kana symbols), Kanji (JIS 1st level)	
	Character cells	7 x 9 dots (one character 8 x 10 dot matrix)	
	Graphics resolution	640 x 400 dots	
	Display functions	Character display, graphic display (overlap display)	
Keyboard		Desk top, flat-type dust proof, for both operation and engineering	
No. of lines		DPCS-E 1 line	
No. of loops		384 points (supervision/operation with instrumentation diagram display) + 512 points (figure indication and setting)	384 points (supervision/operation with instrumentation diagram display) +2,048 points (figure indication and setting)
No. of points of condition change display		–	2,048 points (excluding module alarm)
No. of trend points		64 points	
No. of logging points		70 points	128 points
No. of connected stations		Max. 8 sets (PCS100, HDC100)	Max. 16 sets (PCS100, HDC100, SAS100)
No. of connected printers		1 set (alarm/operation printing, report printing)	Max. 2 sets (alarm/operation printing, report printing)
No. of connected hard copies		1 set (monochromatic)	1 set (monochromatic) + 1set (color)

optical star coupler so as to minimize cable work. In the central master station there are four optical star couplers, and this means that, 32 field instruments can be connected with the central master station.

The interface with the upper level, depending on the type of the master station, can be as follows:

(1) Direct connection to the MICREX-P through a MICREX interface type master station; or

(2) Connection to another system through a panel type master station with a general-purpose RS-232-C interface and process input/output signals.

The first type of connection is called MICREX-P/FFI system. The structure of the MICREX-P/FFI system is shown in *Fig. 6*.

4.2 FFI SYSTEM

4.2.1 Master Station

(1) Summary

The master station is located between the PCS-100 (FFIC), which is the control unit in the MICREX-P/FFI system, and the field instruments, controls the optical transmission, and couples the MICREX-P system and the FFI field instruments.

(2) Functions of Master Station

The master station functions as follows:

(a) Collects transmitter output signals and transmit transmits the signals to the operating ends.

(b) Receives operation signals from the FFIC and transmits the signals to the operating ends. The functions are performed at 0.2 sec intervals.

(c) Monitors the types of the field instruments.

(d) Monitors abnormal conditions of the field instruments.

The master station monitors battery voltage drop, abnormal internal temperature, abnormal parameter setting, etc. of the field instruments.

(e) Monitors field data.

The master station monitors field data overflow and underflow, and abnormal real-back of the operation outputs.

(f) Permits the OCS to remotely set up field instrument parameters.

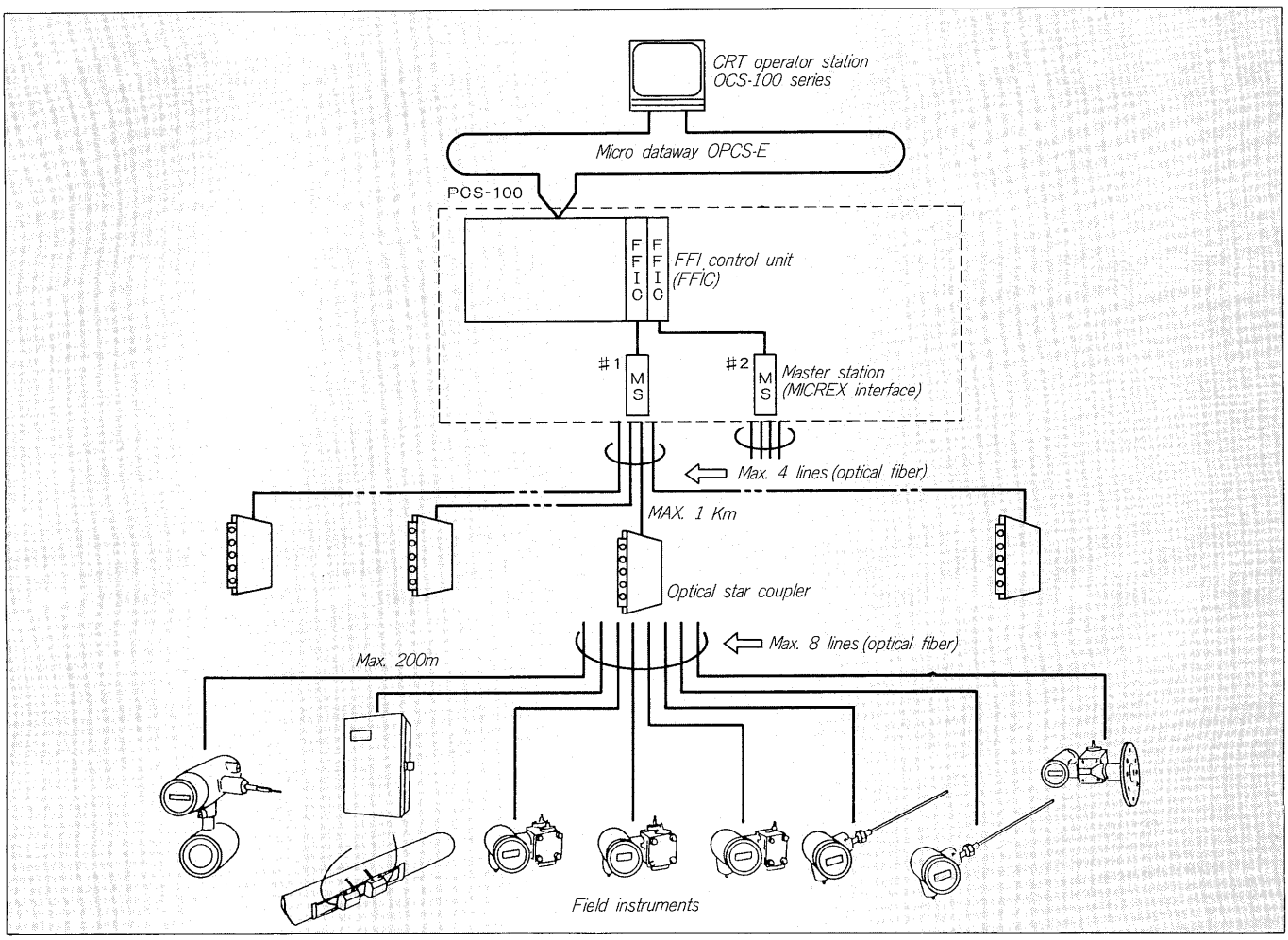
(g) Supervises the transmission lines.

All the functions of above (c) through (g) have been realized on the MICREX-P/FFI system, and they feature this system.

(3) Duplex Master Station

The master station can be provided duplex in pair with the FFIC. The standby master station in this case monitors the communication between the operating master station

Fig. 6 MICREX-P system structure



and the field instruments so as to ensure shockless changeover in control when the standby station becomes operating.

The external view of a panel type master station with general-purpose interface is shown in *Fig. 7*. This station is provided for linking up with another system.

4.2.2 Optical Star Coupler

The optical star coupler is a 2:8 type coupler, employing large-diameter quartz fibers as the mixing rod to equally distribute light. The coupler collects and distributes light for the master station and the field instruments.

Connectors for hand-held communicator (HHC) are provided so that the field instruments can be checked with the HHC.

4.2.3 Optical Fiber Field Instruments

The optical fiber field instruments in the FFI system are classified into two: optical fiber one-line instruments driven by built-in batteries and instruments fed by external power supply.

(1) Optical fiber one-line instruments

Instrument of this type is operated by a built-in lithium battery because the instrument, with CMOS IC, consumes little power on low voltage. Combined with optical fiber transmission, the most simple optical fiber one-line system is realized. Main optical fiber one-line instruments are:

(a) Differential pressure transmitters, flow rate transmitters, pressure transmitters;

(b) Level transmitters, temperature transmitters.

Fig. 8 shows a pressure transmitter. This transmitter consists of an electrostatic capacity sensor part, an electronic circuit part, and a transmitting part containing a battery. To the transmitting part is connected an optical fiber cable through an outdoor water-resistant connector.

(2) Power supplied indytumrnts

Such field instruments that can not be low-powered are supplied external power of, for example, DC 24V. Main instruments of this type are electromagnetic flowmeters, ultrasonic flowmeters, E/O converters, and multi-point temperature converters.

4.3 MICREX-P System

In the MICREX-P/FFI system, the MICREX-P functions:

(1) Connection as the controller of the field instrument side;

(2) Supervision of control operations and process data;

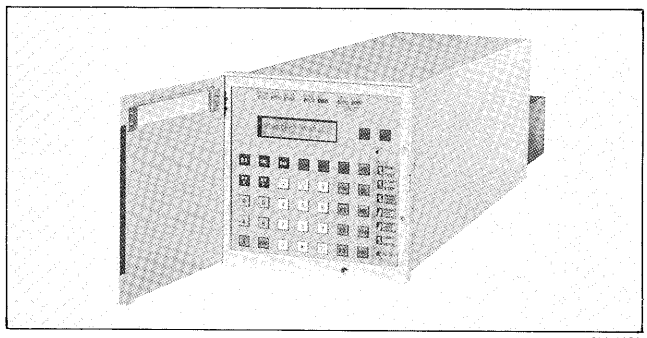
(3) Man-machine interface

The above (1) and (2) are performed by the PCS-100, while (3) is by the OCS-150/200.

4.3.1 PCS-100

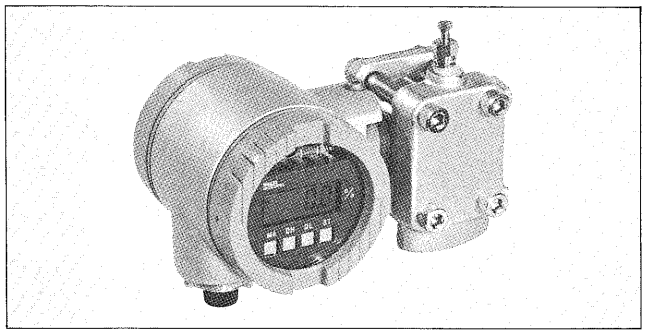
(1) Summary

Fig. 7 FFI panel type master station



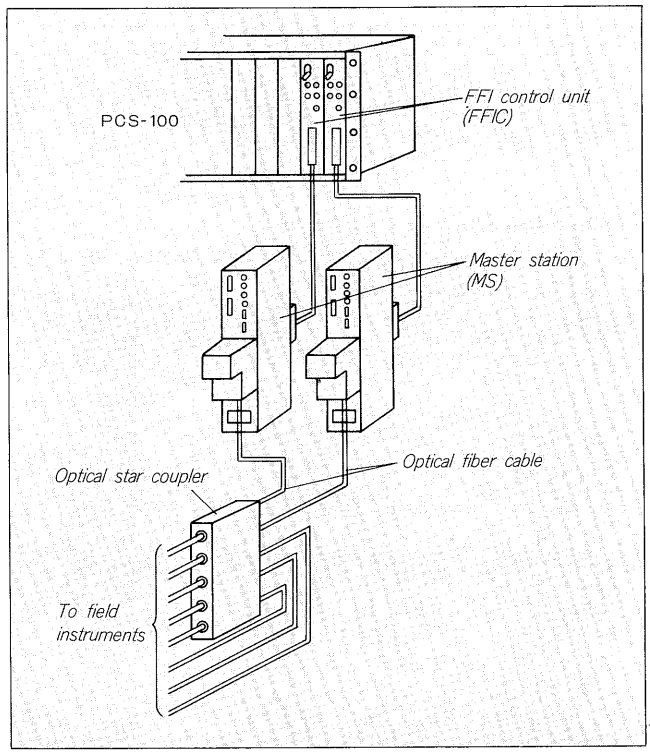
SM-1121

Fig. 8 External view of FFI pressure transmitter



SM-830

Fig. 9 FFI duplex structure



The PCS-100 and the FFI system master station are connected with the FFI control unit (FFIC). The FFIC is of card structure. It is one of the PCS units provided on the PCS-100 shelf, and features the PCS. The PCS-100 has realized:

(a) High reliability of the system through unit redundancy;
(b) Self-diagnosis and abnormality indication;
(c) Hot-line maintenance;
(d) Memory back-up at power failure;
(e) Flexible programming owing to wafer connection and POL.

Fig. 9 Illustrates the duplex system connections.

(2) Functions

The control functions are realized by a control block. The control blocks are available in two types: one is the FFI control block having feedback control functions in maximum 4 loops, and the other is the FFI alarm block having process data supervising function at maximum 16 points and alarm output function.

The functions in the control block can be defined by the user: by describing the functions of the input part, the control operation part, and the output part can be built up an application software.

The functions can be described by connecting wafer (group of unifunctioning programs) software. The wafers are available for PID position output, ratio operation, running average, arithmetic operation, limiter, selector, etc.

Table 2 shows the function specifications of the FFIC.

4.3.2 Man-Machine Interface (OCS-150/200)

(1) Summary

The OCS-150/200, as the man-machine interface of the MICREX-P/FFI system, are provided with the following functions:

(a) Detection of field instrument abnormality;
(b) Definition of the office control method;
(c) Simulation;
(d) Revision of field instrument parameter setting.

These functions are supplied in floppy discs as the FFIC support system of the OCS/150/200, permitting the FFIC to be easily expanded.

(2) FFIC support system of OCS-150/200

(a) Detection and indication of field instrument abnormality

For compatibility with the PCS-100 units in detecting abnormality, the FFIC unit indication has been added to the system condition panel so that the field instruments can be displayed as extended I/O (*Fig. 10*).

(b) Deffinition of FFIC control method

The block wafer connecting definitions in the conventional PCS-100 support system has been extended as they are to the FFIC to ensure the compatiblity between the support systems.

(c) Simulating functions

The support system simulates field instrument operations and FFIC operations in the following four modes to ensure the control (*Fig. 11* and *Fig. 12*):

(1) 'Normal' mode

Table 2 FFIC function specifications

Items	Specifications
No. of control blocks	4 blocks per FFIC unit
Types of control blocks	(1) FFI control block • Feedback control: 4 loops • Operational functions (2) Alarm block • Indication and alarm of process inputs: 16 points
Control operation period	0.2 sec.
Wafer	• Max. 32 wafers per control block • Approx. 170 types: PIO position output, ratio operation, idle time, running average, program setting, analog multiplication, arithmetic operation, estraction of square root, limiter, selector, etc.
No. of objective field instruments	32 instruments per FFIC unit
No. of process data input/output points	Total input and output 258 points per FFIC unit

Fig. 11 FFIC input and output simulation display

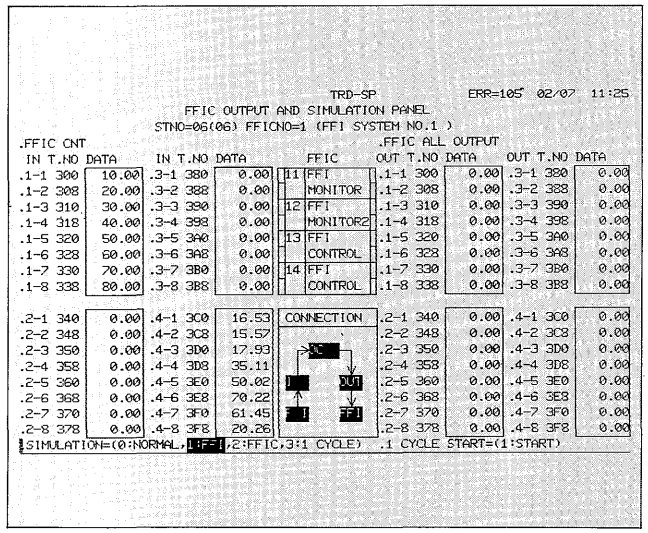
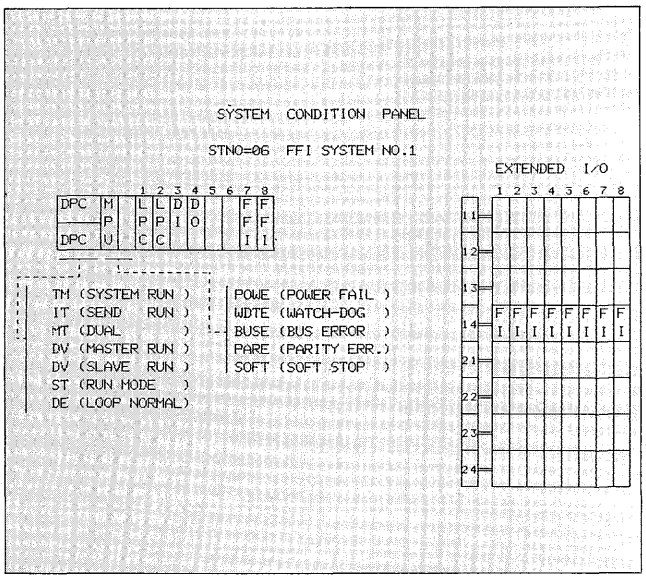


Fig. 10 Detection and indication of FFI field instrument abnormalities



Field instrument data 'input terminal' and FFIC operation data 'output terminal' are supervised.

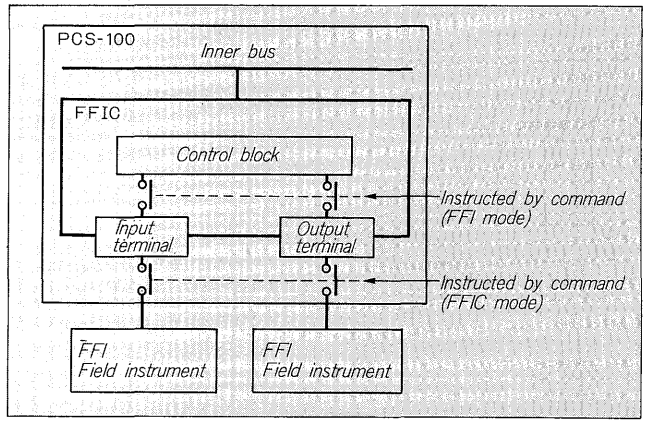
(2) FFI mode

When instructed by a command, the FFIC control block is separated, data from the OCS-150/200 is outputted to the 'output terminal', and 'input terminal' data from field instruments is simulated as the process response.

(3) FFIC mode

Instructed by a command, the field instrument are separated, optional data from the OCS-150/200 is inputted in the FFIC input terminal, and the operation is simulated by supervising the results of operations at the output terminal.

Fig. 12 FFIC input and output simulation mode



(4) One-cycle mode

Operations of (3) are performed and simulated one by one.

(d) Setting and revision of field instrument parameters of the field instruments can be set up and revised through the FFIC, permitting remote maintenance of the field instruments from the OCS-150/200.

5 CONCLUSION

The MICREX-P/FFI system is a distributed digital process control system featuring the optical fiber instrumentation. The system is widely applicable from large-scale to small-scale systems. All the field instruments, the transmission part, and the control part are provided with the optical fiber system: various models have been developed and available. We will continue to develop the MICREX-P/FFI and other products to more functional and easy-to-use systems.