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DISTRIBUTED DIGITAL CONTORL SYSTEM (FUJI MICREX SYSTEM)

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I. INTRODUCTION

The distributed digital control system (FUJI MICREX system) announced in 1975 is being widely used in various control fields, from measurement control for processes to industrial machine control of various industries, including the steel industry.

Fig. 1 and *Fig. 2* shows the position on the FUJI MICREX system construction and the subsystems as configuration elements.

The development concept and features of this system have already been reported. In short summary, the FUJI MICREX system has the following three superior points:

1) Superiority in realization of good performance

Whereas the first sequences and analog controller were special devices limited to I/O signal and calculation functions, the controller to be offered here can handle diverse I/O signals. Moreover, realization of a control system conceived by a control engineer can be realized with simple software. Furthermore, the mixed feed back control and sequence control system can give best performance to the plant starting, stopping, fault tolerance, and other wide ranging needs.

2) Superiority in control system design flexiblity

A control system consists of a part that corresponds to the control object and a part corresponds to the operator who supervises and operates the plant. A complete line-up of controllers for these applications is available. A flexible system from a small scale system to a large scale system can be designed by combining these controllers. Expansion from a single independent type system to a distributed type and hierarchal type system makes system design very easily.

3) Superiority in maintainability

Since a distributed digital control system has the functions distributed among many microcomputers, trouble at one point does not spread through the entire system and so-called danger distribution is realized. Hardware faults can be easily judged to print board units by using a dataway and centralized supervision operator's console. Wide maintenance capabilities, such as controller connection modification, control adjustment work, etc., is really provided.

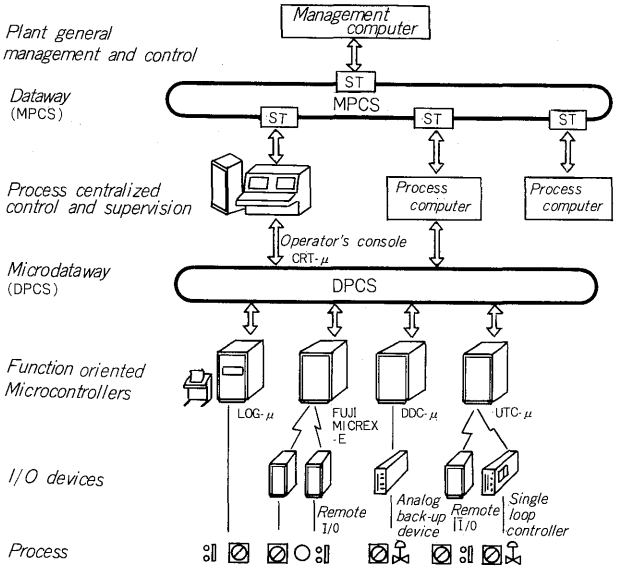


Fig. 1 Construction of total process control system

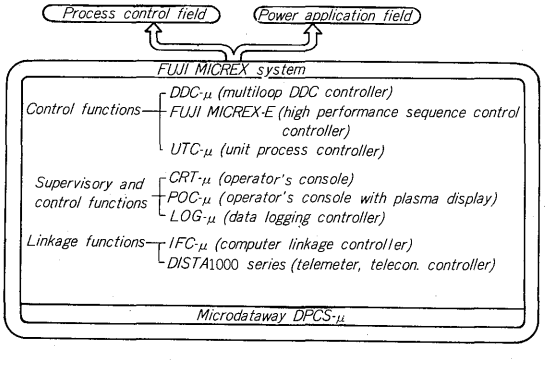


Fig. 2 Series and application of FUJI MICREX system

The FUJI MICREX system can be given more functional specifications as its applications expand. To maintain system safety and safe operation, danger distribution and a back-up system are strongly needed. The unit process controller (UTC-μ) and FUJI MICREX common back-up system (FUJI MICREX-CBS) that meet this need are introduced herein.

II. UNIT PROCESS CONTROLLER (UTC-μ)

1. Background of development

The UTC-μ is a subsystem of the FUJI MICREX system that includes a 1 loop DDC controller using CC data line.

Since an 8 loop multiple loop controller, at the least, was the main part in a distributed type DDC controller that was used as a distributed digital control system, it cannot be said to adequately handle greater danger distribution and flexibility of loop constructions. Fuji Electric announced a 1 loop DDC controller (FUJI COMPACT CONTROLLER: CC-F) in 1979 to meet this need and planned exhaustive danger distribution and more flexible loop construction.

The CC-F is at the top of analog controller without transmission functions and occupies a position as a FUJI MICREX system terminal controller with transmission function.

Whereas the CC-F has a small degree of linkage of a sequence controller containing feedback control and analog calculation and data processing and can replace the so-called loose coupling type multiple loop controller from the functions that it has itself, it did not always correspond to application high coupling and tight coupling types.

The UTC-μ is a continuation of the merging of feedback control and sequence control obtained with the tight coupling type multiple loop DDC controller and is a new product covering such features as exhaust danger distribution of a 1 loop DDC controller and simple architecture in loop units and was planned for merging with the FUJI MICREX system that employs a uniform file concept.

As one feature of the FUJI MICREX system, process control is taken from a uniform viewpoint and the system is constructed from function oriented microcontroller groups (subsystems) and the file construction between each subsystem is based on a uniform concept and data exchange can be freely performed through a dataway.

In addition, supervision and operation of the CC-F from a centralized supervisory system and high level process computer, etc. permits access by the conventional methods through a microdataway (DPCS-μ).

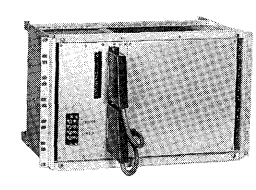
2. Configuration

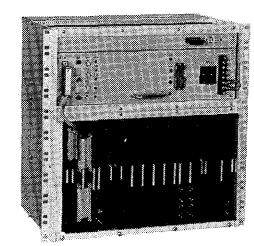
Since the system architecture of the UTC-μ system features a central processor unit and I/O sections and the units are interconnected and CC-F are interconnected by a serial interface, it is extremely flexible. *Fig. 3* shows the system configuration.

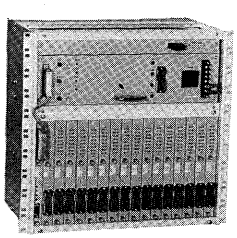
3. Functions

1) High speed calculation function

The microprocessor of the UTC-μ mainframe itself,







Remote I/O unit (RIO)

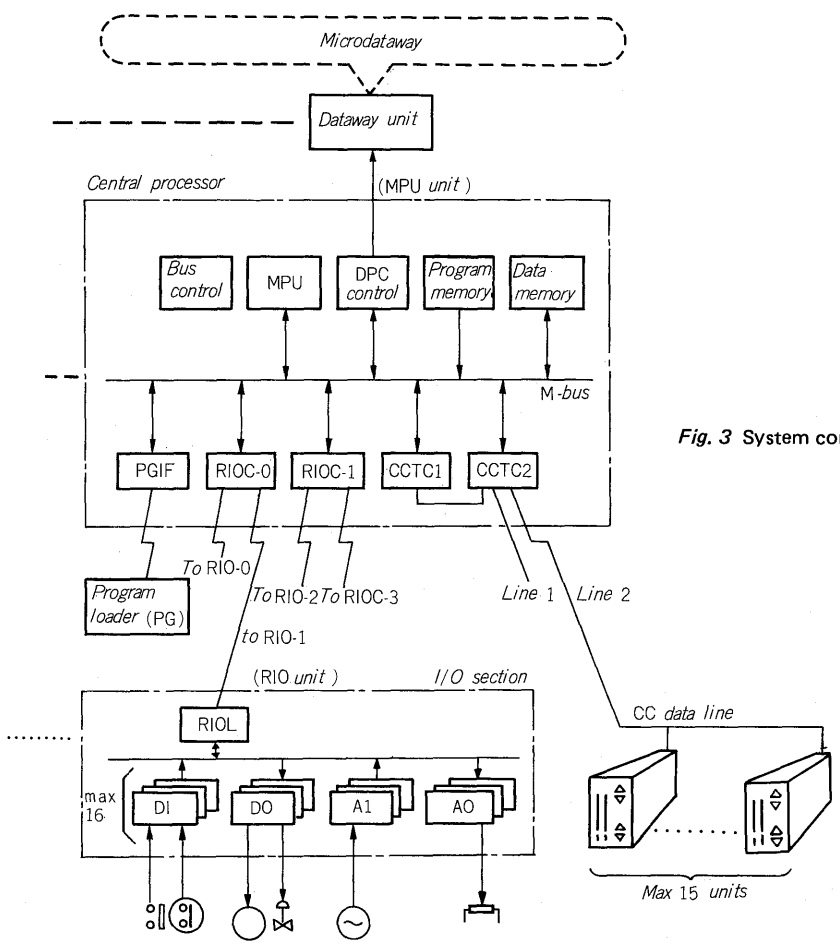


Fig. 3 System configuration of UTC-μ

Table 1 Specifications of UTC-μ

	Item	Specifications
Central processing unit	Control system	Microprogram system
	Instruction	Special control oriented language
	Instruction execution time	Logical operation Differentiation 5.75 μs 40 μs Register operation Integration 3.5 μs 46 μs Addition and subtraction 6.25μs Filter 46 μs Multiplication 22.5 μs Timer 14 μs Division 36 μs
	Register	General purpose registers 7 Index registers 4 Program counter 1 Others 4 Total 16
	Main memory	Element Core or EPROM Wordlength 16 bits + 2 parity bits Capacity Mainframe 4 kw Standard program section 8kw Application program part Standard 4 kW, maximum 28 kW (installation restriction)
	Control function	Normal cyclic control Step sequence control Fixed period sampling control Interrupt control
	Timer counter	Total 240 (counters are reversible)
	Dataway coupling	Microdataway (DPCS) (maximum 16 units)
	CC-F interface (communication control device CCTC)	Lines Maximum 2 lines Number of CC Maximum 30 (maximum 15 for 1 line) Linkage 1:N branch connection Transmission speed 19.2 k bits/sec Transmission distance Maximum 500 m
	Remote I/O interface	Remote I/O unit Maximum 4 Linkage 1:1 Transmission speed 48 k bits/sec Transmission distance Maximum 1 km
I/O unit	I/O channel	Digital I/O Maximum 1,024 channels Analog I/O Maximum 64 channels I/O cards 16/unit Channel capacity/card Digital I/O 16 chs/card Analog input 8 chs/card Analog output 2 chs/card
Power requirement		AC 100/110 V 50/60 Hz or DC 110 V

Table 2 Specifications of teleperm compact controller

Type		Continuous output type controller (model RMK) Intermittent output type controller (model PML)
Input signal	Measured value	DC 1 ~ 5 V
	Externally set value	DC 1 ~ 5 V or pulse width input
	Auxiliary input	AI x 5, DI x 4
Output signal	Operation output	DC 4 ~ 20 mA or pulse width output
	Auxiliary output	AO x 2, DO x 8
Indicator		Solid-state display
Setting unit		Constant, parameters setting and display, calculation wafer connection
Transmission function		Transmission with computer system
Control function		Constant value control, cascade control, variable gain control, proportional control, PID control with dead band, idle time compensation control
Operation function		Linearize, temperature and pressure compensation, multiply and divide, root extraction, addition and subtraction, selector, others
Alarm function		Upper and lower limit alarm, input abnormal check, change rate alarm, output abnormal check, deviation alarm
Power requirement		DC 24 V
Outside dimentions		72(W)x144(H)x400(D) mm

sequence control and various calculation processing that use the data fetched from the I/O units can be performed. It has a standard program (function module) to simplify modification of the setting of the SPC and various parameters for the CC-F as a result of calculation.

2) Feedback function

The feedback function is performed by the CC-F and data communication with a maximum of 30 CC-F can be performed through a CC data line. *Table 2* lists the specifications of the CC-F.

3) Data transmission function

Access to the CC data line is performed on request from another system that is connected to the DPCS-μ or from the arithmetic control function inside the UTC-μ.

The following function can be realized from the centralized supervisory system:

(1) Control of the optimum process value
(2) Operation of actuators
(3) Sensor data and status data supervision
(4) Loop adjustment data and control status display and operation

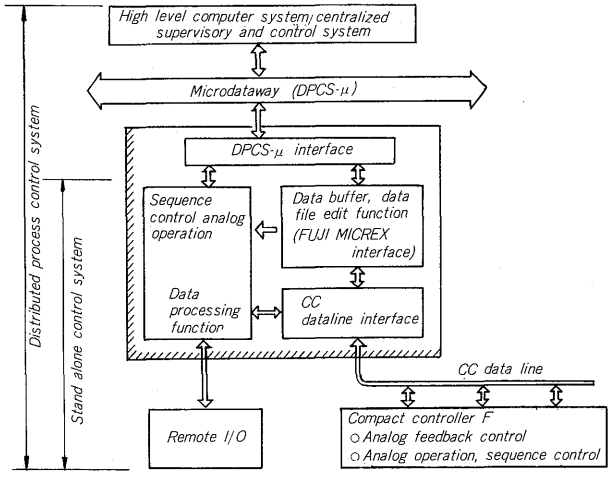


Fig. 4 Functional concept of UTC-μ

(5) Remote diagnosis and maintenance data collection
(6) Collection of other data

This is done to merge feedback control and sequence control with the UTC-μ and CC-F.

Fig. 4 shows the functional concept of the UTC-μ.

4. Applications

The UTC-μ is part of a controller that carries the direct control level of the subsystem group of the FUJI MICREX system and has a wide range of applications from a stand-alone system to a distribute type or hierarchal type system. Its wide use as a system suited for the control field, etc. that require linking with other systems is expected because of its loop independence, exhaustive danger distribution, and dataway.

III. FUJI MICREX COMMON BACK-UP SYSTEM (FUJI MICREX-CBS)

1. Background of development

In FUJI MICREX system, the improvement of system reliability is being searched by the following from its development concept.

1) Improvement of system reliability by small-scale distributed control
2) Completeness of fault diagnostic function to shorten MTTR (mean time to repair)
3) Separation of logic unit and analog output unit, and installation of individual back-up units for important control loops

However, more important control systems require a total high-reliability system for the purpose of reducing the downtime of the entire control system and improving availability, in addition to the individual reliability as described above. This FUJI MICREX common back-up system (FUJI MICREX-CBS) is a total back-up system developed to meet these demands.

2. Features of system

FUJI MICREX-CBS prepare one common standby controller for N units of controllers to back-up in such a way that when one controller goes wrong during process control, it is switched to the common standby controller. The features of this system are as follows.

1) Excellent trade-off for economy and reliability

Since only one standby controller is needed for N units of controllers, this system is very economical, compared with the dual/duplex redundancy system which has conventionally been adopted in mini-computer systems, etc.

2) This system can execute back-up function, without reducing any control functions.

Since the common standby controller executes complicated control functions of each controllers, the entire functions of the control system are fully maintained during back-up period.

3) The process is not affected by back-up switching

Each controller is divided into the common section (MPU section: MPU, memory, bus, etc.), which has serious influence upon many control loops in the case of its trouble, and the individual section (PIO section: Process input/output Unit) the influence of which is limited to individual loop. And only the common section (MPU section) is designed as a multiplex system. Accordingly, the PIO unit directly coupled to the process is not affected by back-up swiching, and the process is not affected by this switching.

4) Simple wiring to process

Since PIO unit is not a redundancy system, the wiring to the process is just the same as in ordinary system, and no

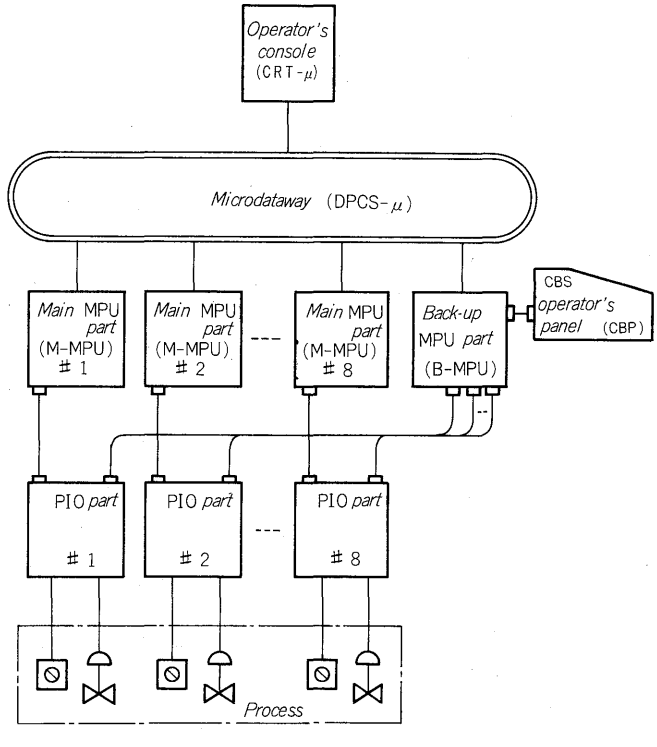


Fig. 5 System construction of FUJI MICREX-CBS

Table 3 Specifications of FUJI MICREX-CBS

Item	Specifications
No. of back-up units	Max. 8 units
Cable length between MPU and PIO	Max. 10 m
Power supply system	Independent power supply for all MPU and PIO units

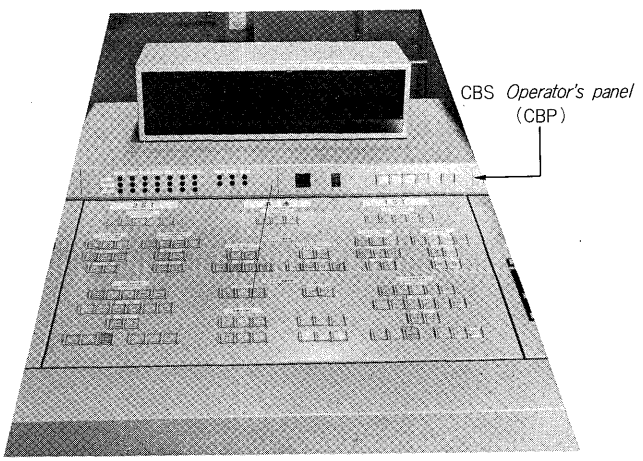


Fig. 6 CBS operator's panel (CBP)

complicated wiring is required.

3. System configuration and specifications

Fig. 5 indicates the system configuration. One of the characteristic features of this system is that each controller is divided into the main MPU unit (M-MPU) and PIO unit, and each PIO is connected to both its own M-MPU and back-up MPU (B-MPU) through cables. Each MPU is connected to the operator's console (CRT-μ) via microdataway (DPCS-μ) in the same way as in ordinary FUJI MICREX system, and this CRT-μ has the control information (FIF/POL) peculiar to each controller. And a CBS operator's panel (CBP) is connected to B-MPU to give the back-up switching operation command.

In this system configuration, each PIO is accessible from only its own M-MPU under normal operating condition, and each controller executes its control functions according to their individual control information. The access route from B-MPU is closed during this time. If an M-MPU goes wrong, the control information of the controller to be backed up is loaded from CRT-μ to B-MPU by the command from CBS operator panel (CBP). The PIO of the controller is accessible from B-MPU according to the MPU switching command from CBP, and the access route from the defective M-MPU is closed. Thus, the control of the defective controller is transferred from M-MPU to B-MPU, and the system functions are fully maintained.

Table 3 indicates the specifications of FUJI MICREX-CBS.

4. Application

FUJI MICREX-CBS has been delivered to a certain steel works, and it is operating satisfactorily at present.

Fig. 6 indicates an outer view of CBS operator's panel.