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MICROPROCESSOR'S APPLICATION FOR ELECTRIC POWER SYSTEM EQUIPMENT

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I. FOREWORD

We have been designing, manufacturing, and supplying various systems, plants, and equipment as a consolidated electrical equipment manufacturer for many years and have ample experience in their control.

We have accumulated a wide range of abundant technology in stored program control systems ranging from large systems, such as large-scale centralized control by PANAFACOM U Series minicomputer, to small system, such as on-site sequence control by F-MATIC SC Series(1), FREDIC(2), etc.

In 1975 we developed a standard series of microprocessor oriented controllers based on this solid fundation and have continued to expand its fields of applications ever since.

The following outlines the hardware of this micro controller system and introduces examples of application of the equipment to the electric power system control field.

II. SIGNIFICANCE OF THE MICROPROCESSOR

The evolution of semiconductor technology has been astounding, and the advant of the microprocessor will probably have a large impact on a wide field of activity.

As is well known, the microprocessor was realized by combining stored program technology, the heart of the electronic computer, with LSI technology through the development of IC. As shown in *Table 1,* its effects of application, including secondary effects, is extremely large, and is a large factor behind the restudy of the design concept of conventional systems and equipment even in the power control field in which RAS functions are especially important.

III. OUTLINE OF FUJI MICROCONTROLLER SYSTEM

1. Features

1) Hardware

Each unit, the basic unit of hardware, is constructed and unified in accordance with the Type 75 Unit System, the circuits and standard construction common to our electronic equipment.

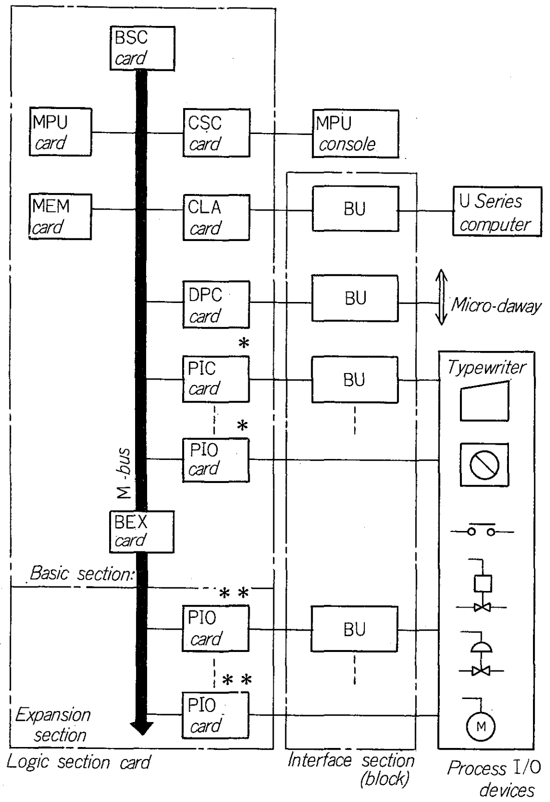
Since the controller is constructed by combining these units in a building block system for the particular application, it is abundantly flexible for expansion and has superior servicability.

2) Architecture

The architecture of the microcontroller is based on a

Table 1 Impact of microprocessors

Feature	Direct effect	Secondary effect
LSI	Compactness Economy	○ Improved system reliability by duplexing, etc. ○ Distribution of danger by distrubuting the functions. ○ Energy conservation.
	Reliability	○ Improved inherent reliability. ○ Improved availability.
Stored program	Improved functions	○ Realization and addition of sophisticated functions. ○ Rationalization of interface by transmission function. ○ Improved operability by improved man-machine interface function. ○ Improved maintainability by addition of self-diagnosis function.
	Flexibility	○ Applicability to diverse request functions. ○ Reduction of initial cost based on expandability.
	Hardware standardization	○ Improved quality. ○ Quick delivery. ○ Rationalization of engineering work. ○ Improved servicability.



BSC : Bus control card
MPU : Microprocessor card
MEM : Memory card
CLA : Computer linkage adapter
CSC : MPU console control card
DPC : Micro-dataway coupling card
BEX : Bus expansion card
PIO : Process I/O card
BU : Block unit

*indicates that up to 16 cards are installable.
**indicates that up to 16 cards are installable by addition a shelf.

Fig. 1 Composition of hardware system

Table 2 Specifications of microprocessor

Item	Contents
Wordlength	16 bits
Instruction format	1 word instruction
Number of instructions	Basic 33 (variations 345)
Data format	Binary fixed point
Registers	Instruction counter (IC) Instruction register (IR) Stack pointer (SP) Status register (STR) Arithmetic register (R0 ~ R4), two of which are index registers (R3, R4)
Addressing system	Direct address 0 ~ 255 IC relative address +127 ~ −128 Index qualification Indirect index qualification
Interruption	Program, status word switching system 3 levels multiple interrupt (external) Mask of each level can be operated by program.
Autostart	YES
Memory addresses	Max. 64 k word (k = 1024) (Note)
Processing speed	Instruction execution time R-R type 3μs or greater.

Note) Since the 4 k words addresses are assigned to the process I/O device, the addresses of a maximum 60 k words are usable as memory.

control data bus called the M-bus. Since this bus does not depend on the individual microprocessor, it is flexible and expandable enough to easily cope with microprocessor improvements and advances.

3) I/O interface

The I/O unit interface is designed for control applications based on our abundant experience and achievements. Both the digital and analog interfaces are centered around the insolated type. The abundantly high I/O level, together with special construction considerations, provide a high noise resistance.

4) System composition

Since connection of individual units, as well as interconnection of multiple microcontrollers and to a higher level computer system, is simple, a distributed control or hierarchy control system can be easily constructed.

5) Trcuble diagnosis function

Distributed control improves system reliability by distributing the danger. Various online and offline trouble diagnosis are also possible to simplify testing and maintenance.

6) Exhaustive quality control

Selection of highly reliable parts, stringent receiving and intermediate inspections, aging to remove initial defects, assembly tests, and other exhaustive controller design and manufacturing quality control procedures improve quality substantially.

2. Hardware composition

Fig. 1 shows the composition of the hardware system.

Each controller is constructed around the previously mentioned M-bus. The microprocess unit that performs arithmethic, control, and other processing according to the program, various memory units that store the program and data, process I/O unit for I/O signals, and other logic units are connected to the bus via a common interface.

Processing I/O unit and external signal connection is performed through an interface unit for isolation, signal matching, connection conversion, etc. as required.

The logic section consists of printed circuit boards called card units and the interface section consists of block units to classify the applications according to the electrical level.

Table 2 lists the specifications of the microprocessor, *Table 3* lists the card units, and *Table 4* lists the most basic block units.

3. Installation conditions

Table 5 gives the basic installation conditions.

Table 3 Card units

Type	Name	Abbreviation	Function
Bus control	Bus control card	BSC	Bus control, clock generation, core memory interface, bus supervision.
Processor	MPU card	MPU	MN1610 (Panafacom)
Memory	Core memory card	CMR	4 k words/card (16 bits + 2 parity bits)
	EP ROM card	ROM	4 k words/card (16 bits + 2 parity bits)
	IC RAM card	RAM	4 k words/card (16 bits + 2 parity bits)
Transmission	CLA card	CLA	For interfacing to U Series computer.
	DPC interface card (S)	DPC-S	Send/receive 1 set, bit serial transmission, max. 4800 bits/sec.
	DPC interface card (P)	DPC-P	Send/receive 1 set, word serial transmission, max. 5000 words/sec.
Process I/O	Interruption input card	DPI	External interruption input level: 2 levels 8 points/level, complies with I/O standard specifications.
	Digital input card	DIH	64 points, complies with I/O standard specifications.
	Pulse input card (1)	DPI	1 bit x 16 points, complies with I/O standard specifications.
	Pulse input card (2)	PIN	8 bits x 8 points, complies with I/O standard specifications.
	Analog input card	AIC	64 points, complies with analog input interface I/O standard specifications.
	Digital output card	DOH	64 points, byte accessible, complies with I/O standard specifications.
	Pulse output card	POD	2 points, output: Minimum pulse width 8 ms, 8 bit counter.
	Analog output card	AOD	2 points, up-down 2 direction output, output: DC 4 ~ 20 mA.
I/O	Serial code transmission card	IOC-S	110, 200, 1200 bits/sec, send/receive 1 set.
	Parallel code transmission card	IOC-P	Typewriter control.
	Bus expansion card	BEX	Bus expansion.

Table 4 Block units

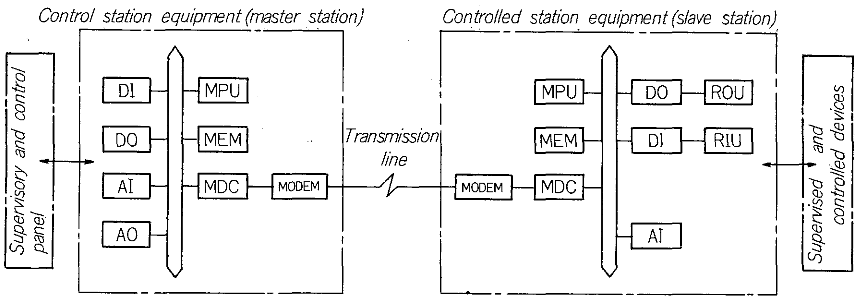
Corresponding card unit	Application	Abbreviation	Functions
Analog input card	AD conversion	BMXR	Multiplexer: reed relay/mercury relay 16 point units.
		BADC	Conversion system: Frequency integration type.
Digital input card Pulse input card Interruption input card	Contact input	BDIC	32 points, photocouplet isolation, with LED display. Supply voltage DC 48 V 5/15 mA, delay time 10 ms.
	Transistor contact input	BDIT	32 points, photocoupler isolation, with LED display. Supply voltage DC 12 V 5 mA, delay time 1 ms.
	Voltage input	BDIV	32 points, photocoupler isolation, with LED display. Input voltage DC 12 V 5 mA, delay time 1 ms.
Digital output card Pulse output card	Transistor contact output	BDOT	32 points, photocoupler isolation, with LED display. Supply voltage DC 5 ~ 24 V 100 mA.
	Contact output	BDOC	32 points, N type relay isolation, with LED display. Supply voltage Max. AC 100 V max. 1 A.
Serial code transmission card	Voltage output	BIOM	MODEM interface isolation.
	DC output	BIOW	ASR-33 interface isolation.
Parallel code transmission code	Output typewriter	BIOP	IBM 735 interface.
DPC coupling card	DPCS	BDPC	Micro-dataway (DPCS-μ) interface.
Computer interface card	U Series	BCLA	U Series PLCA interface.

Table 5 Environmental conditions for installation

Ambient temperature	0 ~ 40°C (cold start)
Humidity	20 ~ 90% RH
Temperature change	20°C/hour
Dust	0.3 mg/m^3 or less
Harmful gas	Must be no corrosive gases
Vibration	0.2 G or less
Shock	Shipment: 5 G or less Operating: 1 G or less
Dielectric strength	AC 500 V or AC 2 kV for one min

IV. APPLICATION TO POWER SYSTEM CONTROL FIELD

The increasing scale, range, and diversity of the control objectives of remote supervisory and control systems used as means of rationalizing and automating operation of remote devices and facilities in power and other systems in recent years has been accompanied by a steady increase in the demand for greater reliability, flexibility and economy.



MPU : Microprocessor module
MEM : Memory
MDC : P/S, S/P converter
MODEM : Modulator/demodulator
DI : Digital input module
DO : Digital output module
AI : Analog input module
AO : Analog output module
ROU : Control output relay unit
RIU : Display input relay unit

Fig. 2 Basic configuration of 1:1 type telecontrol equipment

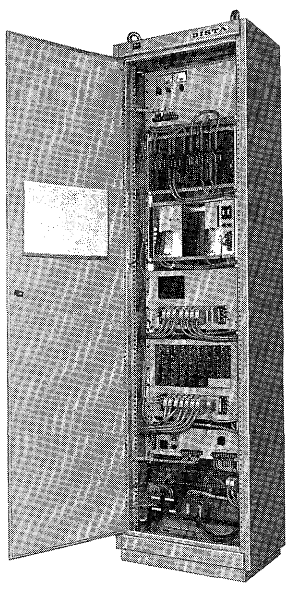


Fig. 3 Exterior view of 1:1 type telecontrol equipment

Various intelligent data transmission equipment – Fuji DISTA Series –
DISTA-1000 cyclic telecon system
DISTA-2000 polling and selecting 1:*N* telecon system
DISTA-3000 compound microprocess telecon applied system
with arithmetic and decision functions centered around the Fuji microcontroller system basic hardware have been developed and commercialized to meet these demands. These systems are outlined below.

1. 1:1 type telecontrol equipment (DISTA-1000)

The specifications of this equipment comply with the Electrical Cooperative Research Society specifications. The basic composition of this equipment is shown in *Fig. 2* and an exterior view is shown in *Fig. 3*.

1) Transmission control functions

This equipment consists of signal transmission modem (MODEM) and S/P and P/S converter (MDC) modules that perform serial-parallel and parallel-serial code conversion. The microprocessor has the following main functions.

(1) Synchronization signal generation and detection control.
(2) Signal double transmission collation test and parity test processing.
(3) Transmission format editing.
(4) Data priority transmission processing (transmission at super commutation, status change, etc.)
(5) Subcommutation processing.

2) Supervisory and control functions

These function consist of digital I/O and analog I/O modules (DI, DO, AI, AO) that interface with the supervisory and control panel operation switches, lamps, and meters, and relay units (RIU, ROU) that interface with the controlled devices. The following main processing functions are executed by the microprocessor:

(1) Selection and control code translation processing.
(2) Display signal status change detection processing flicker processing.
(3) Metering signal scale conversion processing.

The advantages gained by introduction of a microprocessor are:

(1) Flexible expansion and modification of functions.
(2) Flexible format configuration and data exchange between existing equipment and low level devices.
(3) Construction of hierarchal and other systems is possible.
(4) Improved reliability through simplification and unification of hardware and easy maintenance because of detection and display of faulty parts by trouble diagnosis program self-diagnosis function.

2. Control station local supervision and control computer linkage equipment

The central equipment of centralized control systems are often installed in high capacity power station. Therefore, to handle the mass of data in the station itself the same as data from remote stations, it must be converted to the same format and interfaced with the central control computer. A function that passes the control instructions from the computer to the local power station is also necessary *(Fig. 4)*.

The use of the microprocessor system is extremely effective in this case from the standpoints of:

(1) coping with increased capacity,
(2) coping with the corresponding complexity of each item

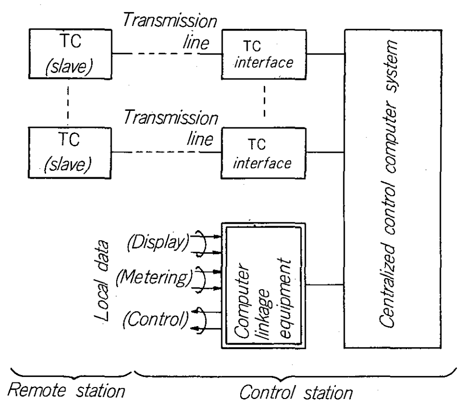


Fig. 4 CPU interface equipment in centralized control system

of the display and alarm system,
(3) coping with complex interlock conditions,
(4) simplification of the computer interface,
(5) abnormality detection and processing capacity.

The specifications of a system constructed for this purpose are outlined below.

Display input: 500 items
Metering input: 128 quantities
Control output: 400 items
Computer interface: Display, metering 2w
Control 2w

Almost all the previously metioned functions can be corresponded by software. Therefore, no matter how large the capacity, the logic and PI/O are standard devices and can be mounted in a single frame, and a compact system can be constructed by housing the relays, mainly used for external interface isolation, in a separate frame. Since the external interfacing is the same as that of a common telecon system, the external sequence can be considered in the conventional manner. The computer interface is the same word serial system as the telecon-computer interface. Therefore, since the computer can perform processing without discriminating between local and remote station, the software can be simplified and the occupancy rate reduced.

3. 1:*N* type telecontrol system (DISTA-2000)

Since constant communication with all the stations is impossible when the transmission circuit between the central station and multiple controlled stations is in the form of a continuous chain, a polling and selecting system is employed. The transmission system is random transmission and data processing message exchange resembles a dialog type data exchange system. The transmission format is a 1 word 24 bits CRC check system matched to this system.

Fig. 5 shows the system configuration and the following gives some typical specifications.

System configuration: 1:7
Control station input: Linking with central control computer
Controlled station capacity: Control 60 items
Display 120 items
Metering 15 quantities
Transmission control system: Polling and selecting
Communication line: Power line carrier line
Communication system: Half duplex
Transmission system: Random transmission
Transmission speed: 600 bits/s
Signal modulation system: Frequency modulation (FS)
Signal frequencies: Center frequency 3,300 Hz
Shift frequency ±200 Hz
Synchronization system: Word start-stop synchronization
Transmission format: NRZ equal length code
Transmission error control system: Word units CRC check
Control system: 1 motion control
(However, selected item resend collation performed.)
Control time: Approx 1 sec
Data transmission modes:
(1) Status change data enquiry and response
(2) Metering data periodic request and return
(3) Display data periodic request and return
(4) Specific station metering or display data request and return
(5) Specific station selection and control

These specifications differ from the Electric Cooperative Research Association type telecontrol equipment mainly used up to now, but in this case, the basic hardware are standard devices and can be functionally corresponded by software.

4. Data exchange equipment (DISTA-3000)

The data exchange equipment consists of a large scale

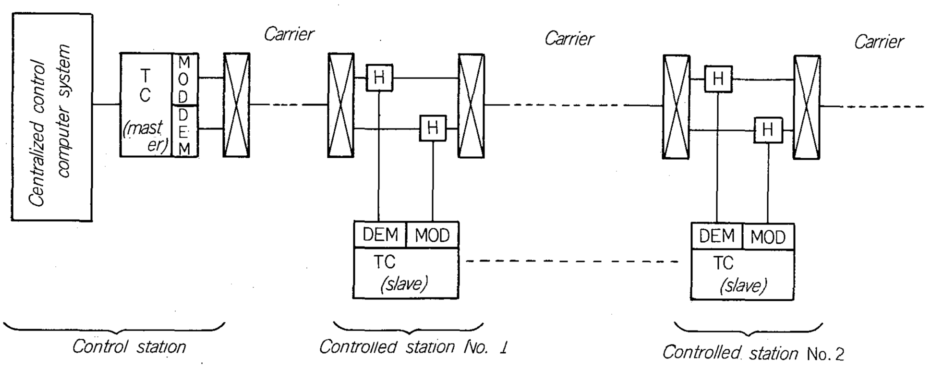


Fig. 5 1:*N* type telecontrol system

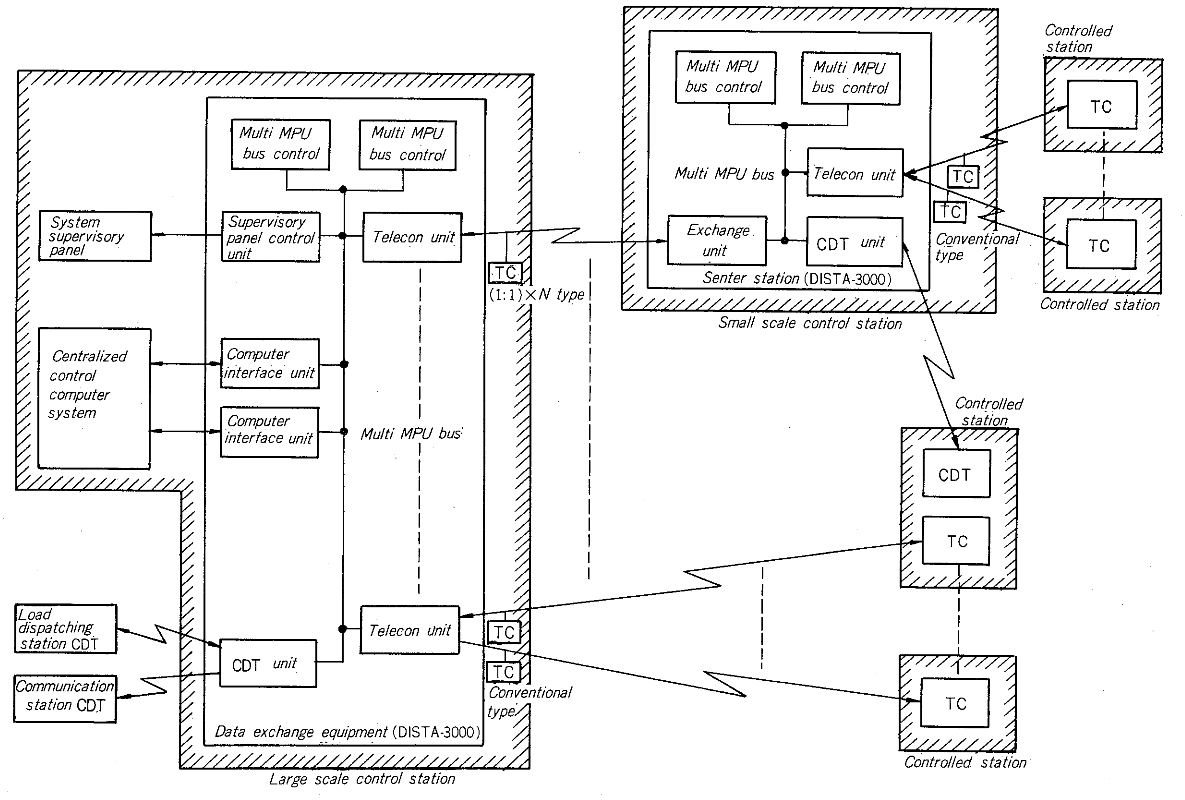


Fig. 6 Configuration of centralized control system

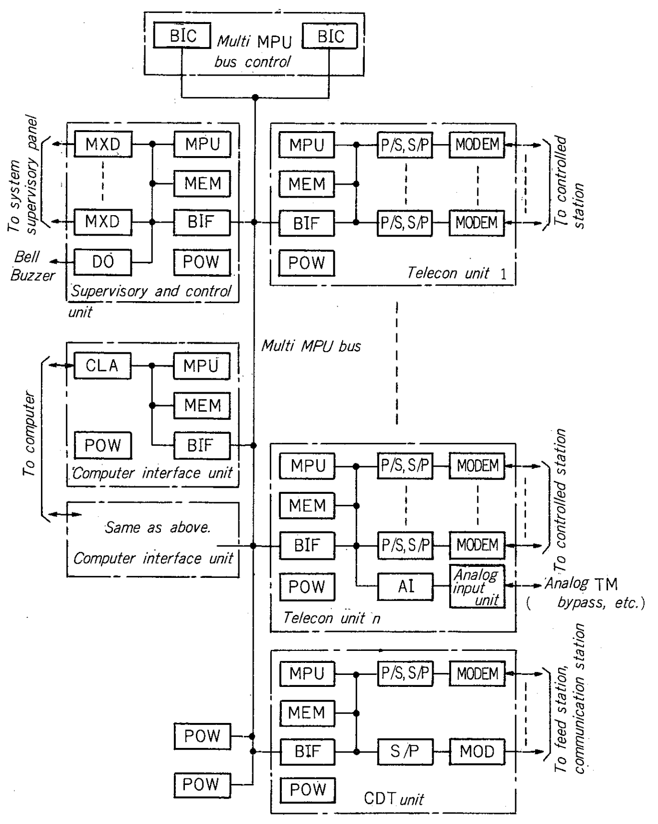


Fig. 7 Configuration of data exchange equipment

control computer system and electric stations data exchange trol computer system and electric stations data exchange (using telecon equipment) connection section, other sections (power stations, communication station, business office) data conversion, macro supervision system supervision function and data exchange function as the intermediate station of a hierarchal system as shown in *Fig. 6*. When the scale is large and a large volume of data is handled, the units must be organically connected. The multi-MPU system was developed for this purpose.

1) Composition

The data relay equipment consists of a building block system of microprocessor units having various functions centered around a multi MPU bus as shown in *Fig. 7*.

Each unit consists of a telecon interface unit that exchanges data with the controlled station, computer interface unit that exchanges data with the computer, CDT interface unit that exchanges data with other departments, and a supervisory and control panel interface unit that performs display and are organically connected by the multi MPU bus.

The important parts of this equipment from the standpoint of the system (multi MPU bus controller, computer interface unit, etc.) are duplexed and consideration has been given so that operation is possible by instantaneous automatic switching if trouble should occur at one of the units. Since the power supply system is independent for each unit, maintenance without stopping other units is possible. The power supply of common parts (multi MPU bus, etc.) is also duplexed.

2) Functions

(1) Telecon interface unit

This unit exchanges data with the various telecon equipments (equal length code and long-short code both possible) installed at the controlled stations. One microprocessor can exchange data with 6 controlled stations at a transmission speed of 600 bits/s. This unit is centered around a microprocessor and consists of S/P converters, that perform serial-parallel and parallelserial code conversion, MODEM, A/D converter, multi MPU bus interface, and other devices. The microprocessor has the following processing contents:

(1) Synchronization signal transmission.
(2) Send/receive signal P/S and S/P conversion.
(3) Control signal check and various interlocks.
(4) Control signal transmission format editing (continuous send bit, parity bit addition, etc.).
(5) SV data status change detection.
(6) Pulse data integration.
(7) Double send collation, parity check.
(8) Metering signal processing.
(9) Processing for data exchange with other units.
(10) Data editing for transmission with other units.

This unit features the intervention of both the hardware and software in P/S and S/P conversion. It can also easily cope with telecon having different transmission formats, priority transmission processing, etc. The functions of the (1:1) type telecon have been retained by incorporating an analog telemeter that transmits from the corresponding controlled station into this unit.

(2) Computer interface unit

This unit is the window between the data exchange equipment and the centralized control computer. This unit handles the various control signals sent from the computer and the various data sent from the controlled stations. Connection with the computer is by channel interface. Data exchange is performed at a high transmission speed of 50 k words/sec. This unit is duplexed and is designed so that the data are not lost even when a malfunction occurs. The microprocessor has the following processing contents:

① Transmission control for data exchange with the computer.
② Data editing.
③ Operating status check of each unit (multi MPU bus operation supervision).
④ Processing for data exchange with other units.
⑤ Switching control betweenduplexed computer interfaces.

(3) CDT interface unit

This unit extracts the necessary data from the data collected from the controlled station, transfers the data of the adjacent electric stations needed for control by the centralized control station to the receiving computer from the load dispatching stations, and passes the data to the supervisory panel.

The microprocessor performs the following processing:

① Extraction and editing of the necessary data from the various data sent from the telecon units, etc.
② CDT transmission format editing.
③ CDT transmission control.
④ Addition, subtraction, etc. of the metered quantity transmitted from the controlled stations,
⑤ Received data status change detection.
⑥ Processing for data exchange with other units.

(4) Supervisory control unit

This unit macro supervises the necessary system operations at the centralized control station. It displays the station of the main hardware (CB, LS, etc.) of each electric station. The operating status of the entire system can be judged at a glance. Since the number of display points is extremely large, the special features of this unit are dynamic display by light emitting diodes and compact size.

The microprocessor performs the following processing:

① Editing of the various data transmitted from the telecon units and CDT unit.
② Flicker processing.
③ Telecon unique display system (A, B, C, D, etc.) processing.
④ Bell, buzzer, and other alarm processing.
⑤ Processing for data exchange with other units.

(5) Multi MPU system

This system can connect 16 microprocessor units with one set of bus control units. An "*N*:*N*" type transmission system by controls the bus support right by monitoring the send/receive requests from the units is employed.

The same high speed transmission of approximately 50 k words/second as that of the computer interface is possible. Since this system uses a common bus (multi MPU bus), each unit has a disconnection function in case trouble occurs so that trouble at one unit has no affect on the sys-

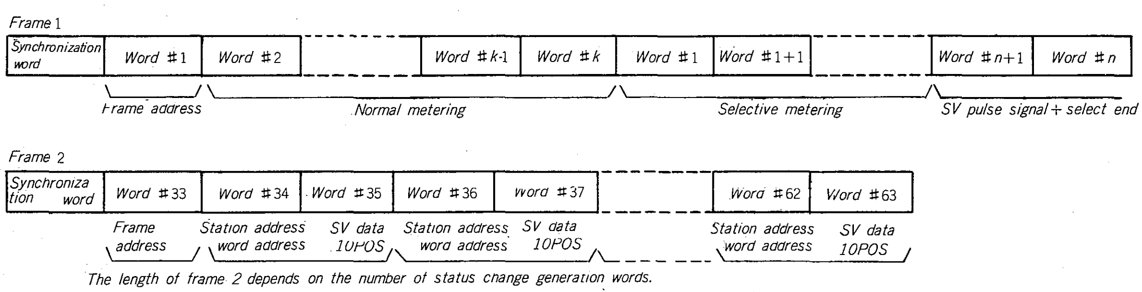


Fig. 8 Method of high speed data transmission

tem and system shutdowns have been minimized. The bus control unit is duplexed. If a malfunction should occur, an abnormal signal is output to the outside and operation is automatically switched to another unit so that the system is not shutdown.

(6) Intermediate station

The data exchange equipment used at the intermediate station is installed at a small control station and consists of a telecon unit that exchanges data with a number of controlled station, CDT unit that fetches the necessary data from the various data collected by the telecon unit and sends these data to other electric stations, exchange unit that performs effective transmission by re-editing the various data collected by the telecon unit, etc. The telecon unit and CDT unit have the same functions as the units previously described.

The exchange unit employs the efficient high speed transmission system shown in *Fig. 8* to transmit the voluminous data collected at the telecon unit to the higher level control station over a small transmission line. Specifically, the metered quantity and SV data that require priority processing (select end signal, etc.) and the SV data that frequently change, such as pulse signals, are transmitted at frame 1. Normally, only this frame is transmitted. Frame 2 is transmitted only when the status of the other SV data changes. Frame 2 can be up to a maximum of 32 words long. However, the transmission efficiency has be raised by varying the frame length of frame 2 according to the number of status change generation words.