FI-Net System

Shunsuke Shikano
Masaomi Fukuda
Masaaki Fujimaki

1. Introduction

Based on the progress of electronic technology, computer applications and the development of data transmission technology, factory equipment and data processing techniques for that equipment which are highly automated, functional, intelligent, energy conserving, with smaller size and increased safety have been developed.

Remarkable progress in supervision and control systems based on data processing technology greatly contributed to the realization of factory automation (FA), computer integrated manufacturing (CIM) and intelligent electric equipment.

The development of electronic devices used in a data processing system such as computers, programmable controllers (PCs), multiplex signal transmission equipment and miscellaneous sensors has also been remarkable.

The development of highly automated, more intelligent and safer electric equipment has become necessary. To meed this requirement, variors data processing techniques have been incorporated into many types of electrical equipment from small to large scale. In addition, it has also become necessary for data transmission network technology to be incorporated into terminal device system.

"FI-Net" (Fuji Intelligent-Network System) is an information network system developed to meet the aforementioned requirements of providing electrical equipment with data network functions and which is compatible with standard devices.

2. Purpose of the FI-Net

So-called standard devices which include power distributor devices, control devices and measuring devices are usually incompatible with an information network. If one wants to supervise and control these standard devices by an FA computer or a PC, the necessary hardware would require much wiring and interface devices, and the costs for designing and maintaining software would be high. These drawbacks further hinder device replacement or flexible design of the system. In view of the above, a goal of the FI-Net is to provide a network that is well suited for operating coupled remote power distributor devices, control devices and measuring devices with a computer or PC which supervises and controls these distributed devices.

Since a standard FA personal computer or PC may be used with the FI-Net, the installation of standard devices in the information processing system is facilitated.

In an intelligent system, on-site diveces must be provided with high level functions.

Therefore, the other goals of the FI-Net are to provide power distributor devices with intelligent functions and to promote a series of remote controllers (distributed control units) which have incorporated functions of the conventional individual devices or remote controllers which will perform by themselves their entire assigned operation.

3. Hierarchy of Device Network

Figure 1 shows the structure of a standard data transmission network. The network hierarchy is divided into an operation system that controls and supervises automatic operation of the devices distributed over the site and a management system that performs total management of the entire network. Functions of a specific hierarchy are partially adopted or functions of several hierarchies are integrated depending on the scale or purpose of the network.

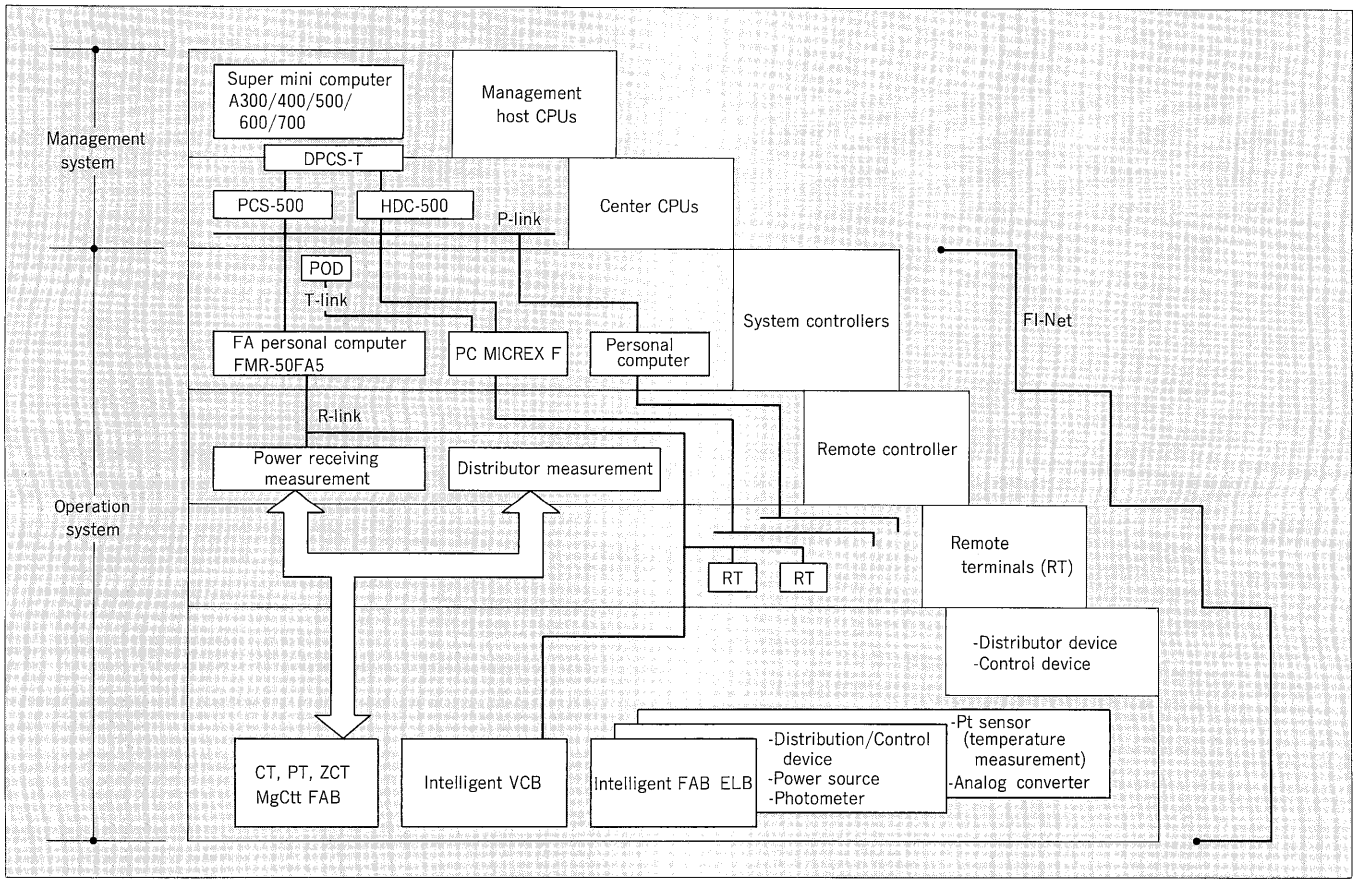
The network of electrical equipment which supports the FI-Net supervises and controls automated function of the equipment and operation system. This network may be subdivided into an operation system and an equipment control system.

It is preferable to use an FA personal computer or PC as a controller if connection to a host system network is desired.

Different types of data transmission systems optimized for their specific purposes are used to link individual devices from each hierarchy based on data capacity, required data transmission speed, required functions, cost and other considerations. Items which are essential for a local network to link electrical devices are listed below.

(1) Long distance data transmission capability which is compatible with devices widely distributed in a building or in a factory.
(2) Widely distributed wiring which is easily designed and constructed (branches and terminal end resistors are

Fig. 1 Standard data transmission network hierachy



eliminated of from the signal transmission line).

(3) Immunity to noise such that installation of the electrical devices at the designated site will result in no problems.

4. Data Transmission in the FI-Net

In local networks which connect distributed devices, priority should be given to specific functions depending upon their use. For example, in a factory which uses FA or machine control, top priority in the standard network is given to high speed data transmission.

However, in a building or factory, top priority for supervising and controlling equipment is given to long distance transmission and wiring design and construction ease, rather than to high speed data transmission. **Table 1** compares the FI-Net with a standard local FA network.

The FI-Net can use a variety of transmission lines such as an optical fiber cable, a trolley line, a slip ring as well as a standard signal transmission line (twisted pair cable). **Figure 2** shows an example configuration of the FI-Net.

Table 1 Comparison of FI-Net with FA

Item	FI-Net	FA
Application	Equipment in factories and others supervision, control and protection	Machine control sequential control
Priority	Long distance	Transmitting speed
Transmission length	2 to 5km	1km
Configuration of transmission network	Bus type	Multidrop type

5. Constituent Devices and their Applications

The FI-Net is comprised of standard devices including power distributor devices such as magnetic contactors, circuit breakers and vacuum circuit breakers, control devices such as compact remote terminals, PCs, FA personal computers, programmable operation displays (PODs) and software packages for supervising and controlling both standard and other miscellaneous devices.

5.1 Provision of intelligence to each device

(1) Intelligent VCB (very high vacuum circuit breaker)
A VCB is provided with preventive maintenance meas-

Fig. 2 FI-Net system of transmission line (R-link)

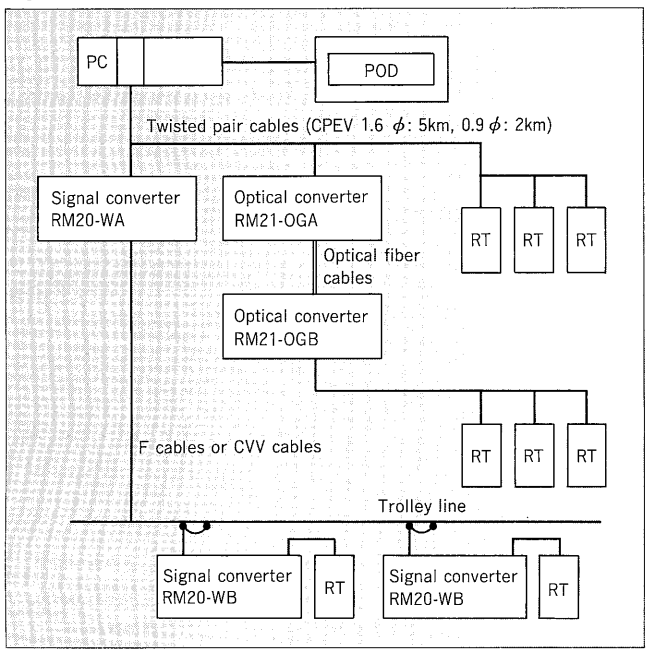
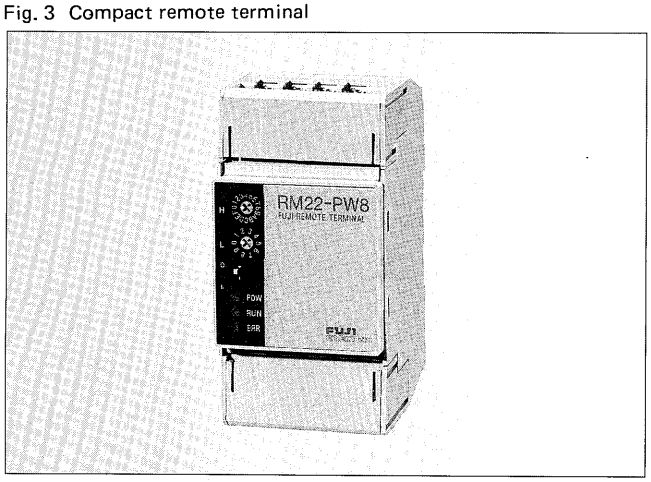


Fig. 3 Compact remote terminal



AF90-295

ures which can detect a wiring break on a trip coil and an abnormal temperature rise in the main circuit terminals. Compatibility of the VCB to any system is enhanced by integrating a data transmission function (FI-Net interface) in the VCB.

(2) Twin breakers with solid state overcurrent relay (FAB, ELB)

Standard breakers are provided with an intelligent box that facilitates adjusting protective characteristics such as rated current, short time operating current and instantaneous operating current, and provides the preventive maintenance features of pre-alarming load and leakage current warning.

5.2 Compact remote terminal

Transmission units of the FI-Net are attached to the remote terminals of the RM20 series, Fuji Electric's multiplex signal transmission devices.

The transmission unit the performs signal transmission between a controller and the devices. Since the size of the transmission unit conforms to the JIS C 8370 standard for molded case circuit breakers, it may be combined with distribution and control devices in a distribution switchboard.

The design and construction of electrical equipment will be highly efficient since these units are compatible with the rails specified by the DIN and the metal fixtures specified for breakers. **Figure 3** shows an exterior view of a transmission unit and **Table 2** lists names, types and basic specifications of the transmission units.

5.3 Remote controller (distributed control unit)

The remote controller is a unit for distributed control in the FI-Net. After completing supervision and control operations, the remote controller transmits the minimum amount of necessary data to a system controller. Thus, data processing loads are distributed to central and local devices, and the load of the system controller is reduced. The remote controller improves system reliability and facilitates maintenance of electrical equipment since it can supervise and control devices by itself if trouble happens in the system controller or in the host transmission system. The remote controller facilitates hardware standardization and efficient wiring through the integration of hybrid functions.

(1) Remote controller for motor

This remote controller integrates a protective function against overcurrent and ground fault, a display and supervise function, a control function (programmable) and a transmission function into one built-in unit. **Figure 4** shows an external view of the remote controller and **Fig. 5** shows the system configuration of the remote controller for a motor. **Table 3** lists names, types and specifications of the remote controller for motor starter measurement.

(2) Remote controller for power receiving and remote controller for distributor measurements

The remote controller for power receiving measurement and the remote controller for distributor measurement integrate measurement, display and supervise functions of electrical quantities, a fault detection function on

Fig. 4 Remote controller for motor starter measurement

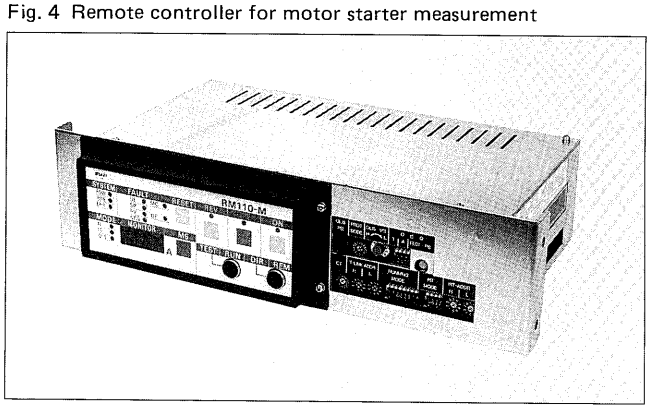


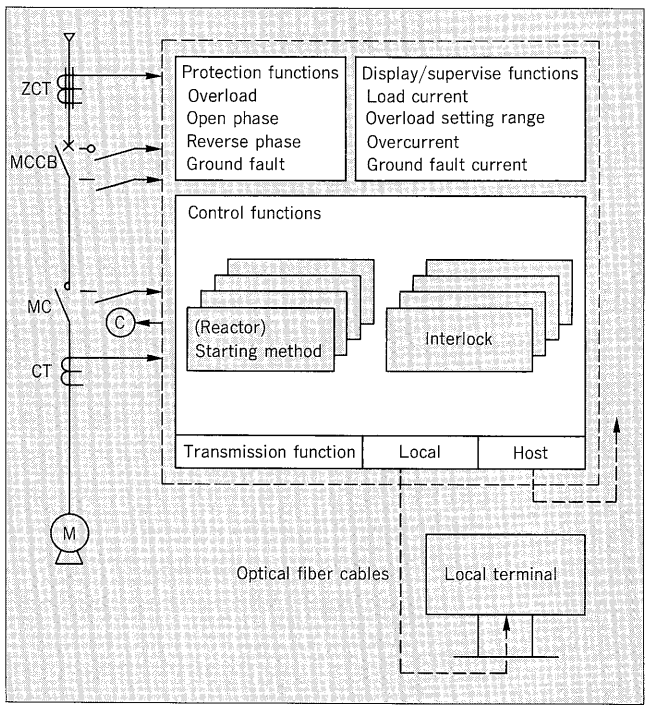
Table 2 Specifications for remote terminals (compact type)

Item		Input/output specification	Use
Type	RM22-TN8	No-voltage contact input: 8 points	Standard devices
	RM22-RR8	Relay contact output: 8 points	
	RM22-PV8	100VAC input: 4 points /Relay contact output: 4 points	
	RM22-PW8	200VAC input: 4 points /Relay contact output: 4 points	
	RM22-PE8	24VAC or 24VDC input: 4 points /Relay contact output: 4 points	
	RM22-SM2	24VAC or 24VDC input: 4 points /Relay contact output: 4 points	MgCtt control units
	RM22-SR4	24VAC triac output: 4 points	Remote control relay control units
	RM22-TA2	0 to 20mADC input: 2 channel (12 bit)	Standard devices
	RM22-TR2	Pt100 (−50°C to 50°C) direct input: 2 channel (12 bit)	
	RM22-TP2	No-voltage contact input: 2 channel (15 bit)	Counting units
Specification	Transmission type	R-link	
	Transmission line	Twisted pair cable CPEV 0.9ϕ (2 cross)	
	Transmission length	CPEV 0.9ϕ: 2km, CPEV 1.6ϕ: 5km	
	Max. number of transmission points	N:N/1,024 points 1:N/1,024 points	
	Transmission speed	7,200 bps	
	Transmission time	64ms/64 points	
	Transmission mode	Time division cyclic multiplex	
	Modulation	RZ pulse width moduration	
	Error check	Parity check, Sum check, Reverse dual-transmission collation check	
Power supply		24VAC (19.2 to 30VAC) or 24VDC (20.4 to 35VAC)	
Dimensions (mm)		100H x 50W x 65D	

Table 3 Specifications for remote controller

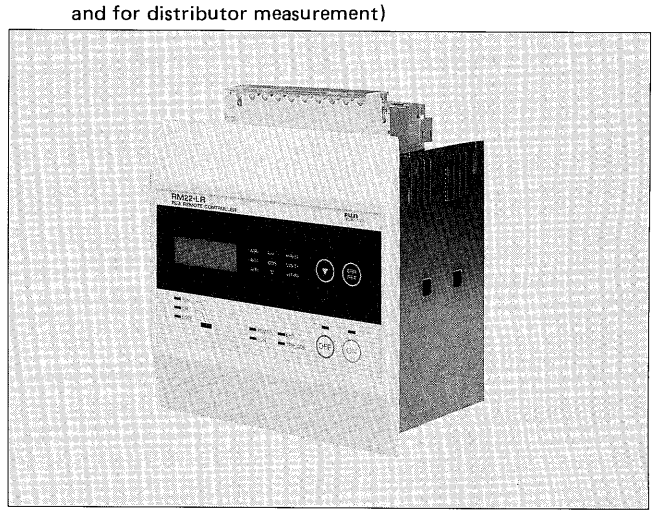
Type		Remote controller for motor starter measurement
1. General specification		
Type designation		RM111-LM
Power supply voltage		100 to 120VAC (50/60Hz)
Ambient temperature		−10°C to 55°C
Ambient humidity		20 to 90%RH (No dewing permisible)
Storage temperature		−30°C to 70°C
Network type		R-link to T-link
2. Function specification		
Measurement input signal		Load current (auxiliary CT input), Earth leakage current (auxiliary ZCT input)
Items to be displayed		Above measured value (7 segment LED, four digits), Conversion from ZCT, CT Driving history data, Setting range, Trouble data
Transmission		One channel from above measured value
3. Control and display function		
Control switch		Control switch to turn normal rotation/reverse rotation/stop, selector switch to change remote/direct state/test mode, selector switch for display
7 segment LED for display		Measured value of current, Display of error, abnormal set, etc, by code
LED for display		POW, RUN, state of motor normal rotation/reverse rotation/stop, state of direct/remote/test set, displaying item on 7 segment LED
4. Protection		
Function		Overload, open phase, overcurrent, undercurrent, ground fault
5. Motor interface (with transmission function)		
Output	Normal rotation	1a contact relay contact point
	Reverse rotation	1a contact relay contact point
	Stop	1b contact relay contact point
	Abnormality alarm	1c contact relay contact point (overload, open phase, ground fault) 1a contact relay contact point (cpu of trouble)
Input	8 points	100VAC input: 5 points (for 88F, 88R, 52, 52 trip) 100VAC input: 3 points (moter-normal rotation/reverse rotation/stop)

Fig. 5 Block diagram of remote controller (for motor starter measurement)



a breaker trip coil, and a transmission function into one built-in unit. **Figure 6** shows an external view of the remote controller. **Figure 7** shows the system configuration of the remote controller for power receiving and for distributor measurements. **Table 4** lists names, types and specifications of the remote controllers for power receiving and for distributor measurements.

Fig. 6 Remote controller (for power receiving measurement and for distributor measurement)



N89-6288-21

Table 4 Specifications for remote controller

Type		Remote controller for power receiving measurement	Remote controller for distributor measurement
1. General specifications			
Type designation		UN1R	UN1F
Power supply voltage		100 to 120VAC, 200 to 240VAC (50/60Hz), 100VDC	
Ambient temperature		−10°C to 55°C	
Ambient humidity		20 to 90%RH (No dewing permisible)	
Storage temperature		−30°C to 70°C	
Network type		R-link	
2. Function specifications			
Measurement input signal		3-phase voltage AC150V, 3-phase current (auxiliary CT input), Pt100	
Measurement		A:R, S, T V:U, V, W kW Pf °C	A:R, S, T V:U, V, W Pf °C
Items to be displayed		Above measured value (7 segment LED, four digits), Conversion from PT, CT	
Transmission		A: one channel from among R, S, T V: one channel from among U, V, W kw Pf °C	A: one channel from among R, S, T kw °C
3. Control and display functions			
Control switch		Control switch to turn on CB, control switch to turn off CB, selector switch to change remote/direct state, selector switch for display (one channel from among A, V, W, Pf, °C)	
7 segment LED for display		Measured value of A, V, W, Pf, °C Display of error, abnormal set, etc., by code	
LED for display		POW, RUN, state of CB-on/off, state of direct/remote set, displaying item on 7 segment LED	
4. CB interface (with transmission function)			
Output	CB on	1a contact point SSR 0.7 sec−pulse output permissible current 5A	
	CB off	1a contact point SSR 0.7 sec−pulse output permissible current 5A	
	the other	1a contact relay contact point (continuous current carry 1A)	
Input	7 points	100VDC input: 1 point (for watch trip coil) No voltage contact input: 6 points (for CB on/off signal and another signal)	

Fig. 7 Block diagram of remote controller (for power receiving measurement and for distributor measurement)

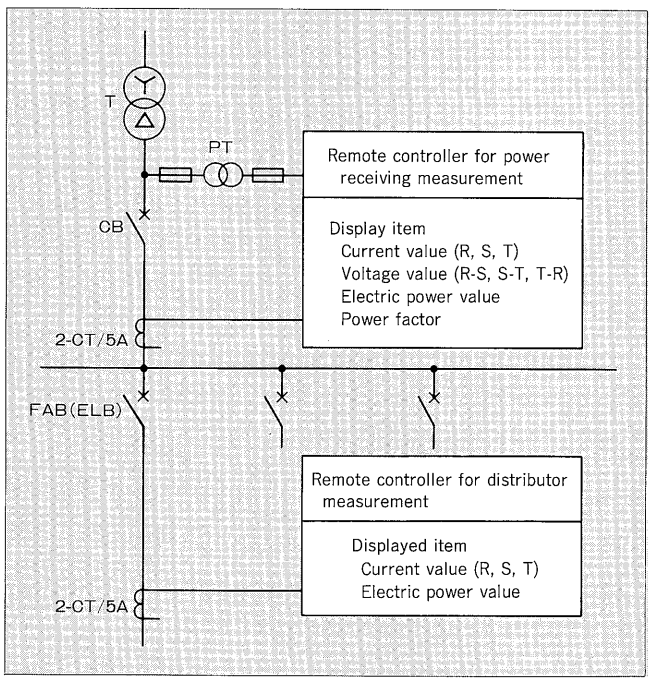
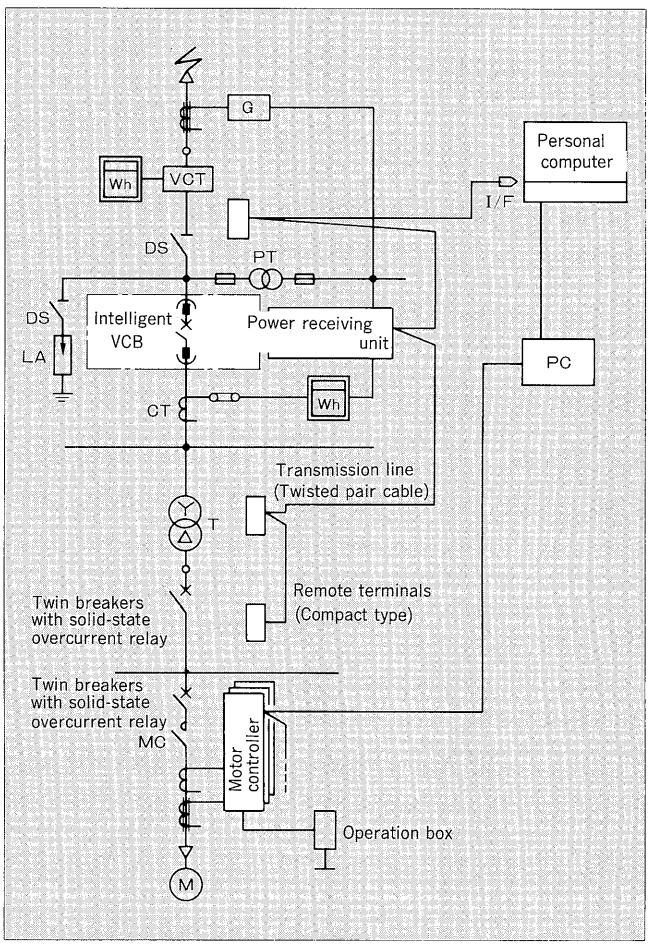


Fig. 8 Application of FI-Net



5.4 System controller

The system controller supervises, controls, and automatically operates the FI-Net system.

Using a standard FA personal computer (FMR-FA type) or PC, the system controller exchanges signals and data, if necessary, with the host computer.

Connection of the system controller to the FI-Net is described below.

(1) FA personal computer as a system controller

When an FMR-FA personal computer is used as the system controller, the hardware is connected by an interface board for the FI-Net with an expansion slot.

(2) PC as a system controller

When a MICREX-F80H or an F120H is used as the system controller, the hardware is connected by an interface module for the FI-Net with a bus.

5.5 Software package for the FMR-FA personal computer

Software production cost can be a major problem in constructing an integrated supervision system that uses a personal computer. In constructing a small or medium scale system, the ratio of software production cost to a total cost becomes high when new software must be developed.

To solve the problem described above, software packages focusing on power distribution and related fields are being made available. The software packages facilitate construction of an integrated supervision and control system at low cost by allowing the user to select necessary functions with simplified settings.

6. Example of Real Network

Figure 8 shows an example configuration of high voltage power distribution equipment which uses the FI-Net. In **Fig. 8**, a power receiving measurement unit, a high voltage breaker, a low voltage breaker and motor circuit devices are connected to the FI-Net, and the devices are supervised and controlled through the FI-Net.

7. Conclusion

The FI-Net integrates standard devices in an information network to which standard electrical devices are easily and functionally coupled. The FI-Net also provides the standard devices with intelligent functions.

Electrical equipment with higher reliability and higher functionality as well as further modification of the component devices and systems will be required. To meet these future requirements, Fuji Electric is exerting its full effort to develop and introduce the necessary devices and functions.