

Latest Expansion of F-MPC Series Power Protection & Monitoring Equipment and its Technology

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1. Introduction

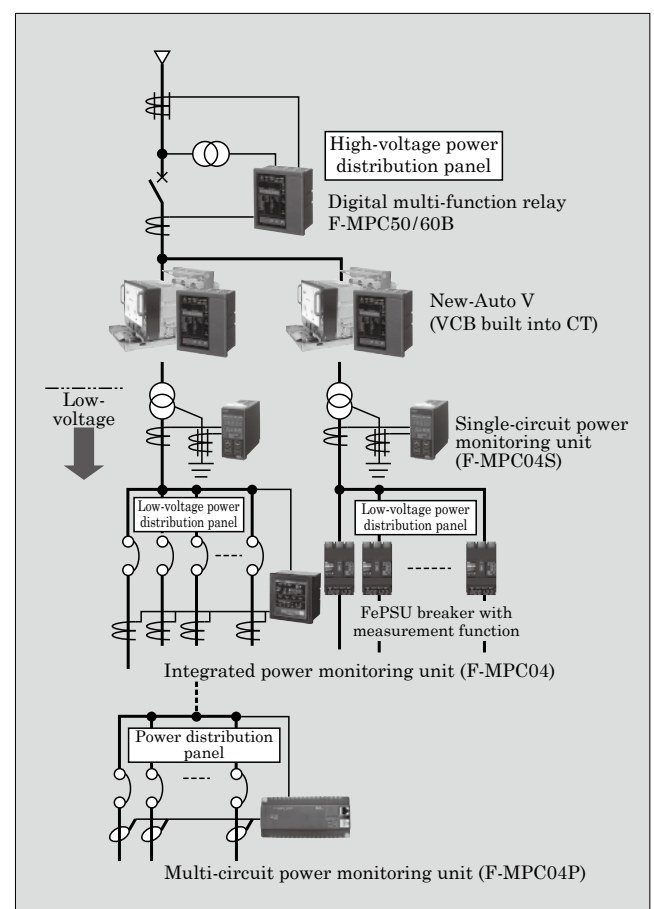
To maintain and manage a power distribution facility, various protective relays and indicators have been used. The elemental technology employed by the measurement and protection functions of such power distribution equipment has evolved from induction type (mechanical), to static type (transistor and analog circuit) and then to digital type (digital and software computation) technology, which is the method most widely used at present.

Capable of maintaining stable characteristics even after long-term use and having high accuracy of measurement and low deterioration of characteristics, digital technology came into use as higher levels of reliability and stability were requested due to the larger loss and greater severity of consequences due to unforeseen trouble with the supply of power as a result of trends toward (1) advanced information as typified by the sudden proliferation of OA equipment and data networks, and (2) the increased automation and higher functionality of manufacturing equipment. Moreover, in the power distribution equipment that forms the basis for the supply of power, greater visibility of the equipment operating state and a higher level of monitoring reliability through the use of networking technology were also required.

Furthermore, in response to the imminent problem of global warming, a reduction in the amount of future energy usage by verifying the recording, managing and verifying the results of more precise usage quantities is requested, and greater multi-functionality and enhanced system compatibility of power distribution equipment is also increasingly requested.

In response to these requests, Fuji Electric has developed the F-MPC series of digital multifunctional relay and power monitoring units, and through combining the multiple functions of power distribution equipment, aggregating multiple circuits into modular units and adding integrated high-voltage and low-voltage circuit breakers, has provided a series of power distribution equipment as shown in Fig. 1, suitable for

Fig.1 Configuration of F-MPC series of power monitoring instruments in a power distribution facility



applications ranging from high-voltage to low-voltage. Incorporating functions and new technologies that support the needs of the times, the F-MPC series has been well-received in applications involving new equipment or during the replacement of equipment, i.e., renewal or upgrading.

On the other hand, products developed in response to such types of wide-ranging requests, uses and applications and that incorporate multiple functions are often cumbersome to use, and a narrowing and refinement of the functions is requested. In consideration thereof, this paper narrows and refines these applica-

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tion fields and uses, and introduces the latest models of a series that includes a system link unit, a high/low voltage transformer panel unit and a transformer protection unit. The F-MPC Web Unit, capable of easily connecting these field devices via a LAN and enabling unified management, is also introduced as a product that facilitates systemization.

2. Expanded Lineup of Digital Multifunctional Relays

2.1 F-MPC50 grid-interconnection unit

Amid the increasing severity of the global warming problem, the Japanese national project known as “Team Minus 6 Percent” and other initiatives are furthering activities to promote energy conservation and deregulation of electric power. Moreover, as targets are set for reducing CO₂ emissions and the scope of mandatory management is expanded in accordance with the revision of the “Act Concerning Rationalization of Energy Usage” (Energy Conservation Act) in

Table 1 Specifications of the F-MPC50 grid-interconnection unit

Item	Specification
Control power source voltage	100 V/110 V DC, 110 V/220 V AC common use
Frequency	50/60 Hz (dual-use, setting selection)
Current (CT secondary) Voltage (VT secondary)	5 A AC (phase current), 110 V AC (line voltage)
Zero phase voltage ZPD method	ZPD: Specified for combined devices ZPD-2 (made by Fuji Electric)
Allowable power outage time	Operation continues for 2 s in the case of power outage from control power source of 170 V AC
Protection elements	Reverse power (RPR), underpower (UPR), overvoltage ground (OVGR), demand power
Measurement functions	RMS value (voltage, current, zero-phase voltage), frequency, active power, reactive power, power factor, demand (current, active power), active energy, reactive energy
Transducer	Active power output: 2 points Output pattern selectable from the following: (1) 4 to 20 mA/ 0 to 100% (100% = 953 W) (2) 2.4 to 20 mA/-10 to +100% (100% = 953 W) (3) 4 to 20 mA/ 0 to 100% (100% = 833 W)
Pulse output	Active energy, open collector output and output pattern selectable from the following: (1) 10 ⁿ kWh/pulse (n = -2 to +4) (2) 2,000 pulses/kWh (3) 10,000 pulses/kWh (4) 12,000 pulses/kWh
Communication function	Standard: EIA RS-485 No. of attachable stations: 32 units max (including master) Address setting: 01 to 99 Transfer speed: 4,800/9,600/19,200 Data format: Start bit, stop bit = 1 (fixed) Data length 7/8 bits Parity none/even/odd Protocol: F-MPC-Net
External dimensions, mass	165 (W) × 131 (D) × 192 (H) (mm), 1.4 kg

Japan, an increasing number of users are installing dispersed power supplies.

In particular, at plants and large-scale commercial facilities where large amounts of energy are consumed, energy savings is being promoted through the use of dispersed power sources such as wind power generators, photovoltaic generators, GHPs (gas heat pumps), micro gas turbines and the like.

With the progress of electric power deregulation, power supplied from a continuous power system and dispersed power sources can be used simultaneously, and the installation of dispersed power sources is being promoted.

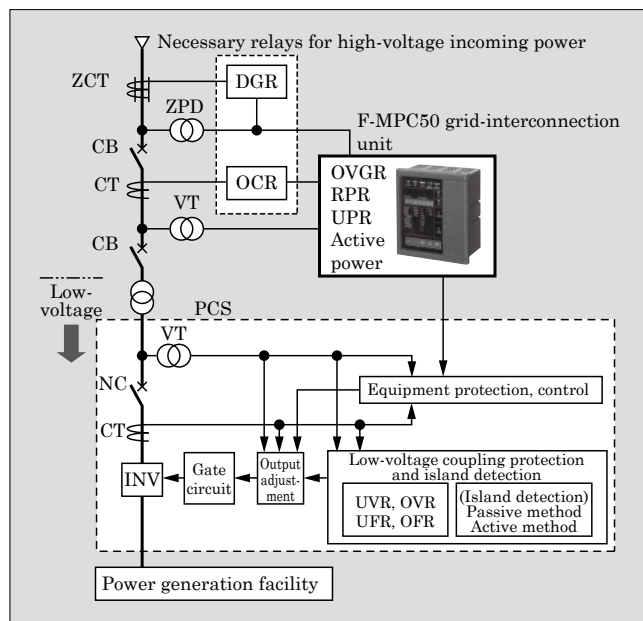
When such dispersed power sources are “grid-interconnected” with coexisting power supplied from a power company, certain prescribed protection functions are essential. Fuji Electric has developed the F-MPC50 series of grid-interconnection units provided with both the necessary protection functions for a grid-interconnection protection system that assumes there is no backward flow (power is not being sold) and the measurement functions necessary for the control of a dispersed power source in a grid-interconnection with high-voltage incoming power using the aforementioned type of dispersed power source.

(1) Specifications of the F-MPC50 grid-interconnection unit

Table 1 lists the specifications of the grid-interconnection unit.

Leveraging the characteristics of a digital multifunction relay, a communication function is provided that enables multiple protection relay elements, various types of measurement functions, an analog output (transducer) function for measured power values, and the construction of a monitoring system.

Fig.2 Applied configuration example (using PCS, no backward flow)



(2) Applicable system and required functions

Assuming there is no backward flow, Fig. 2 shows the system configuration and required protection functions in the case where the dispersed power sources are connected to the low-voltage side and grid-interconnection is implemented on the high-voltage side.

Recent dispersed power sources have a PCS (power conditioner system) on the power generator equipment side, and with this PCS, realize protection functions (islanding detection, over voltage, over current, under voltage) that can be implemented on the low-voltage side to which the power generating facility is connected.

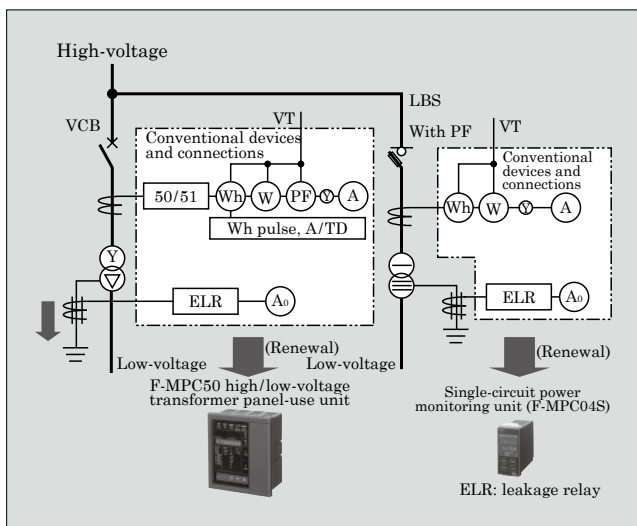
According to the “grid-interconnection code” of the JEA (Japan Electric Association), in the case where a PCS is used and there is no backward flow, grid-interconnection on the high-voltage side additionally requires a reverse power relay, an overvoltage ground relay, and an undervoltage relay as a protection functions at the point of common coupling. Moreover, at a power generating facility, in the case where the consumer-side load is small and the power generation is clearly excessive, measurement of the load power at the receiving point and a process that does not generate power is necessary.

Manufacturers that provide these types of dispersed power sources must add individual devices such as a protective relay and transducer to the PCS and construct a grid-interconnection dispersed power source system. In order to realize these functions in a single unit, the newly developed F-MPC50 grid-interconnection unit enables a streamlined system, a significant reduction in size of the equipment casing, and realizes an overall cost reduction for the system.

2.2 F-MPC50 high/low voltage transformer panel unit

Figure 3 shows the skeletal configuration of a

Fig.3 Example of high/ low transformer panel configured with conventional devices, and replacement using the F-MPC series



high/low voltage transformer panel constructed with conventional devices, and an example of an integrated replacement using the F-MPC series. As a disconnecting device for the main circuit, a high-voltage vacuum circuit breaker (VCB) is used with a large capacity transformer of approximately 500 kVA or higher, and a fuse-switch combination is typically used with smaller transformers. As measuring instruments, in addition to an ammeter, watt hour meters are also being installed recently for the purpose of assessing the energy usage amount and managing energy savings. Also, on the secondary side of the transformer, with the aim of monitoring deterioration in the insulation of a low-voltage distribution cable, leakage relays are being used for monitoring the leakage current of B-type grounding wire on the secondary side of the transformer.

The F-MPC50 high/low transformer panel-use unit integrates overload, overcurrent and low-voltage side leakage relays and meter functions so that the number of devices and the wiring between devices can be reduced significantly when used in combination with a high-voltage VCB. Moreover, earth leakage monitoring of the low-voltage earth leakage wire on the secondary side of the transformer, a characteristic feature of this device, enables monitoring of not only the current level, but also enables preventative maintenance for diagnosing deterioration trends according to continuous current trends with upper level monitoring equipment. Furthermore, similar monitoring on the smaller capacity transformer side that used a load break switch (LBS) is also economically viable, and an upgraded version of the software for the F-MPC04S field device has been developed and prepared as a series product. Table 2 lists a functional summary of these devices.

Table 2 Specifications of F-MPC units for use with transformer panel

Item		F-MPC50	F-MPC04S
Combined devices		VCB	LBS
Protection	50, 51	○	
	Low-voltage ELR	○ (Iob)	○ (Iob/Io)
Alarm	OC alarm	○	○
	OCG alarm	○ (Iob)	○ (Iob/Io)
Measurement	Voltage × 3	○	○
	Current, Demand current × 3	○	○
	Leakage current, Demand leakage current	○ (Iob)	○ (Iob/Io)
	Power, Electric energy, Reactive power, Power factor	○	○
Leakage current measurement, Electric leakage relay specification values		Measurement range: 0 to 2,000 mA Electric leakage relay, Electric leakage pre-alarm 0 to 2,000 mA adjustable With function for recording historical max. value of leakage current demand	

Fig.4 Overview of F-MPC60B transformer protection unit

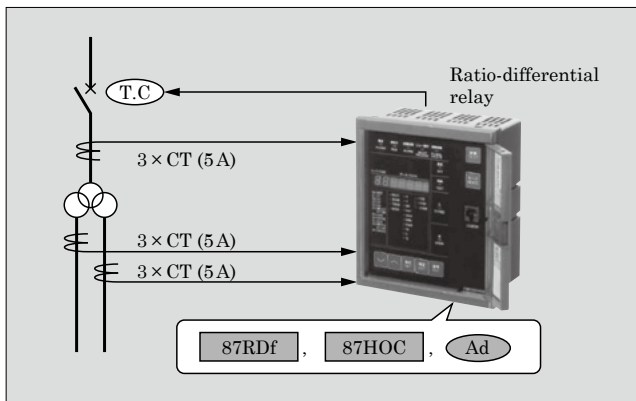


Table 3 Specifications of the transformer protection unit

Item		Specification	
Applied transformer		2-winding transformer, 3-winding transformer	
Rating	Control power source	100/200 V DC (80 to 286 V DC) 100 V AC (85 to 132 V AC)	
	Frequency	50 Hz or 60 Hz	
	CT2 rated current	5 A	
Protection	Ratio-differential (87RDf)	Operating current sensitivity	30% or more of reference current setting
		Ratio characteristics	30%, 40%, 50% (selectable)
		Secondary harmonic current suppression	Does not operate at greater than 15 or 25% (selectable) of secondary harmonic current
	Differential circuit over current (87HOC)	Operating type	$I_a >$ current setting value
Current stabilization		2.0 to 10.0 × the value of the reference current stabilization (Step 1.0)	

2.3 F-MPC60B transformer protection unit

The F-MPC60B series has been expanded with the addition of a ratio-differential relay model for transformer protection. The F-MPC60B series of digital multifunction relays provide full redundancy of the main relay and fail safe relay CPU. The F-MPC60B transformer protection unit is capable of protecting a three-phase double-winding transformer, and an application overview and specifications are shown in Fig. 4 and Table 3, respectively. A secondary harmonic current suppression function is provided to prevent unwanted operation due to the transformer's inrush current, and by adapting the harmonic current suppression to the three-phase total circuitry current, enhanced reliability with regard to the prevention of unwanted operation can be realized.

3. F-MPC Web Unit

With the goal of centrally managing the measure-

ment and monitoring data from the F-MPC series of field devices, the field devices and a PC are connected via a field network, and monitoring data is collected in the PC. Conventionally, with the F-MPC series, measurement and monitoring data is collected and managed with the F-MPC-Net software package running on the PC that collects data using a proprietary protocol via a RS-485 interface, used as a field network, which is highly resistant to noise and for which wiring is easily routed

Meanwhile, LANs (Ethernets*1) are becoming popular as networks suitable for collecting large quantities of data, and large quantities of data can be monitored easily and inexpensively by uploading power monitoring data via a LAN into a PC. For this purpose, Fuji Electric has developed the F-MPC Web unit that easily configures a power monitoring system by converting and connecting the RS-485 interface, provided as standard with the F-MPC series, to a LAN.

A consequence of using a PC to collect the measurement and monitoring data is that the PC must operate 24 hours per day. Also, a server function is needed in order to access the collected monitoring data on each PC connected to the LAN. In a large-scale system with many monitoring points, the installation of a 24-hour-per-day operational server and system operation to centrally manage large quantities of data are becoming widespread. However, in medium- and small-scale power monitoring systems with few monitoring points, the installation of a new server is often viewed as difficult from the standpoints of cost and reliability.

For this reason, the functionality of the F-MPC Web unit was expanded, and functions were added for collecting monitoring data from medium- and small-scale systems having up to 256 monitoring points and then transmitting the collected monitoring data to a PC connected to a LAN (power monitor Web page function). Figure 5 shows the system configuration.

The main characteristics of the F-MPC Web unit are as follows.

(1) Power monitor Web server function

F-MPC Web unit has the Web server function of the power monitoring screen shown in Table 4, and the power monitoring screen can be accessed from a web browser running on a PC.

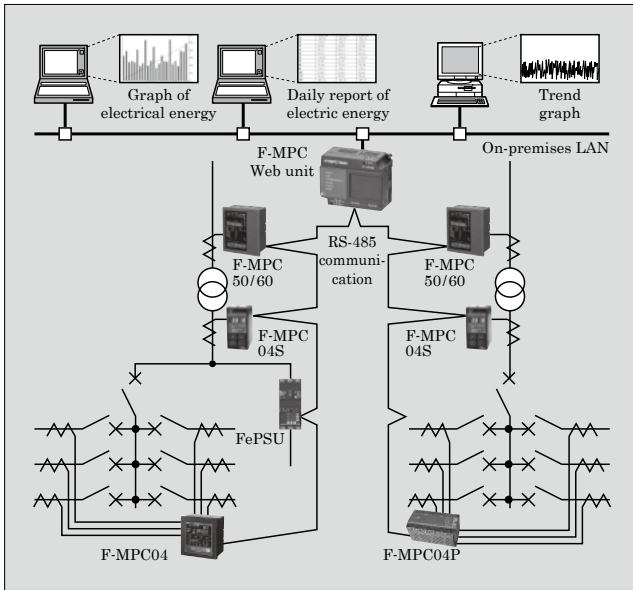
(2) Setting utility having auto setting function

The F-MPC Web unit is provided with a setting utility that automatically recognizes F-MPC series devices connected via a RS-485 interface and automatically creates, with minimum operation, web pages suitable for individual system configurations. Using this setting utility, detailed settings, such as demand monitoring and alarm monitoring, can be implemented.

(3) Data accumulation function with daily, monthly and yearly reports

*1: Ethernet is a registered trademark of Fuji Xerox Corporation.

Fig.5 System configuration of F-MPC Web unit



Daily, monthly and yearly reports can be stored in internal memory. The stored daily, monthly and yearly reports can be accessed with a Web browser, and transmitted as CSV-format files.

(4) Compact dimensions

The F-MPC Web unit has the dimensions of 100 (W) × 56 (D) × 70 (H) (mm), and can be attached to a standard distribution board and to a DIN rail, and is compatible with control power sources of 100 to 240 VAC.

(5) Scalable to large-size systems

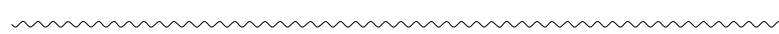
Each F-MPC Web unit can monitor up to 256 points, and if there are more than 256 points, multiple F-MPC Web units may be used or the F-MPC-Net package that supports large-size systems of up to 6,000 points may be installed.

Table 4 Contents of power monitoring Web screen displays

Type of monitoring screen	Screen summary	Auto creation
Power monitoring screen	Display of daily, monthly and annual power graphs	Supported
Trend monitoring screen	Displays analog trend graphs of current, voltage and the like at 2-hour, 4-hour, 1-day and 5-day intervals.	Supported
Power factor monitoring screen	Display of analog trend graph of power factor at 2-hour, 4-hour, 1-day and 5-day intervals.	Supported
Measurement value display screen	Display of list of measurement values for each circuit	Supported
Time setting screen	Setting of internal time for F-MPC Web unit	Supported
Demand monitoring screen	Can monitor power demand for up to 2 points	-
Alarm list screen	Alarm display when preset alarm threshold value is exceeded (mail notification is also supported)	-
Group power	Displays comparative graphs of power for already categorized groups and sub-groups	-

4. Postscript

To support customer needs, the new models of the F-MPC series introduced above have been optimized and commercialized based on Fuji Electric's distribution, protection, control and monitoring technology. As the global infrastructure is digitized and networks proliferate, needs will diversify and higher reliability will be required. In the future, a diagnostic function is planned for each of these models, and Fuji Electric intends to continue to advance timely products.





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