Devices for Facility and Energy Monitoring Systems –Expansion of "F-MPC Series"–

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ABSTRACT

Fuji Electric provides various products to reduce energy consumption and improve power supply reliability in power distribution systems. It offers several new products that promote a recent energy saving trend. One is the "F-MPC04E", a compact electrical power meter that efficiently monitors terminal equipment, such as distribution panels. Another is the "F-MPC I/O unit", a digital input and output unit which measures electrical metering pulses, monitors non-electric energy or other physical flow value, and outputs warnings. One more is the "F-MPC Igr", an Igr type insulation monitoring device that constantly monitors for leakage of electricity from critical intelligent equipment. Combined with the existing "F-MPC Series" instruments and package software, it can provide electrical power monitoring and insulation monitoring simultaneously.

1. Introduction

With the revision of the Japanese "Law Concerning the Rational Use of Energy" (Energy Conservation Law) in 2010, the target of mandatory energy management has expanded from each factory and business office to each company and corporation. Furthermore, the range of factories that are obligated to monitor energy consumption was expanded, commercial sector including offices and convenience stores was added, and the number of factories, offices and stores that are subject to this law has increased significantly.

To solve the power supply shortage stemming from the Great East Japan Earthquake in March 2011, not only must the total energy usage be reduced and leveled through "energy savings," but suppression of the maximum power usage must also be stepped up to the higher "power cutting-down stage."

Moreover, as reduced energy usage is demanded, the automated inspection of facilities and longer intervals between periodic inspections are requested for facility maintenance work mainly at business sites such as data centers and semiconductor fabrication plants where it would be difficult to stop the facility.

2. Background of the Development

As shown in Fig. 1, Fuji Electric has advanced its response to meet the needs for energy monitoring primarily for the electric power in an electricity distribution system and for the status monitoring of electric equipment.

Through ascertaining these needs, this paper introduces monitoring system and the latest devices that aims to provide a stable monitoring of equipment and to realize energy savings and power cutting-down.

Unlike large-scale factories, business office which has newly added to the energy monitoring market by the revision of the Energy Conservation Law, are often unable to set up energy experts into the field. For this reason, Fuji Electric has been offering the "F-MPC Web unit" developed on the concept of easy-to-construct energy visibility system, even when an expert is unavailable. The F-MPC Web unit allows collected data to be checked easily from a general-purpose browser with Web capabilities. As analysis function screens, such as graphs of electric power consumption, trend information, group comparisons, and unit consumption display per production volume, can be viewed without dedicated software, the data can be verified at any time by all users, not just administrators, thus facilitating energy visualization easily.

Fuji Electric has proposed a power and energy monitoring system that uses "F-MPC Series" equipment and ranges from a high-voltage power distribution system to a terminal system (see Fig. 2).

Fuji Electric has also developed the "F-MPC04E"

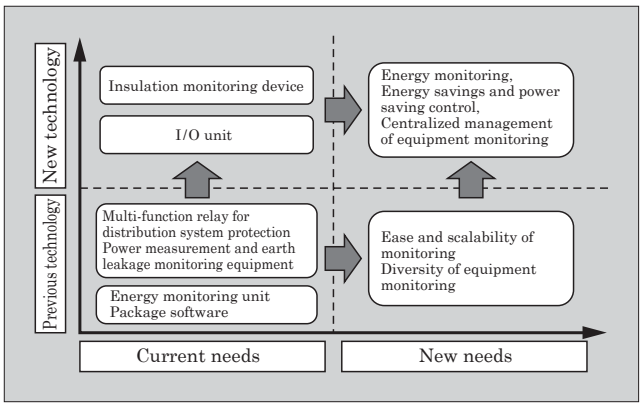

Fig.1 Status of power distribution monitoring

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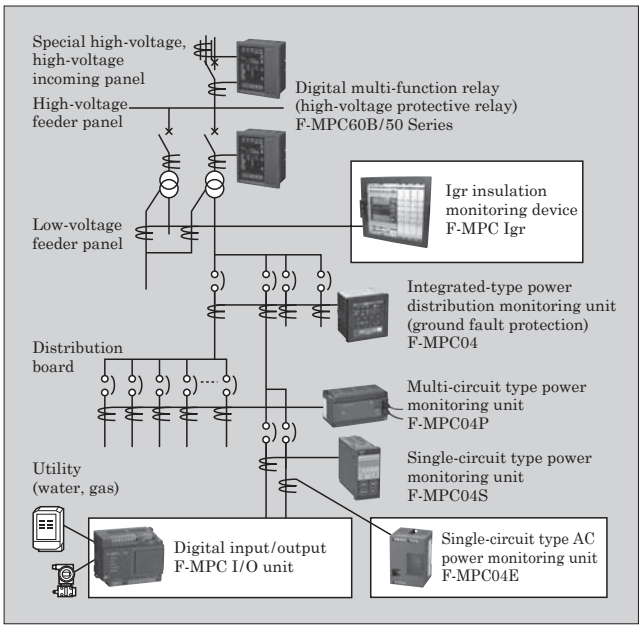
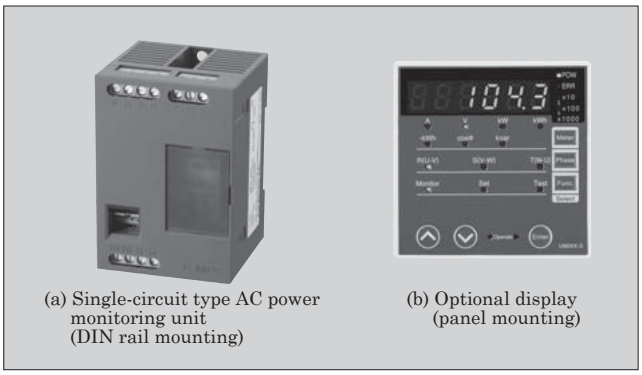


Fig.2 Application configuration diagram of "F-MPC Series"



(a) Single-circuit type AC power monitoring unit (DIN rail mounting)

(b) Optional display (panel mounting)

Fig.3 Single-circuit type AC power monitoring unit

electric power measuring unit, which accommodates the marketplace desire for a low-price measuring device, and the "F-MPC I/O" digital input-output unit, which facilitates the configuration of an energy control system. Additionally, as a facility monitoring device, Fuji Electric developed the "F-MPC Igr" insulation monitoring device which automates insulation monitoring and is highly compatible with the F-MPC Series of energy monitoring systems. Thus, in high-voltage through low-voltage power distribution systems, these F-MPC Series devices can be used to monitor the energy and facility status centrally using a common communication network.

3. Electric power Measuring Device Used in Distribution Panel Inside

As an addition to the "F-MPC04 Series" lineup of electric power measuring units, Fuji Electric developed a compact model, the F-MPC04E, which can be installed easily in an existing distribution panel. The F-MPC04E is a single-circuit type AC power monitoring unit that can be installed easily in a panel by rail-mounting. With a RS-485 communication interface provided as a standard feature, this unit can collect measured electric power values via a communication line, and is well suited for use as a power measuring terminal in an energy monitoring system. Additionally, a dedicated display is available as an option so that the measured values can be checked on a display panel. Figure 3 shows the external appearance of the single-circuit type AC power monitoring unit.

Since the required accuracy for energy monitoring with the F-MPC04E, as same as existing models, is equivalent to the ordinary class specified in JIS, the F-MPC04E is better suited for more economic systems than those existing models. Additionally, setting of the applied current transformer (only for F-MPC dedicated type) and the communication address can be carried out simply by switch operations on the main unit. Consequently, the configuration settings can be implemented easily, without having to connect and energize a display at the time of installation work. As for the measurement of electric power, in a distribution system in which an energy-creating equipment such as a photovoltaic power station is installed, the reverse power flow can be measured and the integrated watt hour value can be recorded in the forward and reverse directions. The F-MPC04E has the following characteristics.

- ○ Size: H80×W55×D58 (mm) (1/2 size of prior model)
- ○ Mass: Approx. 120 g (1/3 mass of prior model)
- ○ Phase and wire system: Single-phase 2-wire, single-phase 3-wire, 3-phase 3-wire (automatic identification)
- ○ Accuracy of the power monitoring: Equivalent to ordinary class specified in JIS
- ○ Communication function: Selectable as either Fuji Electric's F-MPC-Net protocol or general-purpose Modbus/RTU
- ○ Measurement function: Maximum current, average current, minimum current

Maximum current, average current, and minimum current data that are useful in facility management are calculated as root mean square (RMS) values per commercial frequency cycle, and are updated every minute. The latest data is held for 1 minute in the F-MPC04E so that the status of peak current or the like can be managed easily even with a RS-485 low-speed measurement communication line.

Previously, in order to measure the constantly fluctuating inrush current and the like in machinery, instantaneous (waveform) values had to be recorded using an expensive wave recording device. Even with such a recording device, however, data could not be recorded and monitored continuously and permanently, and it was difficult to constantly monitor the operating status of the facility.

For example, in a production line that uses arc

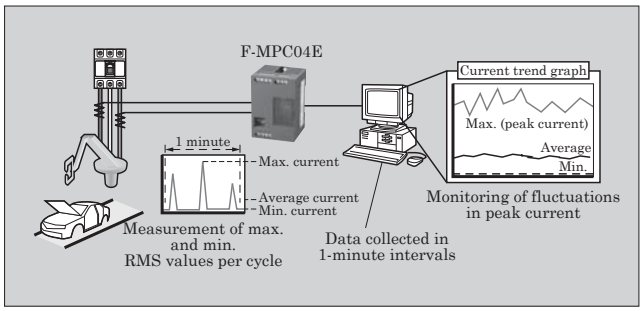


Fig.4 System configuration example of fluctuation monitoring in peak current

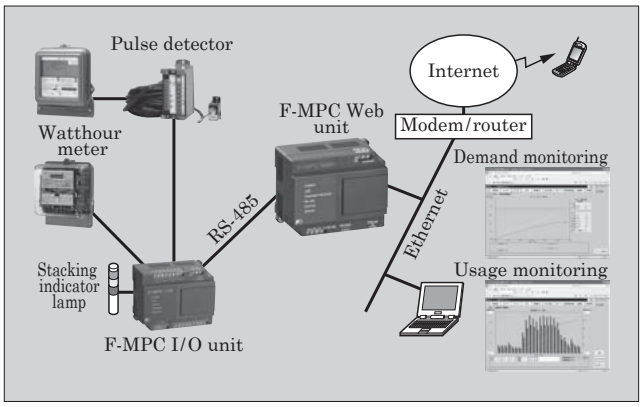


Fig.5 Example of demand monitoring

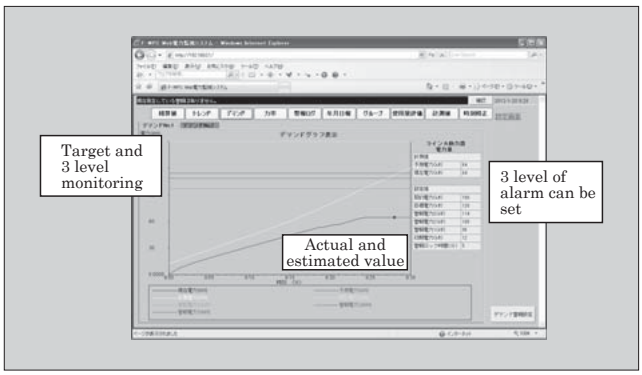


Fig.6 Demand monitoring screen

welding equipment, the value of the arc current is an example of data that is useful for facility management. Because the interval during which arc current flows is extremely short and only lasts for several cycles, it was difficult to manage the arc current with a general-purpose power monitoring system. By using this function of the "F-MPC04E", however, the RMS values of arc current can be recorded and continuously monitored with ease, and can be used as facility management data. Figure 4 shows a system configuration example of the fluctuation monitoring in peak current.

4. I/O Unit Optimally Suited for Energy Monitoring

Since the Great East Japan Earthquake, there has been concern about a supply shortage of electric power, and the purpose of energy monitoring has shifted to peak shaving of instantaneous power. If Japan faces a heat wave in the summer of 2012, a shortage of approximately 10% in peak power throughout Japan is predicted, and ongoing peak shaving should be continued. For this reason, specific measures must be undertaken in a timely manner as the next step after energy visualization. Aiming to facilitate the systematization of such management functions, Fuji Electric developed the "F-MPC I/O unit" that is optimally suited for use in an F-MPC energy monitoring system. The F-MPC I/O unit has the following features.

- ○ Number of inputs and outputs: 6 inputs, 4 outputs
- ○ Size: H80×W100×D58 (mm), same as "F-MPC Web unit", can be installed in a thin-type distribution panel
- ○ Communication function: Fuji Electric's F-MPC-Net protocol or general-purpose Modbus/RTU

Combining the input and output functions of the F-MPC I/O unit and the F-MPC Web unit facilitates coordination for energy visualization with warning alarms and the like.

Figure 5 shows an example of a demand monitoring and alarm system. A single F-MPC Web unit is able to support the demand monitoring of two sites. The F-MPC Web unit sends an alarm message via an Intranet or the Internet when the expected value of electric power is near exceeding a preset alarm level. The F-MPC I/O unit has six digital inputs, two of which are for receiving electric power pulses, and four digital outputs, all of which are relay outputs capable of directly driving a lamp or a buzzer.

In the example of this system, the F-MPC I/O unit counts received power pulses, and the F-MPC Web unit, using a demand monitoring function that estimates the peak power every 30 minutes, issues an alarm by email and by relay output when the target peak power is near to be exceeded. Figure 6 shows a demand monitoring screen of the F-MPC Web unit. Three level of alarm can be set for the target peak power, and because F-MPC04 Series measuring equipment can easily be connected to the RS-485 communication line of the F-MPC Web unit for data collection, the system can be expanded to a more detailed power monitoring system. In this case, an alarm can be output detecting the instantaneous power exceeding with the alarm setting of the F-MPC Web unit, and peak shaving can be realized toward a power-saving target.

Moreover, since the F-MPC I/O unit can count power pulses from a watthour meter for power management, pulses from water and gas meters, and pulses from calorimeters, as well as input power pulses, it can comprehensively manage other utility in addition to electricity.

5. Insulation Monitoring Unit for Equipment in a Live State

In accordance with Japan's "Electricity Business Act," insulation resistance must be measured periodically during power outages as part of the insulation management for low-voltage electrical circuits. For the general measurement of insulation resistance, a facility is required to stop temporarily and then a DC voltage is applied to measure the insulation resistance. The types of loads which cannot be measured with this method, however, are increasing year-by-year. In addition, there are problems such as not knowing the extent of insulation degradation while the facility is operating. Therefore, a function capable of continuous monitoring of the insulation condition during operation of the facility has attracted considerable attention.

According to the Japanese "Safety regulations of electric facilities for private use" that prescribe management of the insulation condition at a facility, by installing a monitoring device that continuously monitors the insulation condition online and outputs an alarm when the insulation condition exceeds a certain level, the inspection cycle can be extended from once a month to once every other month. At facilities such as data centers and semiconductor factories which operate 24-hours a day, the facility status can be monitored during operation, thus enabling prevention of unexpected power outages during operation and fewer power shutdowns for inspections, and therefore, there is increasing demand for an insulation monitoring device that has this type of function.

There are two methods of insulation monitoring, an Igr method which superposes the signal waveform being monitored, and an Ior method which uses the line voltage as a reference. Either of these monitoring methods can be used to manage the insulation condition by removing the higher harmonics contained in the earth leakage current, excluding the earth leakage current due to capacitive components of the cable and the load, and accurately detecting the earth leakage current of the resistance component only. In particular, because the Igr method can be applied to any type of line, can be used to monitor a grounding line and is unaffected by the imbalance among phases in the electrostatic capacitance to ground, the Igr method is superior to the Ior method.

For the F-MPC Series of power monitoring equipment, Fuji Electric developed the F-MPC Igr as an insulation monitoring device that uses the Igr method of superposing the monitoring waveform. Thus, to a conventional power monitoring system, by adding a function for monitoring the insulation state of a facility with the F-MPC Igr, a system can be provided that is capable of simultaneously monitoring both the energy usage status and the insulation status. Table 1 compares the insulation monitoring methods.

Table 1 Comparison of insulation monitoring methods

Item		Io method	Ior method	Igr method
Applicable circuits		All low-voltage circuits	Single-phase 3-wire, 3-phase 3-wire delta	All low-voltage circuits
Detection function	Effect of high harmonics	There is an effect	No effect	No effect
	Effect of electrostatic capacitance to ground	There is an effect	No effect if no imbalance among phases	No effect
	Detection of ground phase	Not possible	Not possible	Possible
Detected components		Magnitude of leakage current	Resistance component within leakage current	Resistance component of superposed low-frequency components
System configuration		Measuring device + ZCT	Measuring device + ZCT	Measuring device + ZCT + injection device + injection transformer
Installation cost		Low	Medium	High

(1) F-MPC Igr configuration

The F-MPC Igr consists of an injection device and an injection transformer to superpose the waveform for monitoring, and a zero phase sequence current transformer (ZCT) and measuring device to measure the current of each circuit (see Fig. 7). The measuring device is configured from a storage case for 4 or 8 circuits, a measuring unit for each circuit, and a base unit for collectively setting data to the measuring units and for displaying data. The conversion from high-voltage to low-voltage is performed by multiple transformers, such as a 3-phase transformer for motor use and single-phase transform for lamp use in a single high-voltage distribution system, and therefore the storage case is selected according to the applied system.

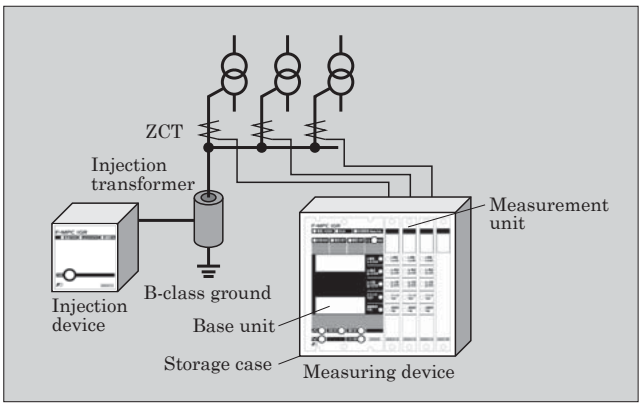


Fig.7 "F-MPC Igr" configuration

Table 2 “F-MPC Igr” specifications

Item	Specification
Superposed frequency	20/15/12.5 Hz
Superposed voltage	10/7.5/6.3 V (linked to frequency)
Injection transformer	30 mm ϕ, 20 turns
ZCT	30 mm ϕ, 1,000 turns
Control power supply	85 to 264 V AC
Measurement function	Leakage current: Io/Iob Resistive leakage current: Igr Capacitance to ground: C
Alarm function	Io/Iob alarm: 0.1 to 3 A, 0.1 to 120 s Igr caution alarm: 5 to 75 mA, 40 s Igr warning alarm: 10 to 200 mA, 10 s
Self-diagnostic function	ZCT connection check function Frequency setting consistency check function Insulation monitoring accuracy check function

(2) F-MPC Igr specifications

Table 2 lists the specifications of the F-MPC Igr. The superposed waveform for monitoring has a minute voltage of 0.5 V or less, and is sufficiently small compared to the voltage of a commercial power supply. Minute earth leakage currents flowing in a circuit are detected with this monitoring waveform, and the F-MPC Igr unit converts the detected values to the voltage level of the applied system to display and monitor those values.

Applied circuit voltages are supported from a minimum of 90 V to a maximum of 440 V in accordance with the distribution system of the manufacturing facility or building.

Utilizing a communication network, centralized monitoring can be performed using Fuji Electric’s “F-MPC-Net Web” power monitoring package software or the like. Moreover, in consideration of stand-alone usage, an alarm output contact is provided for devices collectively and for individual circuits, and the unit is capable of recording the alarm history with a time-stamp for the previous 10 alarm occurrences.

6. Postscript

The “F-MPC Series” of devices for energy monitoring systems supports not only small-scale facilities, but also has superior expandability for supporting medium-scale to large-scale monitoring systems.

The devices introduced herein enable reductions in system cost, facilitate support of warning alarms that lead to energy savings and power cutting down as a next step after visualization, and enable systems to be expanded for facility monitoring.

While continuing to leverage the merits of these advantages, Fuji Electric intends to promote the expansion of systems and devices capable of making positive contributions to energy savings and power cutting down policies, and to contribute to measures for reducing energy consumption by the customers, leading to improvement of the global environment.