

FUJI ELECTRIC REVIEW

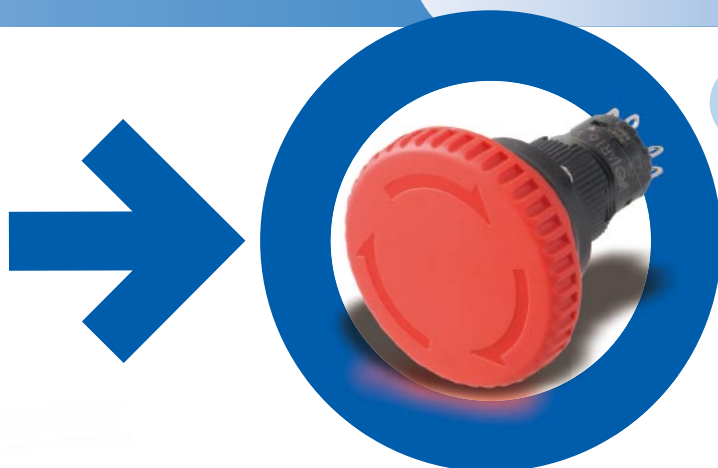
Low-voltage Distribution Switching
Equipment and Monitoring Control
Equipment



2008 VOL.54



Fuji Electric Group



n the Mark

Introducing Miniature Command Switches

Fuji Electric, the world's leading manufacturer of electrical components, expands its distinctive line of reliable push buttons, switches and pilot lights with the new 16 mm **minico** series, featuring the shallowest depth in the market for industrial applications, specifically designed to fit today's ultra-thin control panels and to save wiring time with effective socket accessories.

- *Offered in 16 mm size with monolithic body*
- *Available in 37 shapes*
- *Complete oil-, dust- and water-proof operator module construction (IP65)*
- *Simple design means easy installation and detachment*
- *UL, CSA, TUV and CCC approved; meets RoHS directive*

minico

the right switch



Fuji Electric FA Components & Systems Co., Ltd.

<http://www.fujielectric.co.jp/fcs/eng/>

FUJI ELECTRIC REVIEW

4

2008 VOL.54

Low-voltage Distribution Switching Equipment and Monitoring Control Equipment

CONTENTS

Present Status and Future Outlook for Low-voltage Distribution Switching Equipment and Monitoring Control Equipment	114
---	-----

Expanded Product Line of G-TWIN Series Breakers with Accessories to Enhance Functionality	119
---	-----

Latest Expansion of Command Switch Product Line and its Technology	124
--	-----

Latest Expansion of F-MPC Series Power Protection & Monitoring Equipment and its Technology	129
---	-----

Cover photo:

FA manufacturing enterprises, such as automobile and machine tool manufacturers, are expanding their production bases overseas to countries such as China and India, and are entering those overseas markets where infrastructure improvement and production facility investment are active. Meanwhile, in Japan, their equipment investment is concentrated to achieve high-value-added products. Therefore, Japanese FA manufacturers are changing to adopt a global business structure. In response to these industry trends, electrical equipment manufacturers are actively developing new globally applicable products. Furthermore, the implementation of safety related features in Japanese Industrial Standard based on IEC-style risk assessment, and the acceleration of energy reduction regulation to protect the global environment have affected the requirements for electric equipment.

Fuji Electric has launched new products, such as a G-TWIN breaker, a manual motor starter, and a $\phi 16$ shallow depth command switch, that support such true globalization.

The cover photo illustrates the global compatibility of this equipment with an image of true global equipment for surrounding of the Earth.

FUJI ELECTRIC REVIEW vol.54 no.4 2008

date of issue: November 20, 2008

editor-in-chief and publisher Masaru Yamazoe
Technology Strategy Division
Group Technology and Business Strategy Center
Fuji Electric Holdings Co., Ltd.
Gate City Ohsaki, East Tower,
11-2, Ohsaki 1-chome, Shinagawa-ku,
Tokyo 141-0032, Japan
<http://www.fujielectric.co.jp/eng/index.html>

editorial office Fuji Electric Journal Editorial Office
c/o Fuji Electric Information Service Co., Ltd.
1 Fuji-machi, Hino-shi, Tokyo 191-8502, Japan

Fuji Electric Holdings Co., Ltd. reserves all rights concerning the republication and publication after translation into other languages of articles appearing herein.

All brand names and product names in this journal might be trademarks or registered trademarks of their respective companies.

Present Status and Future Outlook for Low-voltage Distribution Switching Equipment and Monitoring Control Equipment

Katsunori Kuboyama[†]

1. Introduction

Instrument products for low-voltage distribution switching equipment and monitoring control equipment are being used in control panels and distribution panels as critical protection and switching control equipment for low-voltage electric equipment. These instrument products are used not only with the domestic equipment of our customers in Japan but also are being exported for use with overseas equipment.

Additionally, based on the trend of increased local procurement by overseas companies, the globalization of product performance and ability to respond rapidly to requests of overseas markets are important.

This paper introduces characteristics of Fuji Electric's new product series developed in response to market trends for instrument products, and discusses Fuji's plans for future efforts.

2. Trends of Low-voltage Distribution Switching Equipment and Monitoring Control Equipment and Fuji Electric's approach

2.1 Market trends

The global market for low-voltage distribution switching equipment and monitoring control equipment is exhibiting strong growth in India, an economically developing country representative of the BRICs and having a large concentration of IT information companies, and in China where industrial and economic activity is spreading from coastal to inland regions, a social infrastructure is being developed and capital is actively being invested in industrial equipment, and the economic trends of expansion in China and other Asian regions are expected to continue in the future.

Meanwhile, in Japan, affected by the recent sub-prime problem in the US, the rise in crude oil prices, and a sudden rise in materials costs, there is a sense of uncertainty regarding future business conditions, but in the flat panel display and semiconductor industries, capital investment continues to be strong in equipment and facilities that have positioned Japan as a produc-

tion center for high-value added products.

Furthermore, in the automobile industry and the machinery and equipment industry, as represented by machine tools that support the automobile industry, the shifting of production sites to overseas locations and the participation in overseas markets is developing dynamically. Such global investment in equipment and facilities is expected to continue to increase for each industry, both in Japan and overseas.

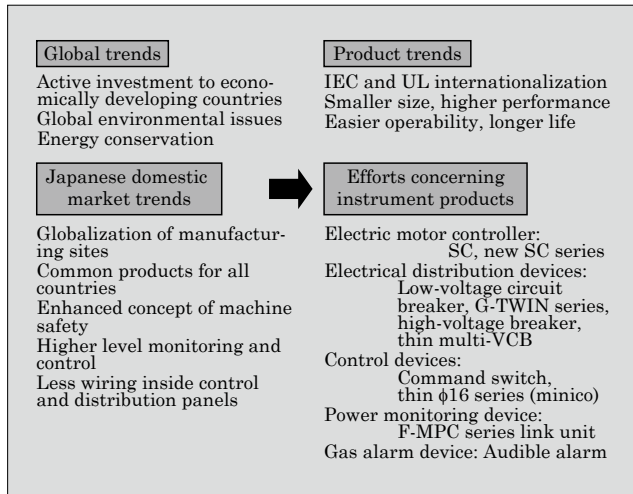
2.2 Technical trends and Fuji Electric's approach

In order to respond accurately to the abovementioned type of market trends as a global top-level component manufacturer, the core technical development necessary for globalization of instrument products forms a basis upon which the ascertaining of customer requests and trends of standards for the machinery and equipment industry and the electrical distribution and control panel industry in which products are used, the determination of the market direction, and the development of ongoing new standard products and creation of new markets will continue to be of vital importance.

For the instrument products used in electrical facilities and equipment in Japan, a new JIS (Japanese Industrial Standard) that incorporates IEC standards (international standards) into the JIS for individual instrument products has been issued, and the JIS C 8201 series, harmonized with the IEC 60947 series, has been established for electromagnetic switch and molded case circuit breakers. This new JIS cites both the Japanese domestic extended official regulations and the public building construction standard specifications, and equipment designers are able to use new JIS products in the same manner as with conventional JIS. The introduction of international standards is also expanding to the general concept of safety for machinery and equipment. In 2006, the Japanese "Industrial Safety and Health Law" was revised, and as a philosophy for machine safety and electrical safety, the implementation of risk assessment to diagnose risk was mandated. With this revision, from the designing of the machine type through all phases of the machine lifecycle, hazards are identified and the removal or minimization of

[†] Fuji Electric FA Components & Systems Co., Ltd.

Fig.1 Market trends and Fuji Electric's efforts concerning instrument products



risk (danger) is sought, and the concept of functional safety is incorporated into not only the hardware, but also the software, i.e., into a series of operation control circuits that range from operation to risk detection and stopping. Fuji Electric intends to create switching equipment and control equipment products that incorporate an HMI (human-machine interface) concept that gives consideration to the safety of the operator based on the development of highly reliable and low-voltage distribution equipment products that meet new JIS, IEC and UL standards.

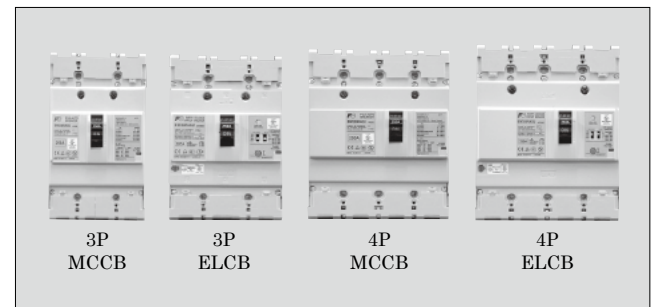
Moreover, responding to the issue of global warming, 2008 marks the beginning of the first commitment period for the "Kyoto Protocol," and countries throughout the world are accelerating full-fledged efforts to reduce energy consumption. In response to increased requests for recording and managing daytime and nighttime load fluctuations and the detailed changes in the usage of electric power that accompany an increase or decrease in production quantity, increased requests for the monitoring of each production facility, and customer needs for both concentrated monitoring and dispersed monitoring of equipment in the power monitoring and control field, the functionality of products used to construct a monitoring system easily must be enhanced in order to support the various energy sources handled by customers.

Figure 1 shows the market trends and Fuji Electric's efforts concerning its instrument product group. The latest new products are introduced below.

3. Approach to Low-voltage Breakers

In 1990, Fuji Electric launched the world's first "Twin Breakers" that unified the external dimensions of molded case circuit breakers (MCCB) and earth leakage circuit breakers (ELCB). As a result of the tremendous response and support from our customers, this concept has become the "de facto standard" in

Fig.2 G-TWIN series (250 AF)



Japan. In recent years, the trend toward globalization in the low-voltage breaker field has accelerated as a result of the harmonization of the conventional JIS with IEC standards. However, due to differences in distribution and control systems and in safety and protection concepts, the IEC standards seem to be coexisting simultaneously with the UL and CSA standards. For this reason, manufacturers from each country had to provide two series of breakers to meet each of these standards.

In addition to providing the required performance of the IEC standard, the provision of the required performance of the UL and CSA standards, which had only been realized with large breakers, achieved "true globalization", and in response to requests for current-limiting interruption performance and earth leakage detection performance, which are highly difficult to realize for both standards, Fuji Electric comprehensively reviewed each individual elemental technology, and moved forward with innovative development. As a result, the 125 to 400 AF (ampere frame) "G-TWIN series" of truly global twin breakers shown in Fig. 2 was introduced to the market. Consequently, the user-side confusion concerning the application of products in the global market was resolved all at once.

The main features of the G-TWIN series are listed below.

- While maintaining the Japanese domestic standard compact size, new JIS/IEC (Japan, Europe), GB (China) standard certification, and UL489 (United States) standard certification has been acquired for the same product (an industry-first)
- Applicable to 480 VAC delta circuit systems of UL489
- Compatible with IEC 60947-2 Ed.III for ELCBs, ensures safety of equipment that detects ground faults reliably even during the loss of one phase, and is equipped with a dielectric test switch for maintenance-use (an industry-first).
- Two series are provided: a G-TWIN global series that supports all standards, and a G-TWIN standard series that support new JIS/IEC and GB standards
- The same internal accessories can be used for both the 125 AF and 250 AF

Owing to the above characteristics, the G-TWIN series meets the requirements of customers considering the deployment of global sites, and are innovative new products that eliminate the labor and complexity involved in selecting equipment models, and contribute to an overall improvement in efficiency.

4. Approach to Operation Indication Devices

Fuji Electric sells operation and switching indicators used in industrial machines, tooling machines, and control panels and distribution panels under the commercial name of “command switches,” and provides a lineup of various such products ranging from flat command switches to command switches for panel cut-out dimensions of $\phi 8$ to $\phi 30$, having a high-brightness display functional, and also including high-function products equipped with an emergency stop pushbutton switch.

Command switches are commonly used in control panels and operator panels (pendants) as HMI devices for providing instructions to machines based on human judgment, and thinner type command switches are increasingly being requested to support the miniaturization of control and operation panels, while maintaining such basic conventional control functionality as safety action mechanisms and switching endurance performance. For this purpose, Fuji Electric has developed the new “minico series” of $\phi 16$ command switches that have a depth dimension of 28.4 mm, which is a significant reduction in size from the 42.5 mm depth of the existing series of $\phi 16$ command switches.

The reduction in size of the minico series has been achieved by eliminating unnecessary stroke length of the contact actuator linked to the control part, and integrating contact structure. Moreover, a click sensation indicating that an operation has been made is also provided. For illuminated products, a small LED, technology for mounting chips onto a lead frame, and thin reflectors were developed, and a reduction in overall size was realized by combining these developments. The main features of the minico series shown in Fig. 3 are as follows.

(a) Simplification of wiring tasks and improved

Fig.3 minico series



safety through development of sockets and protective covers usable by all switches and indicator lamps

- (b) Thin and high-strength lock structure and high brightness illumination technology enable improved design of panel surface operation part
- (c) Acquisition of new JIS/IEC, GB and UL/cUL standard certification in standard products

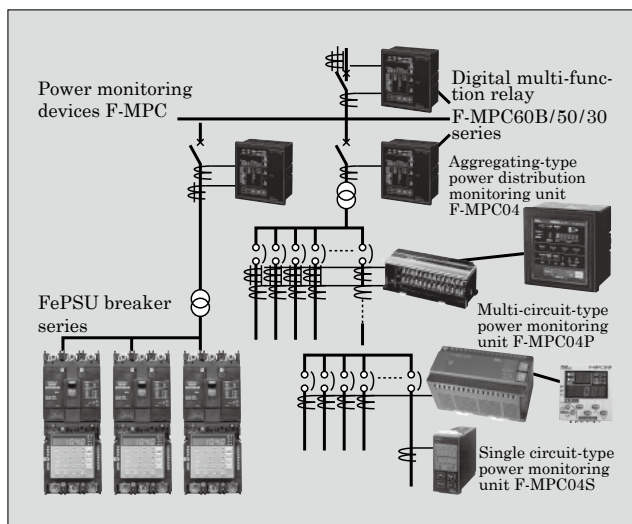
5. Approach to Power Monitoring Devices

In distribution equipment, epitomized by the rapid popularization of OA (office automation) device and information networks, based on advanced information technologies and enabled by the automation and higher functionality of manufacturing equipment, multi-functionality and higher reliability are requested in order to improve the visualization of the operating status of equipment. Moreover, regarding electric power energy, a reduction in the amount of future energy usage through more precise recording, management and verification of results is requested, and greater multi-functionality and enhanced system compatibility is also increasingly requested.

Against this backdrop, Fuji Electric has developed the “F-MPC series” of digital multifunctional relay and power monitoring units, and through combining and integrating 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 high-voltage to low-voltage electrical distribution equipment as shown in Fig. 4. As a product that meets the needs of the times and incorporates new technology, the F-MPC series has been well received in applications to new equipment or during the replacement of equipment, i.e., renewal or upgrading.

Application fields and uses are recently being narrowed and refined, and consequently a system link

Fig.4 Power monitoring devices



unit, high/low voltage transformer panel unit and a transformer protection unit that achieve optimum composite integration have been commercialized. Moreover, an “F-MPC Web unit” that easily connects these field devices via a LAN and enables centralized management has been commercialized as a product that facilitates systemization.

6. Increased Requests for Safety Devices

The recent trends of safety standards, which are very influential, and Fuji Electric’s approach corresponding to the abovementioned instrument products are described below.

6.1 Trends of international standards

In the EU (European Union), a machine directive, a low-voltage directive and an EMC directive have previously been issued, and all types of machines entering the EU undergo a conformity evaluation and are tested based on EN standards that match each of the directives. For machinery and equipment, EN 292 that prescribes basic concepts and design principles relating to machine safety has been adopted as an international safety standard and issued in 2003 as ISO 12100 “Safety of machinery – Basic concepts, general

Fig.5 New international trends in response to EU-issued safety directives

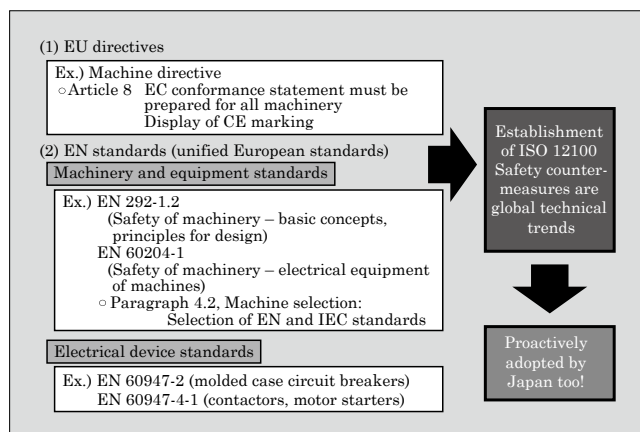
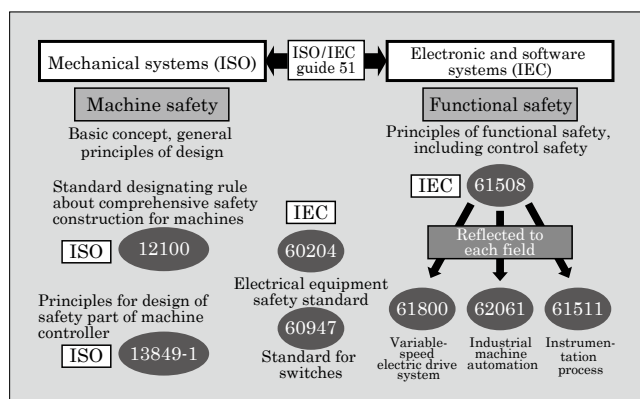


Fig.6 General overview of international safety standards



principles for design”. The gist of this standard is that risk assessment is performed based on the concept that “machinery fails and people make mistakes,” and that “the establishment of a risk reduction process” is required in order to create safety for the equipment and facilities. From the aforementioned basic general standards concerning machinery safety, various international safety standards have been issued including ISO 13849-1 “Safety-related parts of control systems Part 1: General principles for design” which was adopted as an international standard from EN 954-1 for machine system safety, IEC 60204-1 “Electrical equipment of machines Part 1: General requirements” for electrical system safety, IEC 61508 “Functional safety of electrical/electronic/programmable electronic safety-related systems” for control system safety, etc., and the creation of comprehensive safety is of critical importance. (See Figs. 5 and 6.)

6.2 Trends of Japanese domestic standards

ISO 12100, ISO 13849-1 and IEC 61508 have been incorporated into JIS with JIS B 9700, JIS B 9705 and JIS C 0508, respectively, and other international standards are sequentially being incorporated into JIS. As shown in Fig. 7, in Japan, in the “Industrial Safety and Health Law” the “survey of risks and hazards” was cited in April 2006, and the “Guidelines for the Comprehensive Safety Standards of Machinery” was revised in July 2007. As a result, “when new machinery or equipment is installed or changed, or when a work method or procedure is changed” the implementation of risk assessment to diagnose risk is mandated, and even in Japan, designers, manufacturers, installers and operators of machinery and equipment must continuously strive to ascertain safety-related standards and technical trends, and do their best to ensure safety.

6.3 Control panel safety system

Fuji Electric’s approach to safety for control panels for machinery and electrical equipment is explained through a description of Fuji’s product constitution below, using the example of IEC 60204-1, which lists

Fig.7 Trends of safety standards and regulations (in Japan)

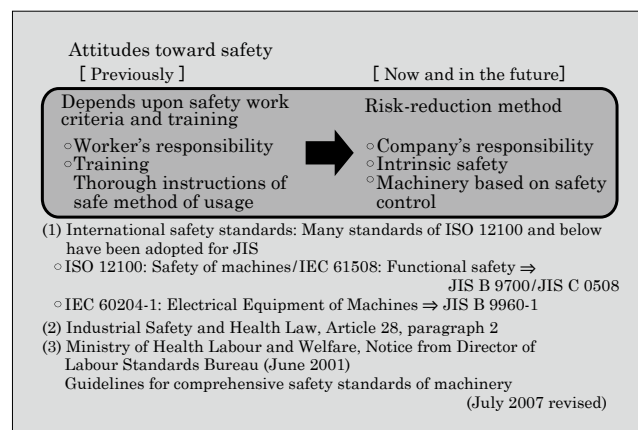
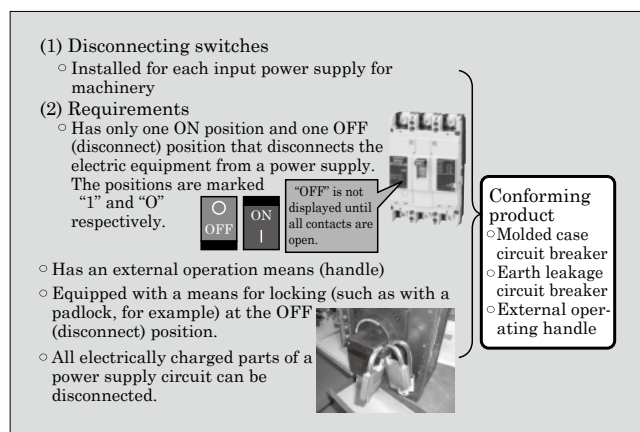


Fig.8 IEC 60204-1 requirements and conforming products



requirements for the power supply isolating devices, overcurrent protection devices and control circuits for electrical equipment.

(1) Power supply isolating device

A power supply isolating device is installed for each input power source to a machine, and conforms with the isolation function prescribed in IEC 60947-2 (JIS C 8201-2-1, 2). As shown in Fig. 8, MCCB, ECCB and external operating handle of G-TWIN series standard products comply with such diverse requests as the provision of ① an OFF/ON indication, ② an external operating means, and ③ a means for locking at the OFF (isolation) position.

(2) Electromagnetic contactor, emergency stop pushbutton switch

Control functions during a malfunction are requested to "use appropriate means to reduce risk during a malfunction" and "to provide duplexed contacts or the like by using a switch equipped with a positive opening mechanism" and so on, and Fuji Electric's electromagnetic contactor "SC series" (SC-03 to SC-N16) is equipped with a safety opening mechanism as a standard feature, and conforms to the "mirror contacts" specified in appendix F of IEC 60947-4-1. By using Fuji Electric's emergency stop pushbutton switch and electromagnetic contactor, a control circuit of ISO 13489-1 safety category 3 or above and that detects single or multiple faults can be configured easily. In particular, an emergency stop pushbutton switch is an operating and opening/closing device that is important for operator safety and machine safety, and further safety design improvements, including the provision of the customer desired operability, must be pursued in the future. Figure 9 shows the evolution of the emergency stop pushbutton switch to support safety requirements.

(3) Support of control panel

Figure 10 shows the IEC 60204-1 safety requirements and corresponding products for the control panels of machinery and equipment. As shown in the figure, in response to the safety requirements, Fuji Electric has prepared a diverse lineup of instrument

Fig.9 Evolution of pushbutton switch for emergency stopping

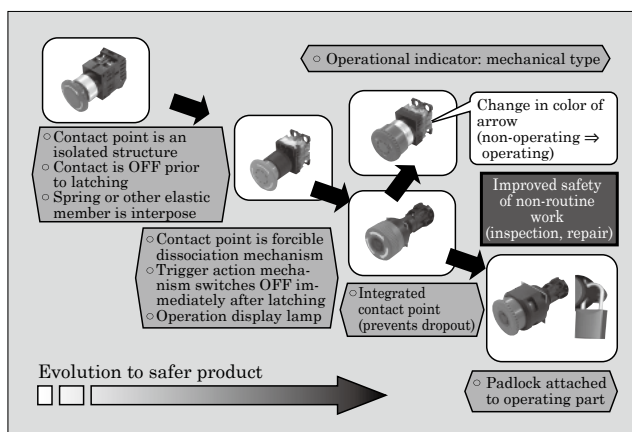
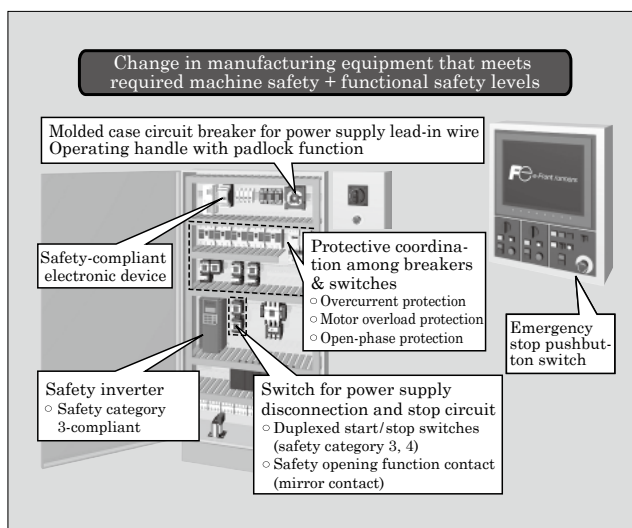


Fig.10 Safety requirements for the control panels of machinery, and the corresponding products



products which also support the risk and safety categories listed in ISO 13489-1. In the future, Fuji Electric will continue to develop instrument products that are responsive to safety needs.

7. Postscript

Market trends of low-voltage distribution switching equipment and monitoring control equipment and recently launched new products have been described, and Fuji Electric's efforts involving technical trends have been discussed above. Requests for systemizing and enhancing the safety of low-voltage distribution switching equipment and monitoring control equipment are expected to diversify and become more sophisticated in the future. Based upon these trends and responding to market needs with high-reliability new technology, and as a supplier of continuing global products, Fuji Electric will strive to make positive contributions worldwide, to continue to seek the opinions of our customers, and to realize additional improvements.

Expanded Product Line of G-TWIN Series Breakers with Accessories to Enhance Functionality

Yasuhiro Takahashi †
Yukata Sato †
Hideki Ishido †

1. Introduction

Standards for individual equipment and products have recently been incorporating international standards at an accelerating rate, and in December 2004, the JIS (Japanese Industrial Standard) for molded case circuit breakers (MCCB) and earth leakage circuit breakers (ELCB) was issued as a new JIS that was consistent with IEC standards, further defining the trend toward globalization. Meanwhile, based on its existing series of twin breakers, Fuji Electric has responded to market needs by expanding its lineup of products conforming to and certified for various standards. With a larger number of product varieties, however, product selection and purchasing become more complicated, and requests for improvement had also increased.

In consideration of these circumstances, Fuji Electric has developed standard and derivative models of 125 to 400 AF (ampere frame) G-TWIN series breakers, a truly global series of twin breakers that conforms to each of the new JIS/IEC (Japan, Europe), GB (China) and UL (United States) standards, as well as accessories for this series.

This paper presents an overview and describes features of the derivative models of the G-TWIN series breakers and their accessories.

2. G-TWIN Series Breakers Accessories

Accessories attachable to the G-TWIN series breakers can be classified as external accessories mounted on the exterior of breakers and internal accessories mounted inside breakers. Figure 1 shows the types of accessories that can be mounted on G-TWIN series breakers.

2.1 External accessories

Some of the external accessories for the G-TWIN series breakers support connection to various types of electrical wiring, some support diverse operation methods, some provide protection and include insulation, and so on.

Fig.1 Accessory variations

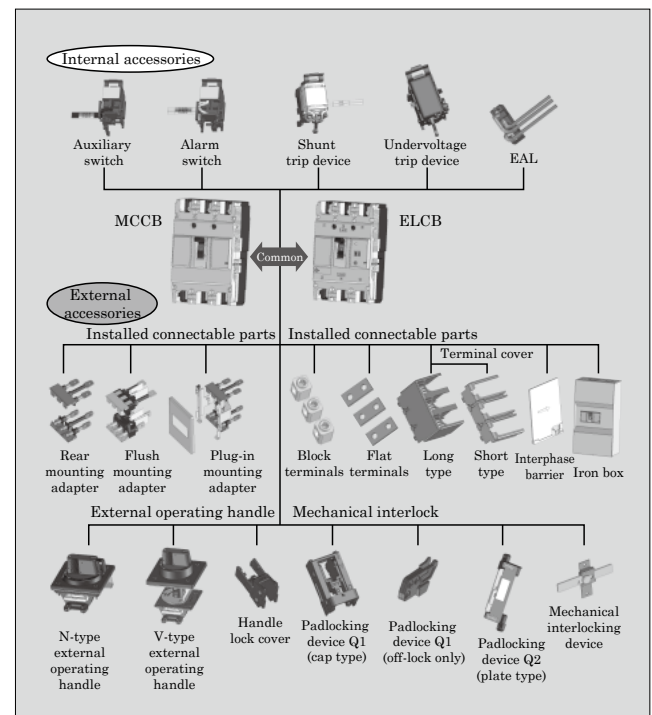
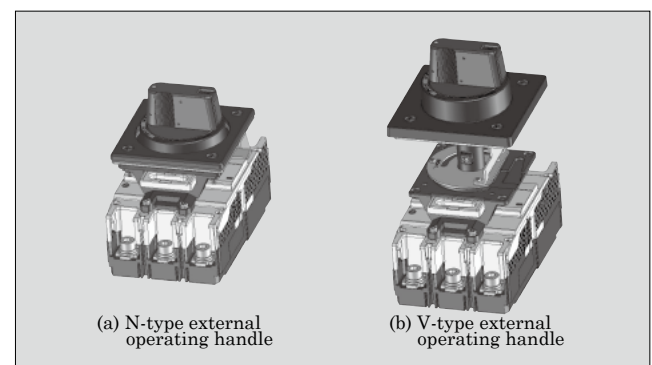


Fig.2 Appearance of external operating handle



(1) External operating handle

External operating handles are used for opening and closing the main power source in such equipment as semiconductor production equipment, machine tools and automotive production equipment. The sale of

† Fuji Electric FA Components & Systems Co., Ltd.

which is expanding to global markets. There is increasing request for certification and compliance with the major global standards, and for improved safety. Therefore, this handle is standardized internationally and incorporates safety and operational improvements into its specifications. Two variations have been developed: an N-type mounted directly on the main breaker unit and a panel-mount V-type that enables the depth direction to be adjusted using an extension shaft and is provided with a panel opening and closing function. Figure 2 shows the appearance of the external operating handle.

(a) Support of international standardization

- 1) So that a single product can be deployed in Japan, Europe, Asia including China, and North America, certification was acquired for CE marking (TÜV certification), CCC marking and UL/cUL listing marking, and all of these standards are displayed on the product.
- 2) With an isolation function enabled by combination with a breaker, an interlock function that prevents breaker turn-on when the switchboard panel is open, and the like, this external operating handle complies with the requested items for an external operating handle as specified in EN 60204-1, IEC 60204-1 and “Electrical Standards for Industrial Machinery” NFPA 79 (US).
- 3) In accordance with the RoHS*¹ directive, the burden on the environment has been reduced.

(b) Improved safety

- 1) While coordinating the design with that of the existing “α-TWIN series,” consideration was given to preventing short circuits and earth faults during maintenance, and molded material was used for the installation frame to increase the insulation strength.
- 2) Protective structure (IEC 60529, JIS C 0920)
 - N-type handle: IP20 (IP50 with dustproof packing)
 - V-type handle: IP54

(c) Improved ease of use

1) OFF locking mechanism

Employing a one-touch pull-out system for the lock plate has improved the ease of use. Specifically, when the lock plate is pressed down at the OFF position, the lock plate will automatically protrude outward, thereby facilitating the locking operation. To return the lock plate, the lock plate is pressed down and is housed and retained at the middle of the grip. Locking devices used throughout the world, such as padlocks (3 padlocks having diameters of 4 to 8 mm), hasps (scissor locks)

used in the United States, and so on can be attached.

2) Lock lever self-retaining function when opening the panel

When the lock plate is pressed down at the open position, a retaining mechanism holds the lock lever. As a result of this function, the panel can be opened freely even when multiple handles are installed on the same board. Figure 3 shows the structure of the external operating handles.

3) Mounting compatibility with existing products

Panel drilling and installation height size

Fig.3 Structure of external operating handles

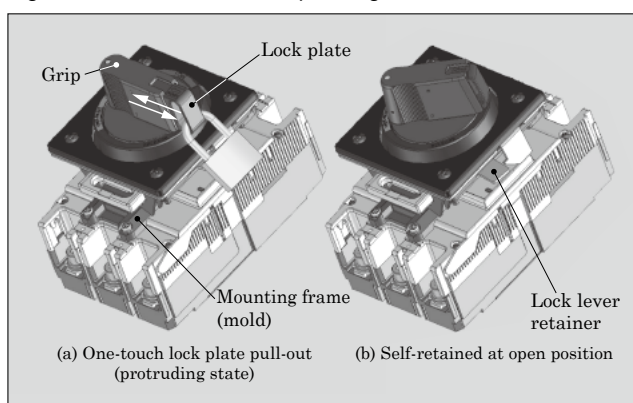


Fig.4 Terminal cover for 250 AF

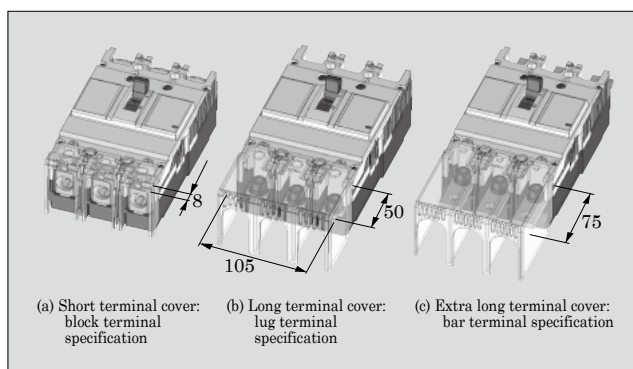
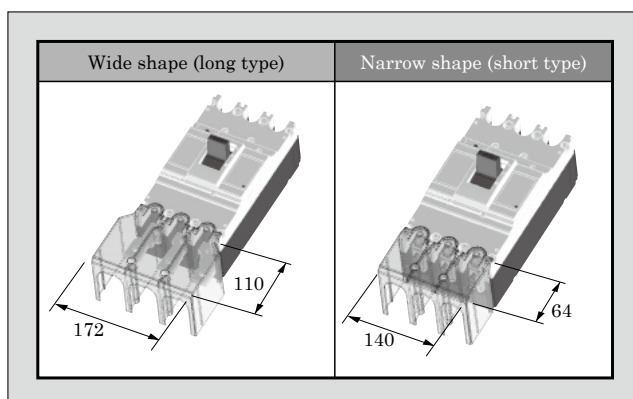


Fig.5 Terminal cover for 400 AF



*1: RoHS is restriction of the use of certain hazardous substances electrical and electronic equipment in the EU (European Union).

were unified with the corresponding specifications of the existing α -TWIN series. With ensured compatibility for mounting, panel design and production were made more efficient.

(2) Terminal cover

The terminal cover for the G-TWIN series breakers was structured to be easily attachable and can be attached with a one-touch operation. The structure can also be fastened with screws (included in the package) so as to comply with the IEC standard safety requirement mandating that a tool be used for attaching the terminal cover.

The 250 AF terminal cover is available as a short-type for connecting screw terminals directly or for connection to a pillar terminal, a long-type for connecting lug terminals, and an extra long-type for bar terminals (Fig. 4). The 125 AF terminal cover also has the same

Fig.6 External appearance of off-lock only padlocking device Q1 (125 to 250 AF)

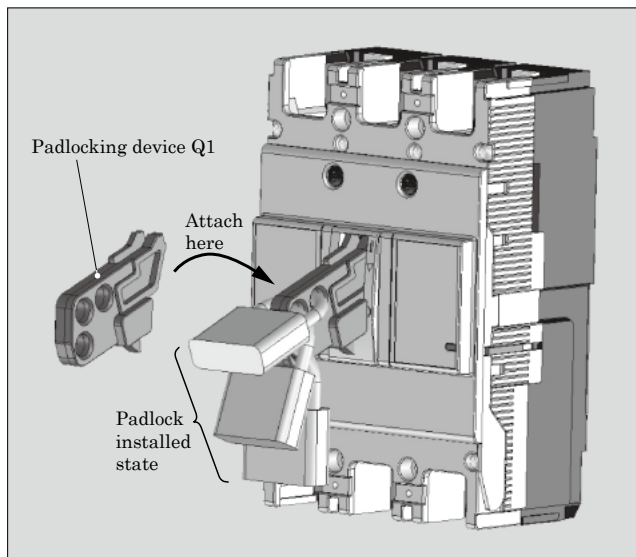
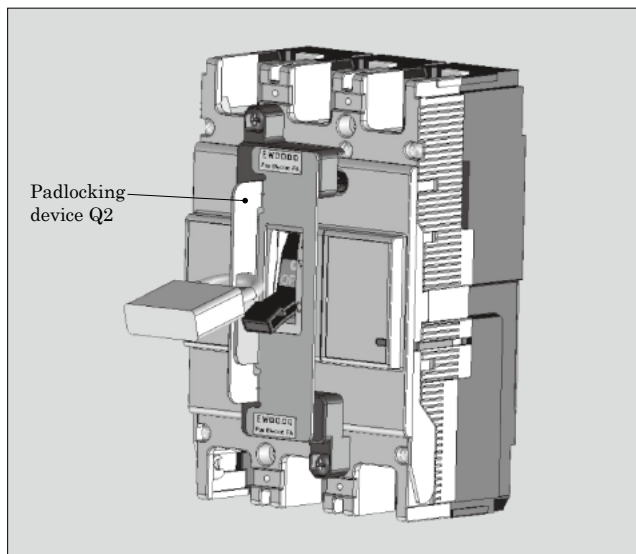


Fig.7 External appearance of padlocking device Q2 (250 AF)



structure as the 250 AF terminal cover. The 400 AF terminal cover is available in a wide shape for connecting lug terminals or a bus bar to a flat bar, and a narrow shape for connecting a block terminal or for detaching the flat bar and connecting a bus bar directly (Fig. 5). Both of these structures provide protection for electrically charged parts.

(3) Handle lock

In order to satisfy requirements of IEC 60204-1, "Electrical Equipment of Machines," the standard handle lock is an off-lock only handle. The cap-method handle lock Q1 shown in Fig. 6 is an off-lock only product that is compatible with overseas specifications for equipment and machinery. Also, the existing plate-type handle lock Q2 product had to be arranged with the breaker itself as a dedicated product, but the Q2 for the G-TWIN series breakers shown in Fig. 7 is configured so as to be mountable in the main unit of the standard product.

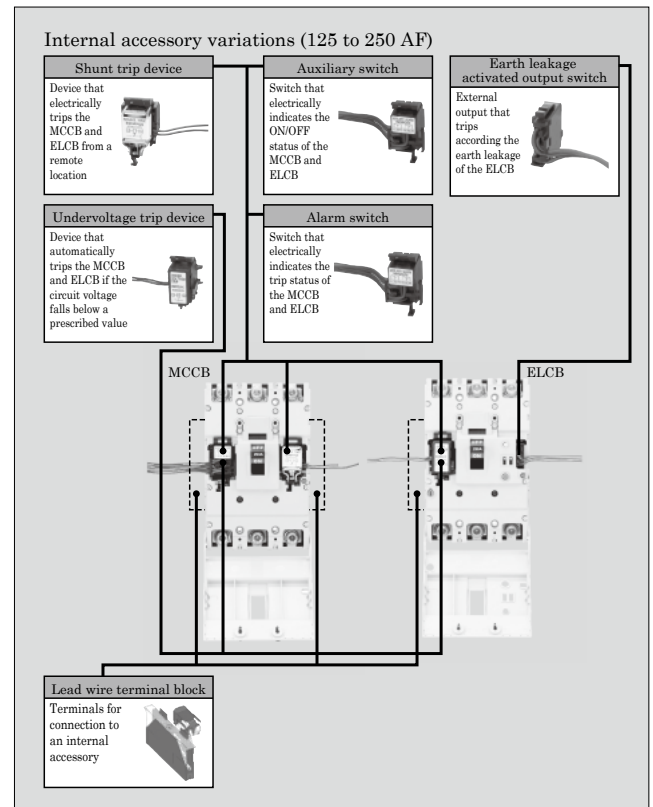
2.2 Internal accessories

As in the case of the main unit, internal accessories

Table 1 Number of varieties of interior accessories (comparison with existing α -TWIN)

AF	α -TWIN	G-TWIN
100/125	8	8
225/250	8	
400	26	6

Fig.8 Varieties of internal accessories (125 to 250 AF)



of the G-TWIN series breakers have also acquired new JIS, IEC, GB and UL certification, so that the same model may be used in all countries.

The internal accessories utilize a mountable cassette, attachable by the customer, so as to flexibly support changes in specifications. With the G-TWIN series breakers, the internal accessories also employ a structure that prevents mis-mounting and improves the ease of attaching by a customer, and as shown in Table 1, there are fewer model varieties since the internal accessories can be shared among frames. Figure 8 shows the internal accessories common to the 125 AF and the 250 AF.

Features of the internal accessories are summarized below.

- (a) New JIS, IEC, GB and UL standard certifications have been acquired for the same structure.
- (b) A structure that prevents mis-mounting improves the ease of attaching by the customer.
- (c) The internal accessories can be used commonly with both the 125 AF and 250 AF, and as a result, the number of varieties has been halved.
- (d) A shunt/undervoltage trip device for the ELCB can be installed inside the main unit.
- (e) The number of varieties has been reduced considerably since the internal accessories are for specific 400 AF products.
- (f) The earth leakage activated output switch for the ELCB is implemented as an internal cas-

sette instead of an externally attached structure.

- (g) Internal accessories also conform to the RoHS directive, an environmental regulation of the EU.

3. Derivative Models of the G-TWIN Series Breakers

A product line of derivative models, shown in Table 2, was organized in consideration of unique applications in Japan. As representative examples, an earth leakage alarm breaker and a non-auto switch are described below.

3.1 Earth leakage alarm breaker

The earth leakage alarm breaker is a compact breaker equipped with both an MCCB function and an earth leakage protection relay function, and as shown in Fig. 9, the existing product was constructed with an earth leakage alarm unit added onto the side of the breaker. With the G-TWIN series breakers, the earth leakage detection unit is miniaturized and installed internally so that the earth leakage alarm breaker has the same appearance as a standard product. Also, in consideration of safety, the method of indicating earth leakage was changed from LED indication, as in the existing product, to mechanical type indication so that a record of the earth leakage history will be maintained

Table 2 List of G-TWIN series breakers derivative models

	Motor protection type	Protection for neutral line failure in single-phase three-wire system	Instantaneous trip	Primary side of transformer type	Non-auto switch	Earth leakage alarm type
MCCB	○	○	○	○	○	○
ELCB	○	○	—	—	—	—
Summary	MCCB/ELCB providing overload protection for motor and overcurrent protection for winding	MCCB/ELCB having neutral line failure protection function for single-phase three-wire circuit	Used in a motor circuit in combination with an MCCB electromagnetic switch having only instantaneous trip characteristics, or used by itself in a semiconductor circuit	Set to a higher instantaneous trip current than a breaker having general characteristics, for the rated current of the transformer, the closest upper level can be selected	Has the structure of a standard MCCB minus the overcurrent trip element, and is used as a switch-disconnector	Compact breaker providing both an MCCB function and an earth leakage protection relay function

Fig.9 Appearance of existing product and G-TWIN earth leakage alarm breaker

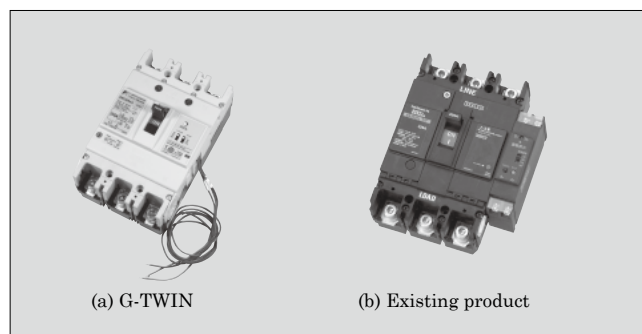
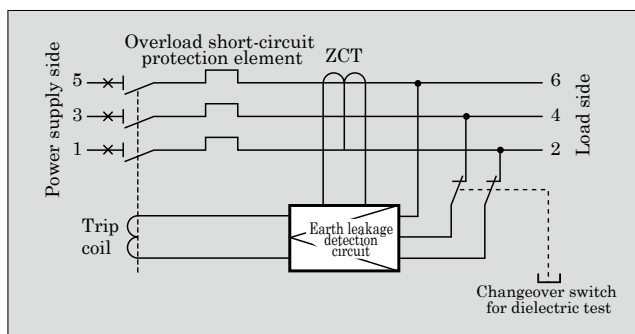


Fig.10 Internal connection wiring diagram for earth leakage circuit breaker



in the case of failure of the line voltage.

Additionally, new functions of the G-TWIN ELCB are also incorporated. Specifically, the G-TWIN ELCB conforms to the revised IEC standard. In order to provide the requested performance level of earth fault operation even in cases where one phase is open in a three-phase circuit, the power supply to the earth leakage detection unit was changed from the previous two-phase implementation to a three-phase implementation. Figure 10 shows the circuit diagram. Also, the provision of a changeover switch for dielectric testing has resulted in a significant improvement in operability since there is no need to remove the ELCB wiring for a dielectric test during an inspection.

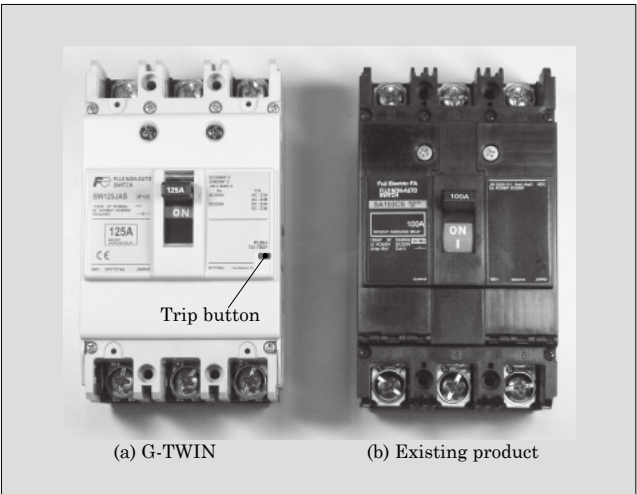
3.2 Non-auto switch

The non-auto switch has the structure of a standard MCCB minus the overcurrent trip element, and is used as a switch. With the G-TWIN series breakers, products were built to comply with IEC 60947-3 so as to be usable overseas as a switch-disconnector. Figure 11 compares the appearance of the G-TWIN series breakers and an existing product. With the G-TWIN series breakers, a trip button is provided on the main unit, and the same internal accessories as used with a standard breaker can be used.

4. Postscript

Accessories and derivative models of the G-TWIN

Fig.11 Appearance of non-auto switch



series breakers have been introduced above. In the future, improving the efficiency of equipment design and production, including domestic electric equipment, and the consideration of safety factors will become increasingly important. The G-TWIN series breakers supports the various diverse requests of customers who have anticipated these needs. In the future, Fuji Electric intends to continue to consult with customers, to further the expansion of accessories and derivative models matched to market needs, and to enhance the G-TWIN series breakers.



Latest Expansion of Command Switch Product Line and its Technology

Motohiro Shimizu †
Noriyoshi Machida †
Minoru Ogasawara †

1. Introduction

Operating switches and indicator lamps used in various machines and equipment must be able to communicate information between humans and machines quickly and accurately. Fuji Electric continues to sell various types of operation switches and indicator lamps under the commercial product name of “command switches,” and these products have been well received by Fuji’s customers. Standard cutouts in a command switch panel range from $\phi 8$ to $\phi 30$. In recent years, control panels and operation panels have become smaller in size, and together with the growing popularity of teaching pendants, the demand for $\phi 16$ panel cutouts is increasing remarkably.

This paper describes the features and relevant technology of Fuji Electric’s new products, as typified by the new $\phi 16$ command switch.

2. Specifications and Features of New $\phi 16$ Command Switch

The command switch product series is as shown in Table 1 for $\phi 8$ to $\phi 30$ panel cutouts. In terms of functions, the command switches are classified as operating switches (having a model number beginning with the letter “A”) and indicator lamps (having a model number beginning with the letter “D”). Additionally, the cutout shapes are classified as round-hole type (symbol R) and rectangular-hole types (symbol F). Accordingly, there is a large variety of command switch products. In particular, the operating switches have the emergency stop pushbutton function of high-end products, and an operating shape that satisfies the needs of many customers.

Figure 1 shows the appearance of representative models of the new $\phi 16$ command switches. Figure 1(a) shows a comparison of the installed condition of the AH165 series, AR16 series and the AF16 series, respectively from top to bottom, as viewed from the side of the panel. In response to customers’ requests for reduced wiring space, the AR16 series (known as

Table 1 Types of command switches

Nominal size	Panel cutout	Model		Comments	Use
		Present	New		
φ30	φ30.5	AR30 model DR30 model		—	Switch-board, machine tool, industrial machinery, etc.
φ22	φ22.3	AR22 model DR22 model AM22 model DM22 model		—	
φ16	φ16.2	AH165 model AH164 model	AR16 model DR16 model	—	
	24.2 × 19.2	—	AF16 model DF16 model	Flush rectangular thing type	
	□ 19.2			Flush square thin type	
	φ19.2			Flush round thin type	
φ12	φ12.1	AH125 model AH124 model		—	Small equipment such as measuring instruments
φ10	φ10.1	AH10 model		—	
φ8	φ8.1	AH08 model		—	

Fig.1 New $\phi 16$ command switch model series



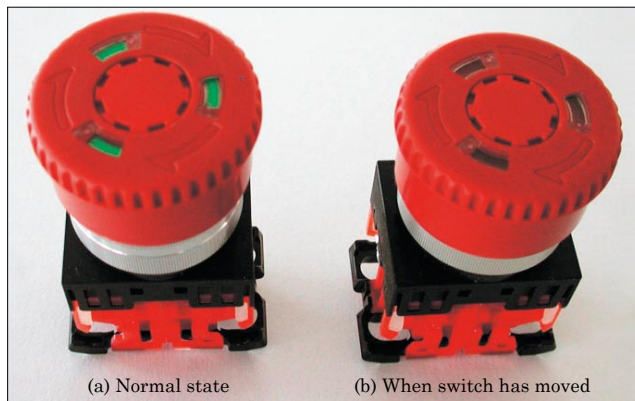
the “minico series”) was developed. The AR16 series adopted an integrated contact structure, and its depth dimension is much smaller than the existing AH165 series. The AF16 series was developed in response to requests for a more elegant design of the control panel surface. Figure 1(b) shows the external appearance, as viewed from the panel surface, of the AR16 series and

† Fuji Electric FA Components & Systems Co., Ltd.

Table 2 Main ratings, performance and specifications of the new $\phi 16$ command switch

Item		(Illuminated) pushbutton switch	Selector switch	Indicator lamp
Rated insulation voltage		250 V AC/DC		
Endurance	Mechanical	Momentary action: At least 1 million times Alternate action: At least 250,000 times	Manual return: At least 250,000 times Auto return: At least 250,000 times	–
	Electrical	At 220 V AC and 0.7 A: At least 100,000 times		–
Open/close frequency		1,200 times/hr (utilization rate: 40%)		–
Withstand voltage	Between live part and ground	2,000 V AC, 1 minute		
	Between live parts of different polarity	2,000 V AC, 1 minute		–
Insulation resistance		At least 100 M Ω (with 500 V DC dielectric tester)		
Resistance to vibration		Resonance test: amplitude width 0.1 mm, frequency 10 to 55 Hz Steady state oscillation endurance test: amplitude width 3 mm, frequency 16.7 Hz		
Resistance to impact		Mis-operation: 100 m/s ² Durability: 500 m/s ²		
Ambient environment for usage		– 10 to + 55 °C, (no freezing, no condensation)		
Protective structure		IP65 oil resistance protection (dust proof type, jet proof type)		
Depth dimension	AR16 series	28.4 mm		
	AF16 series	35.9 mm		

Fig.2 Emergency stop switch with mechanical indicator



the AF16 series.

The new $\phi 16$ command switches can be selected from various illuminated pushbutton switches, pushbutton switches, knob selector switches, key selector switches, and indicator lamps. Additionally, the shape of the operating portion (round, square, rectangular), switching action (momentary, alternate), button color (green, red, orange, yellow, blue, milk-white, black) and number of contacts (1c, 2c) may be combined with these types of command switches. Table 2 lists the main ratings, performance and specifications.

The $\phi 22$ panel cutout-size AM22VME, an emergency stop switch having a mechanical indication mechanism has been developed, by adding variations of the front-mounting type AM22 series were expanded. In its normal state, this switch displays the color green at three window locations (see Fig. 2(a)). However, in the state where the emergency stop switch has been operated, the color displayed from the three window locations changes from green to red (see Fig. 2(b)). Thus, the characteristic feature of this switch is improved

visibility.

Details of the new $\phi 16$ command switch are described below.

2.1 Reduction of panel-mounting depth with integrated contact structure

The existing AH165 series has a depth of 42.5 mm from the panel to the tip of the contact terminals and the lamp terminals. On the other hand, the new AR16 series has a similar depth dimension of 28.4 mm for all products (pushbutton switch, selector switch, indicator lamp). This reduction in depth was realized with the following two achievements: the realization of an integrated contact structure and the elimination of unnecessary strokes for parts coupled to the operating part.

2.2 High brightness LED

A high brightness LED was newly developed as the power source for the illuminated pushbutton switch and the indicator lamp. The AR16 series and the AF16 series consume approximately 25% less power than the existing AH165 series. Brightness was increased by approximately 30%, however, so that visibility was improved for the illuminated pushbutton switch and the indicator lamp. Table 3 compares the specifications between the new high brightness LED and the existing LED.

2.3 IP65 oil resistant protective structure

By increasing the air tightness of the internal structure of the AR16 series and the AF16 series, the requirements for an IP65 protective structure have been met. Accordingly, the AR16 and the AF16 series are usable in environments where oil is used for machine tools and the like. To realize this IP65 oil resistant protective structure, the following internal struc-

Table 3 LED comparison between new series and existing series

Specification item		New product	Existing product
LED type (24 V rated product, green color)		DR6L695-EG	AHX695-24G
Command switch type	Illuminated pushbutton switch	AR16FON, etc. AF16FON, etc.	AH165-TL, etc.
	Indicator lamp	DR16FON, etc. DF16FON, etc.	AH165-ZT, etc.
Rated voltage		6, 12, 24 V AC/DC	5, 6, 12, 24 V DC
Power consumption (24 VDC product)		0.28 W	0.37 W
Brightness peak on surface of color cap (green)		1,800 cd/m ²	1,340 cd/m ²
LED color varieties		Green, red, orange, yellow, blue, milk-white	Green, red, orange, yellow, blue, milk-white

tures were developed. In a pushbutton switch, a packing ring structure that ensures a 3 mm stroke, and the fixed shape thereof, were developed. Additionally, in a selector switch, a packing ring structure having good durability against rotational operation was developed.

2.4 Support of internationalization

In the AR16 series and the AF16 series, IEC and C-UL certification were acquired for standard products. Additionally, in order to expand into China whose market has been growing rapidly in recent years, GB certification was also acquired for those standard products.

2.5 Socket lineup

Sockets and protectors usable in both the AR16 series and the AF16 series were developed as accessories. As a result, handling by the customer and wiring work have been simplified.

3. Development of New $\phi 16$ Command Switch

3.1 Development of contact element by using simulation technology

In reducing the depth of the command switch, the following three technical challenges were identified for realizing a contact element having a small snap action structure.

- (1) Snap action structure that provides a sufficient operating feel

Figure 3 shows the change in force when the color cap of the pushbutton switch is moved. The snap action creates points of force change in both the push and the return operations. An operator senses this change as the operating feel. The operating feel is an important property for providing optimum operability and preventing mis-operation.

The new contact element has external dimensions of 4.4(W) $\times$ 12.8(D) $\times$ 16.6(H) (mm) and is extremely small. Accordingly, the structure was realized with a

Fig.3 Change of operating force on pushbutton switch (momentary action)

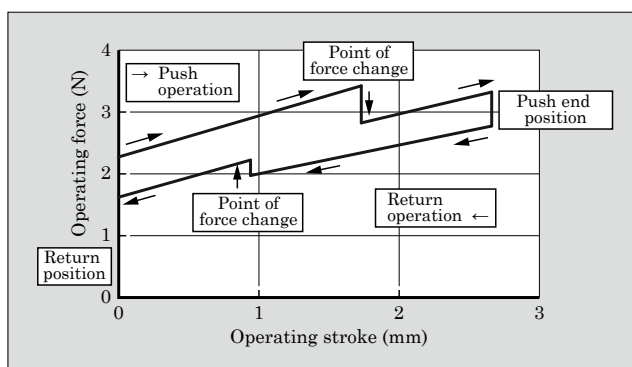
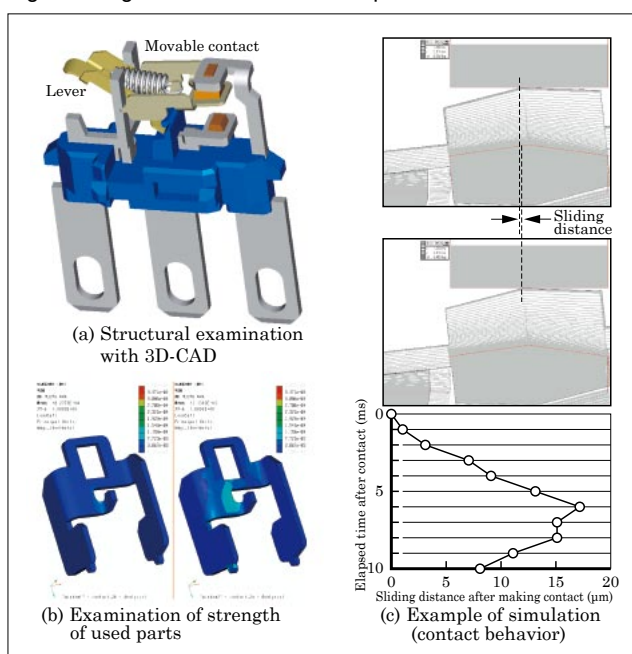


Fig.4 Design considerations for snap action structure



detailed study using 3D-CAD. (See Fig. 4(a).)

- (2) Mechanical durability more than 1 million operations

As is shown in Fig. 4(a), the new contact element uses an extension spring to obtain the required contact force. This extension spring attaches to a hook provided on a lever component and to a hook provided on a movable contact, and expands and contracts according to the snap action. In order to satisfy the switch specification requirement for mechanical durability more than 1 million operations, the structure was designed using 3D-CAD and stress analysis was performed for the coupled lever and the movable contact. Figure 4(b) is an example of a contour diagram that examines the reduction of stress in the hook part of the movable contact.

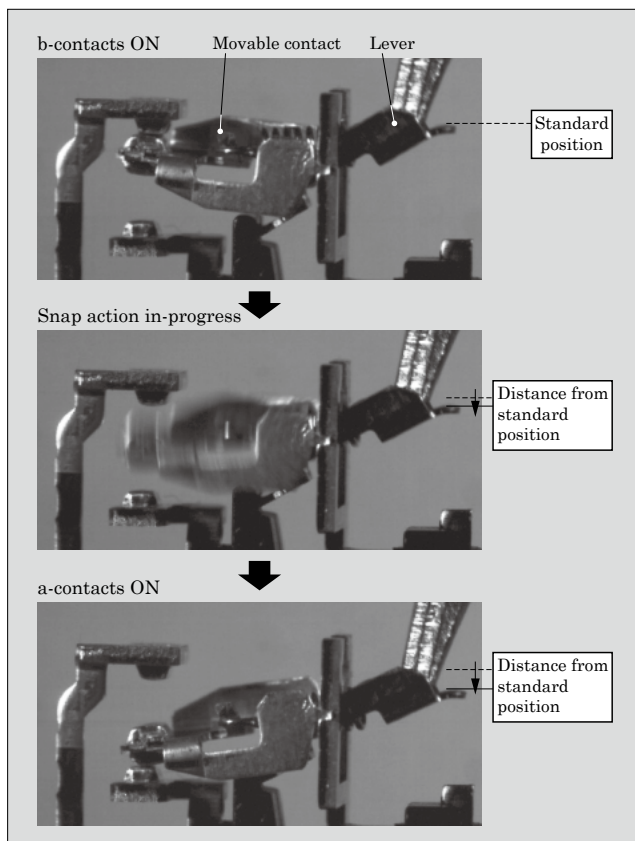
- (3) Realization of high contact reliability

In the field of small switches, such as $\phi 16$ command switches, the realization of high contact reliability with a minimum switching capacity of 5 V 1 mA is

an important performance. Accordingly, a structure capable of ensuring the sliding distance of the contact was sought. By ensuring a large sliding distance of the contact, the oxidation film and sulfuration film generated on the contact surface are destroyed, and stable contact resistance is obtained. Similarly, a control relay having high contact reliability uses the elasticity of a leaf spring so that after making contact, the contact angle changes, and such a relay typically exhibits a sliding distance of 5 μm or more. In this structure, the movable contact is a rigid body, and the common terminal supporting the hinge of the movable contact is designed to be an elastic structure so that the desired amount of contact sliding is obtained. Figure 4(c) shows an example simulation of the horizontal distance traveled by a pointed contact tip moving from the contact start to the contact end. Moreover, the figure shows a graph of the transition in sliding distance up to 10 ms after the start of contact.

Figure 5 shows the behavior observed using a high-speed camera of the sliding distance of a movable contact in a snap action operation. As a result, it was determined that the movable contact was sliding in an actual device. When the lever in the upper right-hand corner of this figure is moved in the vertical direction, the distance of motion of this operation corresponds to the operating stroke of Fig. 3. Figure 5 shows a series of processes of the inversion from the initial ON state of the b-contact initial to the ON state of the a-contact,

Fig.5 Observation of behavior of snap action structure



wherein as a result of operation of this lever, the movable contact performs a snap action at the point where the force of the pushing operation changes.

Additionally, the extension spring, which is an essential component of the snap action mechanism, not only provides simple expansion and contraction, but is also coupled to the inverting operation of the movable contact, and its orientation changes. By observing the above behavior, we were able to determine that there is no obstruction due to impact with the coil part or the like.

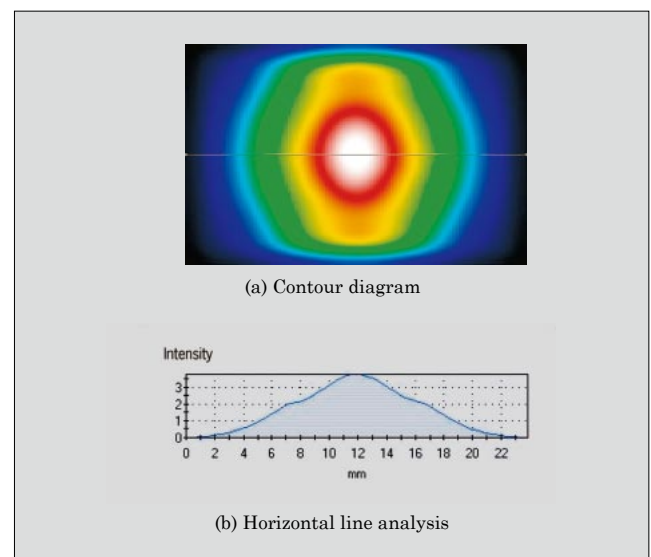
3.2 Illuminated structure developed by using simulation technology

One development challenge for the new $\phi 16$ command switch was how to illuminate the “OFF”, “ON” and other lettering printed on the inside of the color cap so as to be clearly visible to the operator. In order to overcome this challenge, we established the goal of developing an illuminated state with no light unevenness when viewed from the front face of the color cap on the panel surface. In particular, a light transmitting reflector and scattering plate structure were added to disperse light smoothly from the center to the tip of the color cap which receives light emitted from the newly developed high brightness LED.

(1) Design of reflector and scattering plate by simulation

We set about to quantify the illuminated state. Several proposed shapes of the reflector and scattering plate were analyzed using optical simulation. Figure 6 is an example analysis that shows a contour diagram of the intensity of light emitted from the LED as seen from the front face of the color cap. A diagram of the intensity along a horizontal line passing through the center of the color cap is also shown. In this diagram, the combination of the reflector and scattering plate has not been optimized and “light unevenness” can be

Fig.6 Analysis of illumination intensity by optical simulation



seen. Characteristics of the case when “light unevenness” exists can be understood as follows.

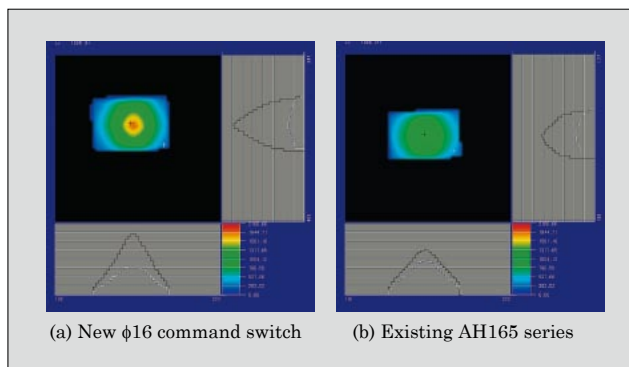
- (a) There is a large difference in illumination between the center part and the tip.
- (b) There is a large change in intensity between the -3 mm and + 3 mm positions of the graph’s horizontal axis (corresponding to the outer periphery of the internal LED).

From the proposed shapes of the reflector and scattering plate, a shape that results in no light unevenness was selected. Additionally, the illuminated state was quantified, partially based on the results of spectral ray tracing analysis that resolved the light into many light rays and analyzed the trajectory of the individual light rays. Based on these analyses, the shapes of the reflector and scattering plate were determined.

- (2) Measurement to verify effectiveness of reflector and scattering plate combination

To evaluate the developed products, brightness at the color cap surface for each of the six colors was measured using the latest brightness meter. The results showed that the new product achieved high brightness, with peak brightness values of 110 to 130% compared to those of the existing AH165 series. Figure 7 shows brightness measurement results for the new command switch and the existing AH165 series as viewed from the front face of the color cap (green). As in the case of the simulation, the brightness along horizontal and vertical lines passing through the center of the color cap is shown graphically. As a result, the appropriateness of the illuminated state determined by simulation and the shapes of the reflector and scattering plate

Fig.7 Example of measurement with brightness meter (green color cap)



were verified. Also, energy savings was achieved with an approximate 25% reduction in power consumption compared to the existing AH165 series.

4. Postscript

With the new φ16 command switches, Fuji Electric has developed a new series having such characteristics as small size, high brightness and wire savings, and has used the latest analysis software and measuring instruments to realize an improved operating feel for the contact element and improved visibility for the LED. Fuji Electric intends to continue to develop human-machine interface products that support new customer needs and that seek the appeal of such sensations as operability and visibility.

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

Shunsuke Shikano[†]
Satoshi Machida[†]
Toshiaki Tani[†]

1. Introduction

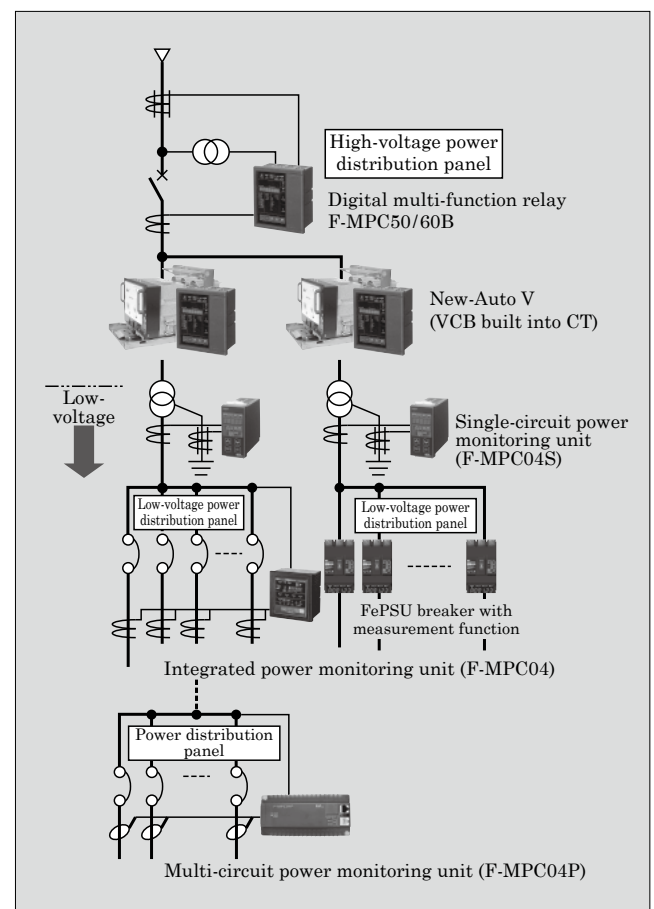
To maintain and manage a power distribution facility, various protective relays and indicators have been used. The elemental technology employed by the measurement and protection functions of such power distribution equipment has evolved from induction type (mechanical), to static type (transistor and 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-

[†] Fuji Electric FA Components & Systems Co., Ltd.

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 ⁻⁶ 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.

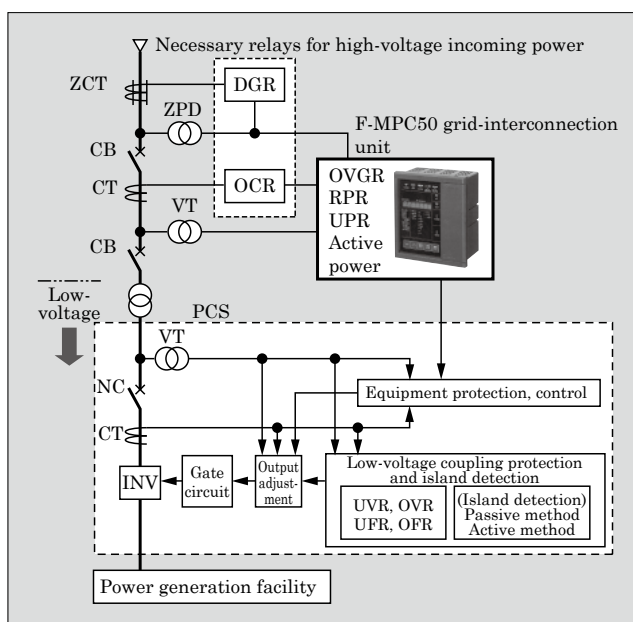
When such dispersed power sources are “grid-interconnected” with coexisting power supplied from a power company, certain prescribed protection functions are essential. Fuji Electric has developed the F-MPC50 series of grid-interconnection units provided with both the necessary protection functions for 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 multi-function 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.

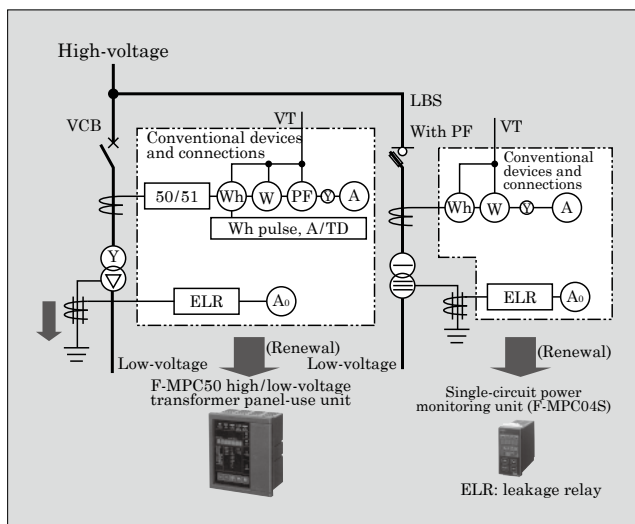
According to the “grid-interconnection code” of the JEA (Japan Electric Association), in the case where a PCS is used and there is no backward flow, grid-interconnection on the high-voltage side additionally requires a reverse power relay, an overvoltage ground relay, and an undervoltage relay as a protection 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

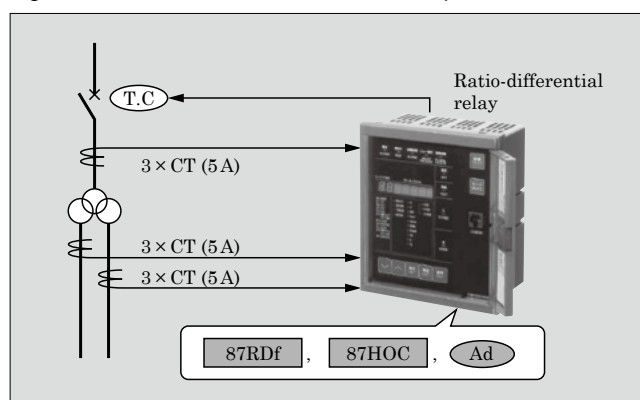


Table 3 Specifications of the transformer protection unit

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 $\times$ 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.

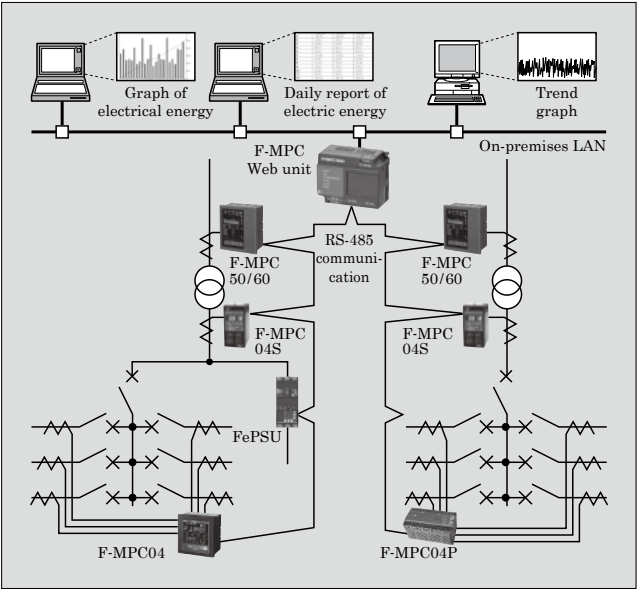
(2) Setting utility having auto setting function

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.

Main Businesses of Fuji Electric Group

Energy & Electric Systems Group

Fuji Electric Systems Co., Ltd.

Fuji Electric FA Components & Systems Co., Ltd.

Drives : Drive control equipment, Drive systems, Power supplies, Rolling stock/
Special machinery

Automation : Sensors, Measuring instruments, Controllers, Manufacturing solutions,
Energy solutions, Social solutions

Industrial plant engineering : Industrial power supplies, Substation equipment for facilities,
Substation equipment for electric railroads, Clean rooms

Electric power systems : Thermal power, Nuclear power, Hydraulic power

Plant facility construction : Electrical installation work, Air conditioning systems, Water supply/
drainage installation work

Electric distribution and control equipment : Magnetic contactors, Manual motor starters (MMSs), Operation
indicators, Molded-case circuit breakers (MCCBs), Earth-leakage
circuit breakers (ELCBs), High-voltage vacuum circuit breakers, Low/
high voltage fuses, Gas detectors, Energy management equipment

Electronic Devices Group

Fuji Electric Device Technology Co., Ltd.

Semiconductors : Power MOSFETs, IGBT modules, Rectifier diodes, Power supply ICs,
IGBT-IPMs, Pressure sensors

Magnetic disks : Aluminum media, Glass media, Aluminum substrates

Imaging devices : Photoconductive drums, Peripheral imaging devices

Retail Systems Group

Fuji Electric Retail Systems Co., Ltd.

Vending machines : Various vending machine models

Food service devices : Assorted dispenser products, Tea servers, Refrigerated showcases

Currency handling systems : Coin mechanisms, Bill validators, Currency exchange machines,
Automatic change dispensers, Coin mechanisms for leisure facilities,
Non-contact IC card systems

Cold-chain equipment : Various types of store display cases, Store-related equipment, Store
design, construction and maintenance services

Global Network

AMERICA

- **FUJI ELECTRIC CORP. OF AMERICA**
USA
Phone: +1-201-712-0555 Fax: +1-201-368-8258
- ◆ **FUJI ELECTRIC DEVICE TECHNOLOGY AMERICA INC.**
USA
Phone: +1-732-560-9410 Fax: +1-732-457-0042

EU

- **FUJI ELECTRIC HOLDINGS CO., LTD.**
Erlangen Representative Office
GERMANY
Phone: +49-9131-729613 Fax: +49-9131-28831
- **FUJI ELECTRIC FA EUROPE GmbH**
GERMANY
Phone: +49-69-6690290 Fax: +49-69-66902958
- **FUJI ELECTRIC DEVICE TECHNOLOGY EUROPE GmbH**
GERMANY
Phone: +49-69-6690290 Fax: +49-69-6661020
- ◆ **FUJI ELECTRIC FRANCE S.A.**
FRANCE
Phone: +33-4-73-98-26-98 Fax: +33-4-73-98-26-99

ASIA

East Asia

- **FUJI ELECTRIC HOLDINGS CO., LTD.**
China Representative Office (Shanghai)
CHINA
Phone: +86-21-5496-3311 Fax: +86-21-5496-0189
- **FUJI ELECTRIC HOLDINGS CO., LTD.**
China Representative Office (Beijing)
CHINA
Phone: +86-10-6505-1264 Fax: +86-10-6505-1851
- **FUJI ELECTRIC FA (SHANGHAI) CO., LTD.**
CHINA
Phone: +86-21-5496-1177 Fax: +86-21-6422-4650
- ◆ **FUJI ELECTRIC (CHANGSHU) CO., LTD.**
CHINA
Phone: +86-512-5284-5642 Fax: +86-512-5284-5640
- ◆ **WUXI FUJI ELECTRIC FA CO., LTD.**
CHINA
Phone: +86-510-8815-2088 Fax: +86-510-8815-9159
- ◆ **FUJI ELECTRIC DALIAN CO., LTD.**
CHINA
Phone: +86-411-8762-2000 Fax: +86-411-8762-2030
- ◆ **FUJI ELECTRIC MOTOR (DALIAN) CO., LTD.**
CHINA
Phone: +86-411-8763-6555 Fax: +86-411-8762-4077
- **FUJI ELECTRIC MOTOR (SHANGHAI) CO., LTD.**
CHINA
Phone: +86-21-5239-9681 Fax: +86-21-5239-9680
- ◆ **SHANGHAI FUJI ELECTRIC SWITCHGEAR CO., LTD.**
CHINA
Phone: +86-21-5718-1495 Fax: +86-21-5718-5745
- ◆ **SHANGHAI FUJI ELECTRIC TRANSFORMER CO., LTD.**
CHINA
Phone: +86-21-5718-1495 Fax: +86-21-5718-5745

- ◆ **FUJI ELECTRIC SYSTEMS(SHANGHAI) CO., LTD.**
CHINA
Phone: +86-21-5496-2211 Fax: +86-21-6417-6672
- ◆ **DALIAN FUJI BINGSHAN VENDING MACHINE CO., LTD.**
CHINA
Phone: +86-411-8730-5902 Fax: +86-411-8730-5911
- **DALIAN JIALE VENDING MACHINE OPERATION CO., LTD.**
CHINA
Phone: +86-411-8665-0277 Fax: +86-411-8596-2732
- ◆ **HANGZHOU FUJI REFRIGERATING MACHINE CO., LTD.**
CHINA
Phone: +86-571-8621-1661 Fax: +86-571-8821-0220
- ◆ **FUJI ELECTRIC (SHENZHEN) CO., LTD.**
CHINA
Phone: +86-755-2734-2910 Fax: +86-755-2734-2912
- **FUJI ELECTRIC FA (ASIA) CO., LTD.**
HONG KONG
Phone: +852-2311-8282 Fax: +852-2312-0566
- **FUJI ELECTRIC DEVICE TECHNOLOGY HONG KONG CO., LTD.**
HONG KONG
Phone: +852-2664-8699 Fax: +852-2664-8040
- **FUJI ELECTRIC SYSTEMS CO., LTD.**
Taipei Representative Office
TAIWAN
Phone: +886-2-2501-1256 Fax: +886-2-2501-1250
- **FUJI ELECTRIC TAIWAN CO., LTD.**
TAIWAN
Phone: +886-2-2515-1850 Fax: +886-2-2515-1860
- **FUJI ELECTRIC FA TAIWAN CO., LTD.**
TAIWAN
Phone: +886-2-2370-2390 Fax: +886-2-2370-2389
- ◆ **ATAI FUJI ELECTRIC CO., LTD.**
TAIWAN
Phone: +886-3-321-3030 Fax: +886-3-321-7890
- **FUJI ELECTRIC FA KOREA CO., LTD.**
KOREA
Phone: +82-2-780-5011 Fax: +82-2-783-1707

Southeast Asia

- **FUJI ELECTRIC SYSTEMS CO., LTD.**
Bangkok Representative Office
THAILAND
Phone: +66-2-308-2240 Fax: +66-2-308-2242
- **FUJI ELECTRIC SYSTEMS CO., LTD.**
Jakarta Representative Office
INDONESIA
Phone: +62-21-572-4281 Fax: +62-21-572-4283
- ◆ **FUJI ELECTRIC (MALAYSIA) SDN. BHD.**
MALAYSIA
Phone: +60-4-403-1111 Fax: +60-4-403-1496
- ◆ **FUJI ELECTRIC PHILIPPINES, INC.**
PHILIPPINES
Phone: +632-844-6183 Fax: +632-844-6196
- **FUJI ELECTRIC SINGAPORE PRIVATE LTD.**
SINGAPORE
Phone: +65-6535-8998 Fax: +65-6532-6866
- **FUJI ELECTRIC FA SINGAPORE PRIVATE LTD.**
SINGAPORE
Phone: +65-6533-0010 Fax: +65-6533-0021

