New Global MCCB/ELCB G-Twin Breaker Series

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1. Introduction

In 1990, Fuji Electric began selling the "Twin Breaker," the world's first series of molded case circuit breakers (MCCB) and earth leakage circuit breakers (ELCB) that have common external dimensions. The Twin Breaker was well received and supported, thus this concept has become the de facto standard in the industry.

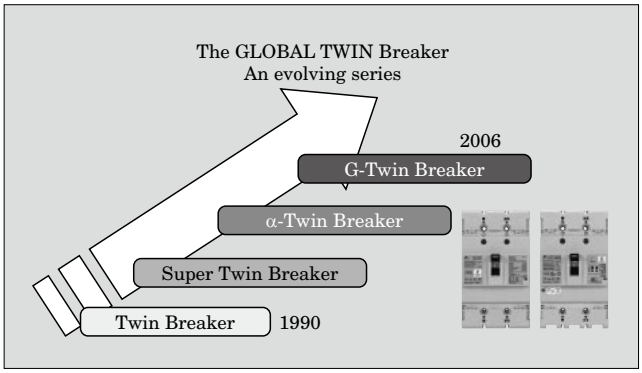
Then, in 1992 Fuji Electric introduced the "Super Twin Breaker" which, for the first time in Japan, enabled user installation of internal accessories, and in 1995 introduced the "Super 60 Series" that further advanced the concept of modularization.

Constantly anticipating changes in the market, in 2001, Fuji Electric began selling the "α-Twin Series" that achieved even smaller modularization of the 100A Frame (AF) class or lower. It was marketed as a multi-standard product that supports all standards worldwide.

Recently, the trend of market globalization has been accelerating at an increasing rate. Each country's standards for low voltage electric installations are moving toward conformance with the IEC standards, and the trend toward globalization is evident in the electrical devices used in such installations. Fuji Electric has responded to the needs of the market by acquiring certification of various standards to satisfy global customers, and by expanding its variety of products based on the Twin Breaker Series. On the other hand, as more product variety leads to more cumbersome selection and procurement of equipment, users are requesting its improvement. Under these circumstances, Fuji Electric has moved ahead with innovative technical development for low voltage circuit breakers, and has developed a 125 to 400 AF "G-Twin Series" as a global MCCB/ELCB series. (See Fig. 1.)

This paper describes the features, specifications and configuration of the G-Twin Series.

Fig.1 History of Fuji Electric's Twin Breaker Series



2. Background and Goals of G-Twin MCCB/ELCB Development

2.1 Background of development

Due to Japan's policy of harmonizing with IEC standards, as shown in Fig. 2, the JIS for low voltage circuit breakers is harmonized with the IEC standard. As a result, Japan has adopted unified new JIS series standard for low voltage circuit breakers. Main different points are described below.

(1) The three standards for conventional molded case circuit breakers, earth leakage circuit breakers, and low voltage circuit breakers are separated and

Fig.2 Technical harmonization with IEC standards in Japan, New JIS system for MCCB/ELCB

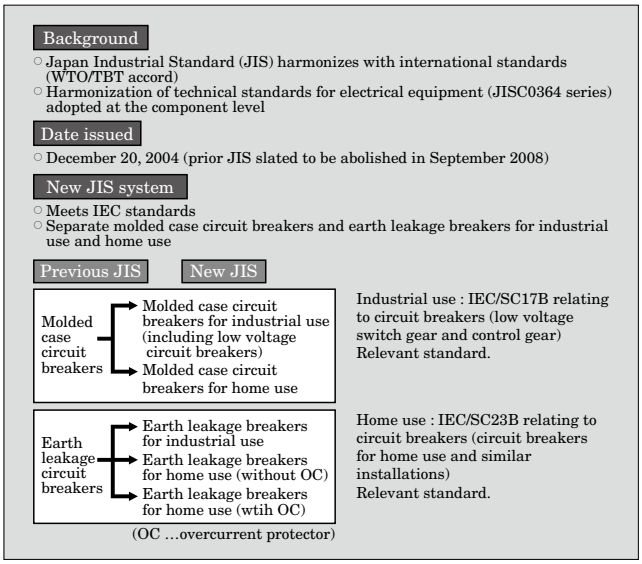


Fig.3 IEC harmonization in Japan, New JIS classifications

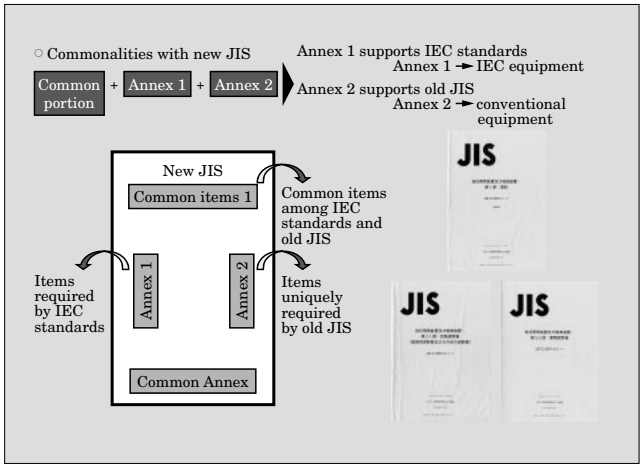


Fig.4 IEC harmonization in Japan, application categories of low voltage circuit breakers

New equipment classifications for industrial-use and home-use = Place of use + User classification

Electrical equipment classification	Usage classification (user)		Ordinary		Skilled, instructed	
	Classification	Standard No.	Office	Factory	Office	Factory
New JIS Annex 1	Industrial use	JIS C 8201-2-1	△	△	○	○
IEC electrical equipment		JIS C 8201-2-2	△	△	○	○
+ New JIS Annex 2	Home use	JIS C JIS C 8211	○	○	○	○
Conventional electrical equipment		JIS C 8221 (without OC)	○	○	○	○
		JIS C 8222 (with OC)	○	○	○	○

△: Can be used with distribution board if terminals and insulation are given careful consideration

Ordinary person : An uninstructed or unskilled person
Skilled person : A person with technical knowledge or sufficient experience to enable him/her to avoid dangers which electricity may create.
Instructed person : A person adequately advised or supervised by skilled persons to enable him/her to avoid dangers which electricity may create.

reconfigured as a Common Standard, and two volumes for Circuit Breakers and three volumes for Earth Leakage Circuit Breakers. (See Fig. 3.)

(2) In the five volumes listed above, circuit breakers are classified according to either the Japanese conventional electric installations of Annex 2 or the IEC installations of Annex 1.

(3) Applications are separated into industrial-use circuit breakers to be used by persons skilled in electricity, and home-use circuit breakers to be used by ordinary persons. (See Fig. 4.)

(4) Industrial-use ELCBs are prescribed by Annex B of IEC 60947-2, and are prescribed by the new JIS with the independent standard JIS C 8201-2-2. (See Fig. 4.)

(5) The new JIS for ELCBs additionally incorporates IEC 60947-2 Edition III (operation during open phase). (See Fig. 5.)

Thus, with the issuance of the new JIS in Japan, low voltage circuit breakers will have to meet standards for the installation. Furthermore, markings indicating the circuit breaker model and the like must also be categorized. Harmonization with IEC standards is

Fig.5 IEC 60947-2 Ed. III, ELCB compatibility with 3-phase power supply

Change of IEC standard
IEC 60947-2 and JIS C8201-2-2
○ Section 3.1.2.2.1 : Shall be operable in cases of an abnormal state occurring during loss of supply voltage.
○ Section 8.9 : Verification of operation of supply-voltage-dependent-type ELCB classified according to section 3.1.2.2.1, during loss of the supply voltage
○ Section 8.9.1 : In the case where one phase of a three-phase system is operating in open phase mode (for 3-pole and 4-pole ELCBs), 0.85× the voltage is applied to the ELCB main unit. Next, one-phase is open-circuited and the leakage trip time is measured for two-phase operation.

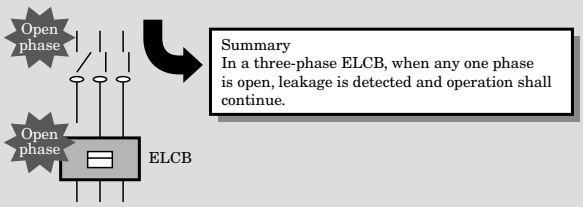
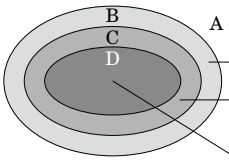


Table 1 G-Twin MCCB/ECLB customer applications

Series	G-Twin (global standard)	G-Twin (multi-standard)	α-Twin
Indication of standards	UL/CE/CCC/ New JIS	CE/CCC/ New JIS	New JIS
Model series	Fuji gray-color  Terminal cover standard installation	Fuji gray-color 	Fuji black-color  Japan-use only product
Category	A B C (D)	A (B) C (D)	D
Customer selection	 A: Overseas customer; B: Global customer; C: Customer that exports from Japan; D: Japan-use only customer		

advancing rapidly in Asian countries, and Japan is no exception.

2.2 Development goals

Based on an analysis of the changing circumstances surrounding low voltage circuit breakers, and in order to anticipate the customer needs of the future, Fuji Electric determined that it was necessary to develop a novel-concept MCCB and ELCB, and moved ahead with technical development to commercialize the "G-Twin" Global Breaker. (See Table 1.) The development goals of the G-Twin are summarized below.

(1) Compatibility with global standards for low voltage circuit breakers

To realize a single model certified for all standards,

thus it is more efficient than former products that were issued in various configurations to comply individually with various international standards

(2) Technical support synchronized to revisions of IEC standards

To reconsider and catch-up basic circuit breaking functions corresponding to the latest IEC standards

(3) Conformance with the European Union's RoHS standards and domestic environmental standards

To remove designated hazardous metals, reconsider lower-cost materials, and reconsider the method of production

(4) Unification of new JIS, IEC, and UL 489 compatible circuit breaker

To realize a single product series that unifies both a UL 489 certified 480 V product and an IEC 60947-2 certified 400 V product, while maintaining the present compact size.

(5) Easily distributable circuit breaker and accessary system throughout the world.

To realize unified circuit breaker accessories that are configured so as to permit user installation.

As various countries adhere to IEC standards, circuit breakers that realize the abovementioned goals are anticipated to become the global standard of the future.

3. G-Twin Features

Figure 6 shows the appearance of G-Twin Breakers. The molded cover is colored "Fuji gray" (light gray) and projects a new global image. On the other hand, the black cover of the α-Twin Breakers matches the existing equipment in Japan, and this color scheme is maintained in consideration of those customers who are presently using the α-Twin Series. Therefore Fuji Electric provides two series of breakers to conform to standards throughout the world. The G-Twin Series consists of the following two product lines, one of which displays the UL 489 standard. (See Table 1.)

① A universal MCCB/ELCB G-Twin Series that can be used in all installations throughout the world (including Japan)

② MCCB/ELCB α-Twin Series used mainly with electrical installations in Japan

The five major features of the G-Twin are described below.

(1) A multi-standard product that maintains Japanese standard dimensions

Figure 7 shows the concept of a unified G-Twin Series. For the first time in the world, while maintaining Japanese standard dimensions, a single product has obtained IEC, new JIS, GB, and UL (480 V delta system) certification and can be used in any country in the world. In eliminating the previously required task of selecting a particular circuit breaker from among models having the same functionality for use in a particular country, this new product is extremely convenient.

Fig.6 Appearance of G-Twin MCCB/ELCB

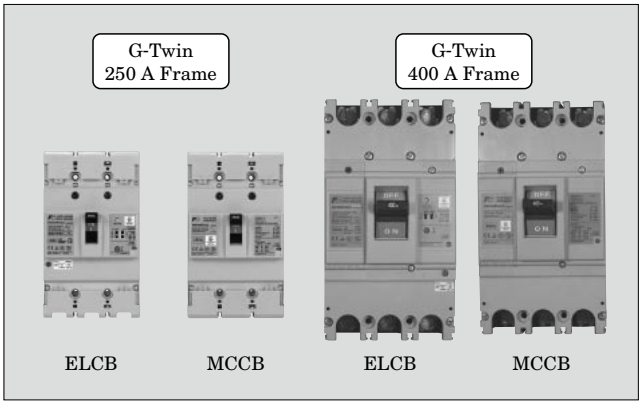
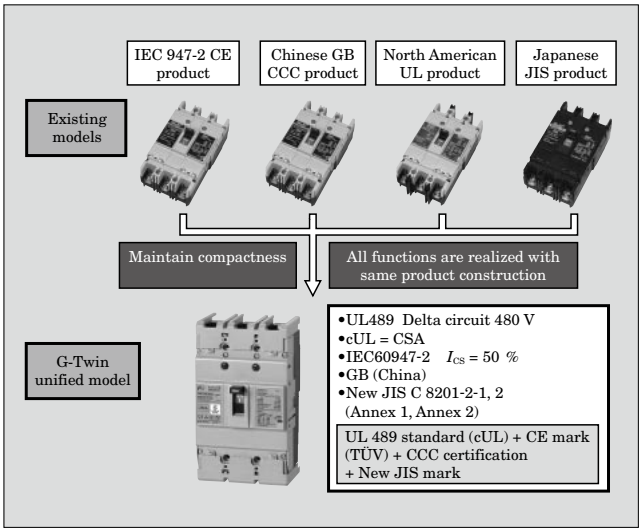


Fig.7 Concept of unified G-Twin Series



(2) Incorporation of IEC 60947-2 Ed. III and improved maintainability

A CE*1 mark must be affixed to export to the EU community. A circuit breaker to which a CE mark is affixed must satisfy the latest technical requirements of IEC 60947-2. In particular, with an ELCB, due to differences in distribution voltages or grounded systems, it is necessary to be careful about whether IEC 60947-2 technical requirements are being satisfied. The G-Twin completely conforms to IEC 60947-2, supports CE marking, and improves the ease of maintenance. Examples of the improvements are listed below.

① The detection circuit power supply of the ELCB is changed to a three-phase input to realize reliable operation during open-phase operation. (See Fig. 5.)

② A dielectric test switch is provided to enable the easy implementation of an insulation-to-earth resistance test of the wiring or equipment on the load-side of the ELCB. (See Fig. 8.)

(3) Conformance with the US-based UL 489 480 V AC

*1: CE mark is a marking certifying that a product complies with Europe's safety requirements.

Fig.8 Equipping with maintenance-use dielectric test switch

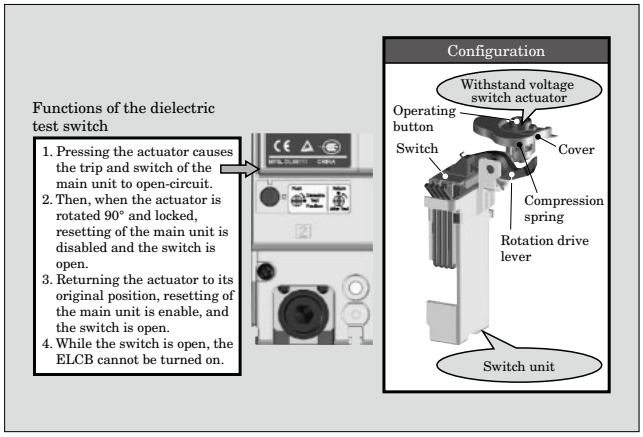
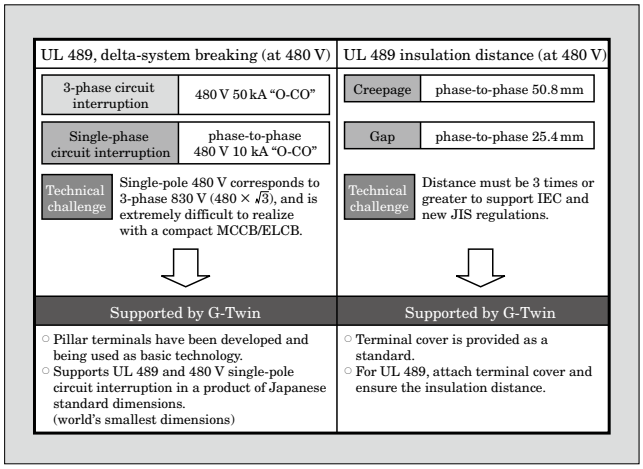


Fig.9 Breaking duty and insulation distance of UL 489 delta-system



delta connection system

The greatest technical challenge for the globalization of low voltage circuit breakers is with keeping Japanese standard compact size is making it possible to satisfy the duty of a UL 489 480 V AC delta connection. The G-Twin Breakers maintain the Twin Breaker principle of common dimensions for the MCCB and ELCB, and they are the world's first MCCB and ELCB to have met this challenge. (See Fig. 9.)

(4) User-friendly configuration

125 AF and 250 AF frame sizes were selected as these are the global standard for circuit breaker frames. Also, the number of connection terminals was increased for 400 AF frames to enhance compatibility with distribution switch gear. (See Fig. 10.) Internal accessories (auxiliary, warning switch, voltage trip coil, etc.) for installation inside the circuit breaker are streamlined into two series of common accessories for 125 AF to 250 AF and for 400 AF and larger sizes, thus improving the ease of user installation.

(5) Industry's highest level environmental protection and energy savings

The G-Twin Breaker, including the main unit and accessories, completely conforms to the EU's environmental standard known as the RoHS directive.

Fig.10 400 AF terminal variation

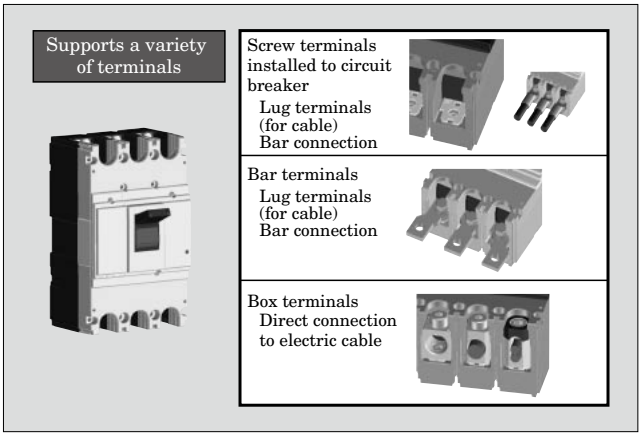


Fig.11 G-Twin FePSU Breaker equipped with power monitoring function

A model variation, the G-Twin FePSU Breaker, having a function for monitoring electric energy at the branch circuit and a function for transmitting its data, was added to the lineup of this breaker series. Therefore Fuji Electric's series of energy-savings support devices was expanded. (See Fig. 11.)

4. Summary of G-Twin Ratings and Specifications

With the completion of the G-Twin MCCB/ELCB, Fuji Electric's twin breaker series is configured as shown in Fig. 12. In other words, the G-Twin product line consists of the following two series.

(1) High-end series: Highest-level "global breaker" series capable of supporting all standards worldwide in the same model

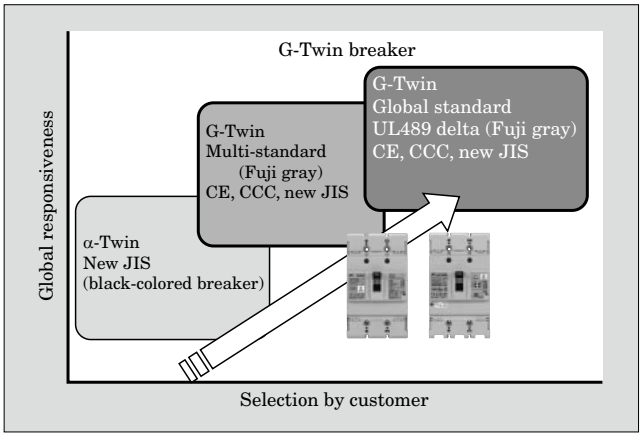
(2) Middle-class series: "Multi-standard breaker" series that supports Japanese and IEC standards.

Customers who use either series (1) or (2) above

in accordance with their percentage of MCCB/ELCB usage for each standard (IEC standard, UL standard, new JIS, GB standard) will be free of the task of choosing series of MCCBs and ELCBs according the application, and therefore, the tasks of designing and stocking equipment will become more streamlined.

Table 2 lists the main specifications of the global twin breaker, and Fig. 13 shows the main nameplate.

Fig.12 MCCB/ELCB series



5. G-Twin Breaker Structure and Technology

The basic structure of the G-Twin was determined according to the primary goal to realize the maximum level of performance while maintaining the Twin Breaker concept, i.e. maintaining the same external dimensions with the ELCB and MCCB.

As shown in Fig. 14, an improved product was successfully realized by applying a new arc-extinguishing principle utilizing ablation technology, technological advances developed through a full reassessment of

Table 2 G-Twin MCCB and ELCB specifications

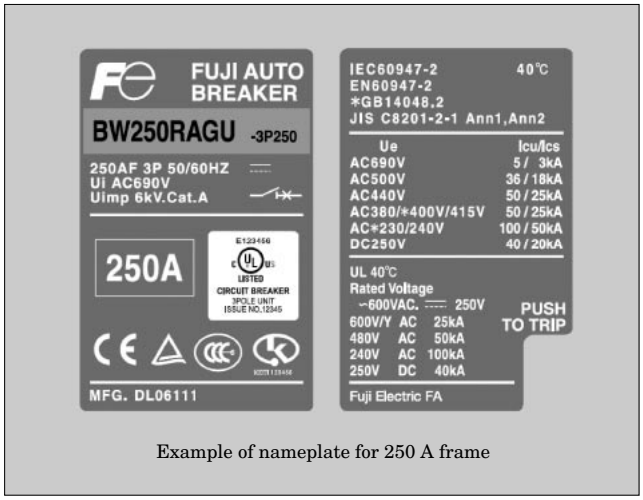
(a) MCCB

Frame			125 AF		250 AF		400 AF		
Number of poles			2, 3 ,4		(2), 3, 4		(2), 3, 4		
Rated current (A)			15, 20, 30, 40, 50, 60, 75, 100, 125		100, 125, 150, 175, 200, 225, 250		250, 300, 350, 400		
Model number			BW125JAGU	BW125RAGU	BW250JAGU	BW250RAGU	BW400SAGU	BW400RAGU	BW400HAGU
Rated insulation voltage (V)			690		690		690		
External dimensions (mm)		2 poles	W : 60, H : 155, D : 68	W : 90, H : 155, D : 68	W : 105, H : 165, D : 68		W : 140, H : 257, D : 103		
		3 poles	W : 90, H : 155, D : 68		W : 105, H : 165, D : 68		W : 140, H : 257, D : 103		
		4 poles	W : 120, H : 155, D : 68		W : 140, H : 165, D : 68		W : 185, H : 257, D : 103		
Breaker capacity (kA)	JIS C 8201-2-1 Annex 1, Annex 2 IEC60947-2 GB14084.2 I_{cu} / I_{cs}	690 V	–	5/3	–	5/3	10/5	15/8	20/10
		440 V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
		400 V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
		240 V	50/25	100/50	50/25	100/50	85/43	100/50	125/63
	UL489 delta-system cUL	480 V	25	50	30	50	35	50	65
		240 V	50	100	50	100	85	100	125

(b) ELCB

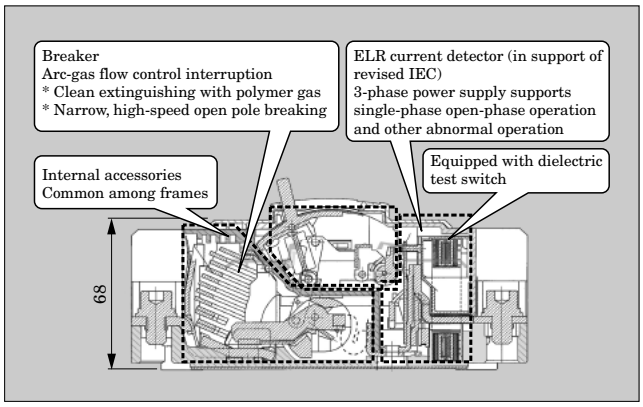
Frame			125 AF		250 AF		400 AF		
Number of poles			3, 4		3, 4		3, 4		
Rated current			15, 20, 30, 40, 50, 60, 75, 100, 125		100, 125, 150, 175, 200, 225, 250		250, 300, 350, 400		
Model number			EW125JAGU	EW125RAGU	EW250JAGU	EW250RAGU	EW400SAGU	EW400RAGU	EW400HAGU
Rated voltage AC (V)			100-230-440		100-230-440		100-230-440		
Rated sensitive current (mA)			30, 100/200/500		30, 100/200/500		30, 100/200/500		
Tripping time (s) at/delta n			0.1		0.1		0.1		
External dimensions (mm)		3 poles	W : 90, H : 155, D : 68		W : 105, H : 165, D : 68		W : 140, H : 257, D : 103		
		4 poles	W : 120, H : 155, D : 68		W : 140, H : 165, D : 68		W : 185, H : 257, D : 103		
Breaker capacity (kA)	JIS C 8201-2-2 Annex 1, Annex 2 IEC60947-2 GB14084.2 I_{cu} / I_{cs}	440 V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
		400 V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
		240 V	50/25	100/50	50/25	100/50	85/43	100/50	125/63
	UL489 delta-system +UL1053 cUL	480 V	25	50	30	50	35	50	65
		240 V	50	100	50	100	85	100	125

Fig.13 Main nameplate of the G-Twin MCCB



Example of nameplate for 250 A frame

Fig.14 G-Twin ELCB structural cross-section and development technology



the earth leakage trip unit, and technological breakthroughs in environmental technology and the like achieved in the development of new materials. Items of significance are described below.

5.1 Realization of both IEC-standard interrupting duty and UL-standard 480 V delta-system interrupting duty

(1) Difficulty of compatibility with both IEC 60947-2 and UL 489

Table 3 lists the differences between the IEC standard/new JIS and the UL standard. From this table, it can be seen that UL 489 has stricter requirements. As previous UL-listed products were larger in size than IEC-standard products, it was distributed as a separate series for the North American market.

In particular, a large obstacle to product design was keeping the single-pole interrupting duty assuming a single-line ground fault in a delta-connection 480 V grounded system, and ensuring the insulation distance.

(2) Realization of both IEC and UL interrupting duty with ablation-based interrupting technology

In order to increase the initial open acceleration of the movable contact, a magnetic yoke and a stationary contact are positioned in combination, and a three-dimensional simulator was used heavily to determine the optimal positioning. Moreover, the ablation gas effect is added to the arc plate, to cool the arc, thus achieving a dramatic improvement in the current-limiting performance, and 70 % reduction of let-through energy (I^2t) during an IEC standard 440 V AC/50 kA interruption compared to the conventional 225 AF.

In addition to the improvement in current-limiting performance, the flow of exhaust gas from the arc plate to the load-side of the breaker is controlled by the structure of the case and cover so that the arc meets the current zero-point reliably on the plate. As a result of this effect, the UL standard for 480 V single-pole interruption duty is kept. (See Fig. 15.)

Table 3 Differences between UL 489 and IEC 60947-2 requirements

Main requirements			UL 489	IEC 60947-2, new JIS
Rated voltage			Requirements of 480 V, delta-connection to ground system	Requirements of 400 V, Y-connection to ground system
Structure	Creepage insulation distance	Phase to phase	50.8 mm	10 mm
		To ground	25.4 mm	10 mm
	Creepage insulation clearance	Phase to phase	25.4 mm	5.5 mm
		To ground	12.7 mm	5.5 mm
	Double insulation		Not required	Necessary
	Isolation		Not required	Necessary
Electrical	Impulse withstand voltage		Not required	6 kV
	Electrical durability (250 A)		4,000 cycles at I_n (4,000) mechanical	1,000 cycles at I_n (7,000) mechanical
	Overload switch		50 cycles at 6 I_n	12 cycles at 6 I_n
	Temp. rise of terminal		50 deg. or less	70 deg. or less
Short-circuit breaking	Limiting interruption (I_{cu})		"O" to "CO" at 480 V (twice)	"O" to "CO" at 400 V (twice)
	Service interruption (I_{cs})		Not required	"O" to "CO" to "CO" at 400 V (three times)
	One-phase ground fault interruption		"O" to "CO" at 480 V for each phase	Not required (manufacturer's value)
	Withstand voltage after interruption		960 V, 1 minute	1,380 V, 1 minute

5.2 Technical advances of the earth leakage trip unit

(1) Realization of an earth leakage trip unit that conforms to IEC 60947-2 Ed. III

When a certain earth leakage current occurs, the earth leakage trip unit outputs a signal to the detection circuit to make the trip coil operate to trip the connection of the main unit. In IEC 60947-2 Ed. III, assuming the use of a fuse or the like as an overcurrent protector, an internal power supply circuit is required so that earth leakage current can be detected and the

Fig.15 Configuration of breaker unit in G-Twin Breaker

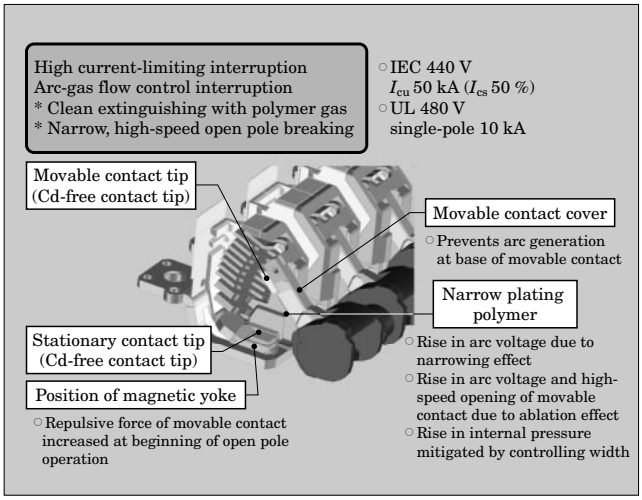
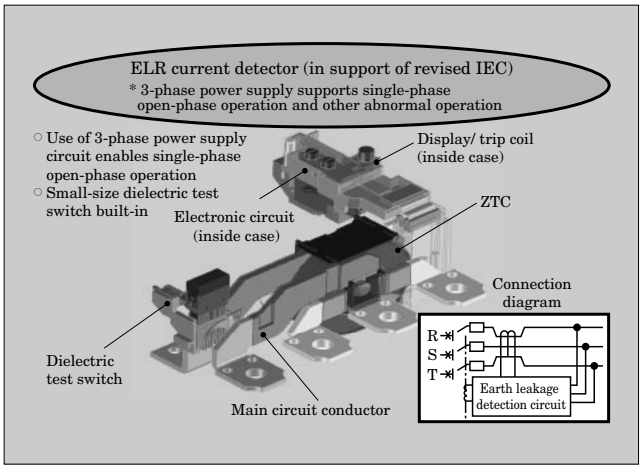


Fig.16 Configuration of G-Twin's internal earth leakage relay

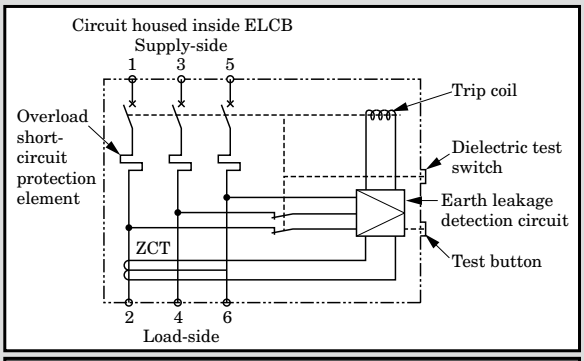


circuit tripped even in cases where one of the three phases is an open-phase. To support this requirement, a new small-size power supply circuit was developed and applied. In addition, ultra-miniaturization of the trip coil and modularization of mechanical parts that transfer motion enabled the successful development of a small-size earth leakage trip unit. (See Fig. 16.) As a result, the product was commercialized without having to modify the external dimensions of conventional products.

(2) Installation of dielectric test switch for maintenance use

The power supply circuit for the earth leakage trip unit is connected to the main circuit inside the ELCB. Therefore, during dielectric testing of the electrical connections, the high voltage that is applied between phases may cause damage to the circuit elements. For this reason, previous ELCBs were provided with warnings not to perform a phase-to-phase dielectric test, and to remove the ELCB wiring when performing a dielectric test. To eliminate such inconvenience, the G-Twin ELCB is equipped with a switch that provides voltage withstand performance between the earth leakage trip unit and the internal main circuit conductor. This dielectric test switch is provided as a standard feature in 125AF and higher G-Twin ELCBs. (See Fig. 17.) By operating this switch during dielectric testing, maintenance inspections can be performed with dramatically improved ease.

Fig.17 Dielectric test switch circuit and specifications



Specifications

- Rated voltage 100 to 480 V
- Rated current 1 to 30 mA
- Contact resistance 100 mΩ or less
- Withstand voltage 2,500 V AC
- Insulation resistance 100 MΩ or higher
- Lightening impulse withstand voltage U_{imp} 6 kV
- Electrical durability 100 cycles
- Mechanical durability 1,000 cycles

Operation

- Press button and turn switch off during test of main circuit withstand voltage
- Self-holding mechanically
- Mechanically interlocks with breaker

6. Conclusion

The development, features and specifications of the G-Twin have been presented above. The use of global products in electrical installations worldwide will become increasingly important for realizing more efficient equipment design and production. The G-Twin Series anticipates these needs and we are confident that the G-Twin will be able to satisfy a diverse array of customer requirements. In addition, we believe that our low-voltage circuit breakers which incorporate this concept will become the de facto standard for the next generation of products. Fuji Electric will continue to seek advice from customers, and will strive to develop an even broader product line in the future.