

# Low-voltage Switching Devices for the Global Market

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## 1. Introduction

As society has become more industrialized over the last half-century, low-voltage switching devices such as magnetic contactors and circuit breakers have evolved greatly as the main components for electrical equipment. Recent conditions such as full-scale global deployment and an upsurge in environmental protection measures are requiring new advances in these components.

Fuji Electric has always produced and provided distinctive products that have pioneered technical trends and have met market demands.

This paper introduces Fuji Electric's recent series of low-voltage switching devices and our efforts to satisfy the latest market demands and to incorporate new technical trends.

## 2. Trends of Low-voltage Switching Devices and Fuji Electric's Activities

### 2.1 Market trends

The size of the global market for low-voltage switching devices, assumed to consist mainly of circuit breakers, earth leakage circuit breakers, magnetic contactors (MCs) and overload relays, was approximately 700 billion yen in the year 2001. In China where economic condition is especially good, market growth is continuing at a rate of several percent or more.

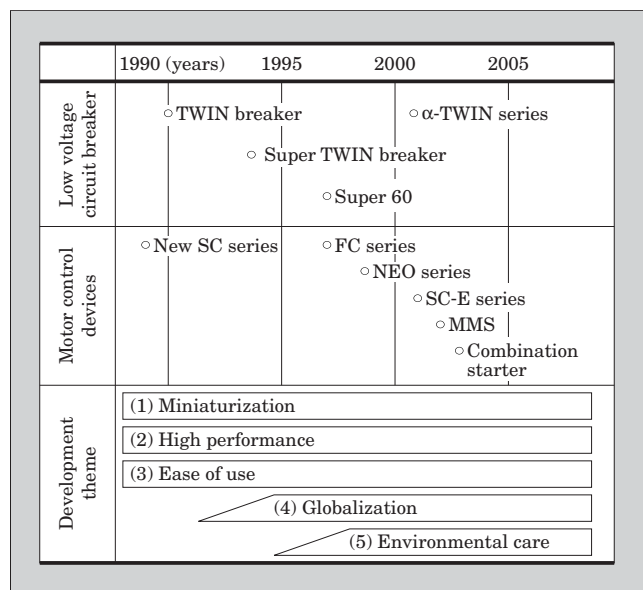
In response to these international market trends, customers' business is rapidly expanding into global markets. Therefore, the necessity for products that comply with global standards and specifications is increasing rapidly.

### 2.2 Technical trends and Fuji Electric's activities

Figure 1 shows the history of development of our main products in the field of low-voltage switching devices and their underlying development themes.

Until now, development pursued the main three themes of: ① miniaturization, ② high performance and quality, and ③ ease of use. These of course are all universal themes that are still continued to be pur-

Fig.1 New product development and development theme



sued.

The TWIN Breaker and the new SC series of magnetic contactors announced in 1990 were innovative products which pursued, to the extent possible, miniaturization, high performance and ease of use. These devices are still popular today. Meanwhile, over the past several years themes such as ④ globalization and ⑤ environmental care have rapidly been increasing in importance.

Below, we introduce specific examples of Fuji Electric's efforts in the low-voltage circuit breaker and motor control fields.

## 3. Fuji Electric's Efforts Relating to Low-voltage Circuit Breakers

Fuji Electric has long been providing circuit breakers and earth leakage circuit breakers.

These devices have been marketed under the name of the Fuji auto breaker (FAB) and the Fuji earth leakage breaker (ELB), respectively, and have been well received in the market.

The TWIN breaker put on the market in 1990

(shown in Fig. 1) was an innovative series that featured, for the first time in the industry, the same external dimensions for FAB and ELB. The concept of standardized external dimensions has been inherited as a basic concept for FABs and ELBs, and has also become a market standard in the Japanese market.

### 3.1 Characteristic of $\alpha$ -TWIN series

Fuji Electric's FAB and ELB series are shown in Fig. 2. The TWIN breaker concept unifies the whole region from 30 A to 800 A. Within this region, the  $\alpha$ -TWIN covers the range from 30 A to 100 A, which is the region of most usage. The  $\alpha$ -TWIN has been designed not only to achieve ultimate miniaturization, but also to comply with the increasing demands for globalization and environmental consideration on an advanced level. The external appearance of the  $\alpha$ -TWIN is shown in Fig. 3.

#### (1) Ultimate miniaturization

Figure 4 shows a cross-sectional view of the  $\alpha$ -TWIN ELB together with a superimposed rendering of the dimensions of the previous TWIN breaker and a former model. Over the past ten years, the length of the ELB has been reduced from 200 mm (former model) to 130 mm (TWIN) and then to 100 mm ( $\alpha$ -

TWIN). There is no doubt that this 50% reduction achieved by the  $\alpha$ -TWIN can be called the ultimate miniaturization.

Figure 5 shows accessories for the  $\alpha$ -TWIN. Since panel specifications may change during manufacture and operation, the  $\alpha$ -TWIN has been designed for flexibility and most of its accessories can easily be attached by the customer.

#### (2) Globalization of the $\alpha$ -TWIN

The  $\alpha$ -TWIN complies with major international and domestic standards (such as JIS, IEC, and UL/CSA), and as such, displays CE and UL markings.

Fig.2 FAB and ELB series

		Ampere frame size (AF)							
		30	50	60	100	225	400	600	800
Short circuit breaking capacity $I_{cu}$ at 440 V IEC947-2 (kA)	1.5	α-TWIN series							
	2.5	α-TWIN series							
	7.5	α-TWIN series							
	10	α-TWIN series							
	15				Super 60				
	25						Super TWIN breaker		
	35						Super TWIN breaker		
50						Super TWIN breaker			

Fig.3 Appearance of MMS  $\alpha$ -TWIN



Fig.4 Cross-sectional view of  $\alpha$ -TWIN

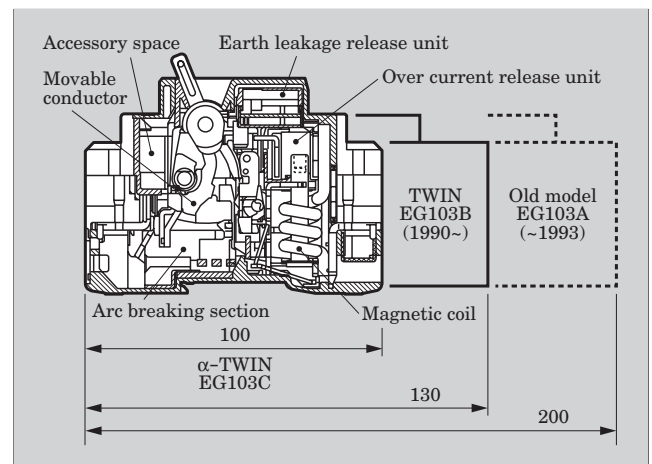
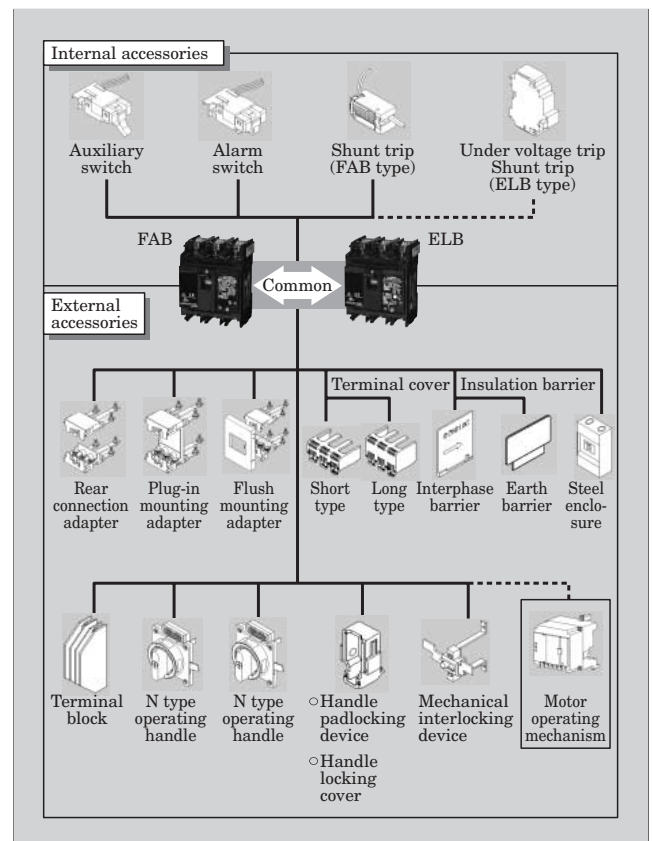


Fig.5  $\alpha$ -TWIN accessories



Therefore, the  $\alpha$ -TWIN has been designed in response to customer demands for equipment suitable for deployment overseas. Moreover, environmental measures (such as the use of lead-free material, for example) have also been applied.

### 3.2 Design and manufacturing technology to achieve miniaturization

The ultimate miniaturization of the  $\alpha$ -TWIN is a result of marginal design of each component such as the short circuit breaking mechanism, arc extinguishing chamber, overcurrent detection, and earth-leakage detection units, while making full use of simulations based on previously accumulated characteristic technology.

## 4. Efforts to Develop Motor Control Devices

For nearly 50 years, Fuji Electric has been providing motor control and switchgear equipment such as magnetic contactors (for motor control) and thermal overload relays (for overload protection). In this paper we will focus on the new MC and TOR series which target the global market, the MMS, and the combination starter that combines the MC and MMS into a single compact unit.

### 4.1 Product series targeting the global market

In Japan, the process of unifying the JIS standard with the IEC standard is being undertaken in every field. Since the JIS standard for MCs and TORs did not differ greatly with the corresponding IEC standard, a unified JIS standard was announced in 1999, thereby eliminating any remaining barrier due to international standards. Moreover, although the unification of standards is advancing globally at a quick pace, the standard specifications created by the industrial culture of a market are actually difficult to unify. A good example is the difference in electric wire connecting systems for different markets. Fuji Electric's MC and TOR series are available in two series of differing terminal structures, one that connects ring-shaped terminals and another for direct wiring. These structures enable the devices to be useable in any market in the world. The MC, TOR, and MMS series are shown in Fig. 6, and the terminal structures of the MC are compared in Fig. 7.

### 4.2 Support of advanced motor circuit protection functions

In Japan, most power supplies for a motor circuit are 200 V, and 400 V systems are very rare and account for only about 10 % of all systems. The 400 V system, however, is the most common system overseas, and the difference in circuit voltage has led to differences in the degree of protection perceived to be required for short circuit and electric shock accidents. A short circuit accident in a 400 V system involves a much larger amount of energy than in a 200 V system,

Fig.6 MC, TOR and MMS series

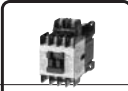
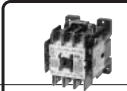

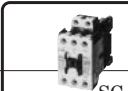
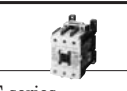
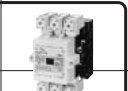


		Small capacity	Middle capacity	Large capacity
AC-3, 400 V (A)		up to 25	32 to 65	80 to 150 to 800
Ring terminal wiring type	CTT			
	TOR	New SC series	NEO series	
Direct wiring type	CTT			
	TOR	SC-E series		
	MMS			

Fig.7 MC terminal structure comparison



thus leading to the requirement for a short circuit protector with a large breaking capacity. Nowadays, technical competition for short circuit protection is focused on developing ways to reduce the energy during a short circuit accident and thereby prevent damage to a MC and TOR.

The manual motor starter (MMS), introduced below, is a newly developed product series that satisfies the safety requirements of overseas 400 V motor circuits.

#### (1) MMS

The MMS is a product that combines the short circuit function of a low voltage circuit breaker and the overload function of a TOR into a single compact component. The external appearance of the MMS series is shown in Fig. 8. One of the greatest features of the MMS is its enormous current limiting performance during the breaking of a short circuit current. Figure 9 shows the current limiting characteristic of the MMS. It can be seen that the MMS suppresses the energy generated during a short circuit to about ten times lower than that of an ordinary circuit breaker.

The structure of the MMS is shown in Fig. 10. The main feature is the current breaking section. The aim

Fig.8 Appearance of MMS series

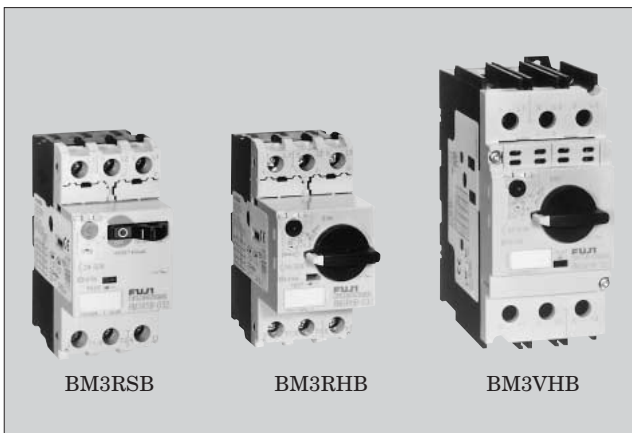
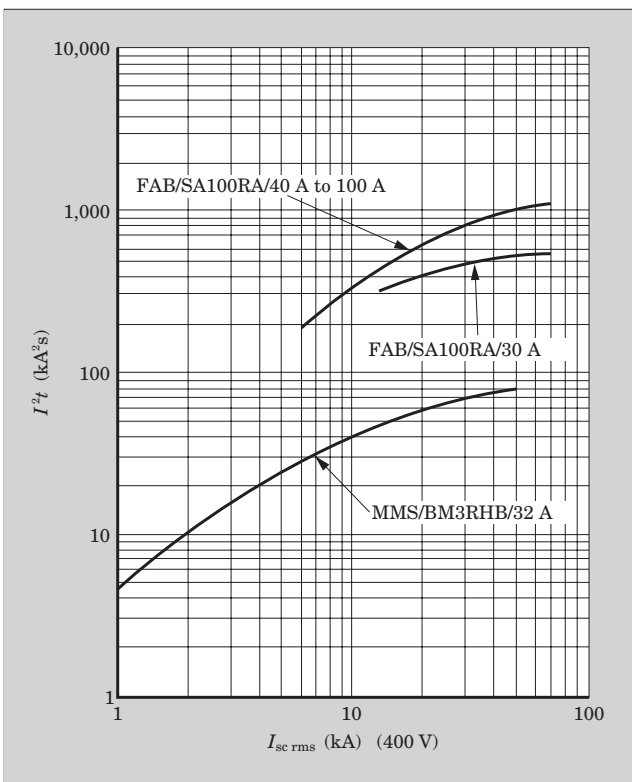


Fig.9 Current limiting characteristic



to rapidly increase the arc voltage and to limit the let through current at the time of a short circuit has been achieved by positioning two arc chambers in series per pole.

Of course, the MMS can be used independently as a manual switch for an electric motor, but generally, it is used in combination with an MC. The high current limiting capability prevents damage to the MC in the case of a short circuit accident. The level of short circuit coordination is defined in IEC 60947-4-1 as either “type 1” in which the MC cannot be re-used, or “type 2” in which re-use of the MC is possible.

In the design of modernistic automation equipment, specifications calling for “type 2” coordination are expected to increase in order to reduce the

Fig.10 Internal structure of MMS

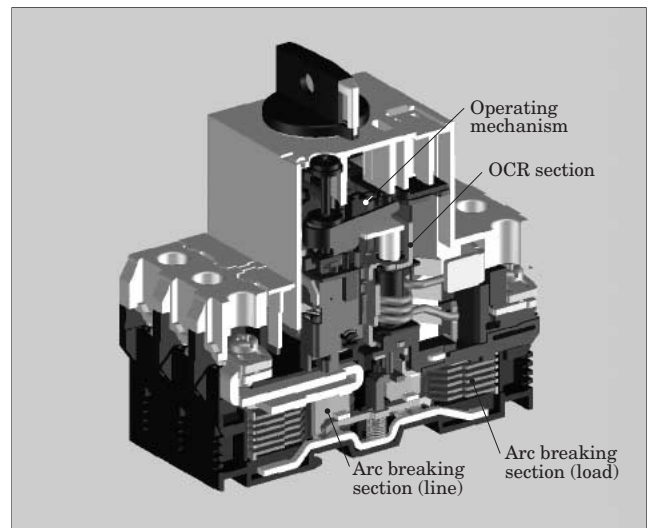
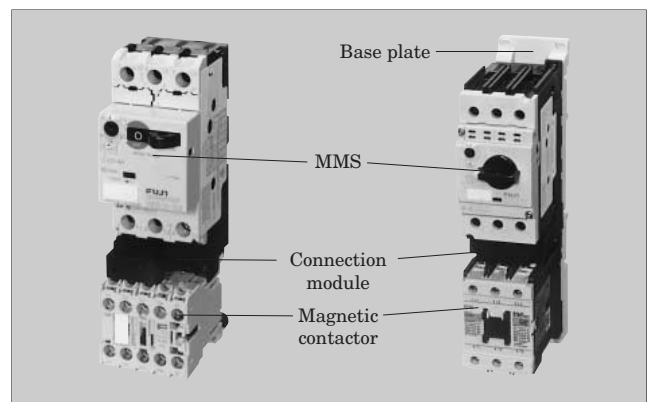


Fig.11 Combination starter



maintenance downtime of the equipment after an accident. Fuji Electric’s MMS is just the right product to fulfill these specifications.

## (2) Combination starter

The combination starter shown in Fig. 11 is an MMS and MC combined by a special interconnect component. The advantage of combining both an MMS and MC into a single unit is that it simplifies the selection of the coordination level and additional wiring is unnecessary, it also reduces the wiring work and requires less space for installation.

## 5. Conclusion

This paper has introduced Fuji Electric’s efforts in response to market and technical trends, and the main new series of low-voltage switching components recently put on the market. It is thought that market demands will become increasingly diversified in the future and will become much more complicated.

Fuji Electric intends to utilize leading edge technology as well as its accumulated experience and technical know-how to continue to function as a valuable component provider for the world market.



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