Magnetic Starters and Relays with Spring Clamp Terminals

Author: *Tohru Hayashi**

1. Introduction

When electrical apparatus is installed on control boards and equipment, connecting wires to the screw terminals is laborious and workers require skill to maintain high quality. In addition, when electrical apparatus is delivered and inspected, it takes much time to ensure quality (e.g., additional tightening and other operations) and also other costs are incurred.

The declining birthrate, aging population, and other similar problems in recent years have caused labor shortages and reduced the number of skilled workers. Therefore, to reduce time and cost, there is strong demand for products with spring clamp terminals as screwless terminals featuring simple wiring and less maintenance. Spring clamp terminals are commonly used in Europe and many products to be exported to Europe contain parts that utilize these terminals.

Mitsubishi Electric Corporation has developed magnetic starters and magnetic relays with spring clamp terminals that satisfy such requirements, in addition to the conventional magnetic starters and magnetic relays with screw terminals. Small frames which sell in large quantities were developed; as shown in Table 1, 12-A and 20-A magnetic contactors and 5-pole magnetic relays are available.

This paper describes the advantages of the products developed this time.

2. Advantages of the Developed Products

2.1 Wiring[1]

The advantages of wiring to our newly developed magnetic starters and magnetic relays with spring clamp terminals are described below.

2.1.1 Solid conductors, stranded conductors, flexible stranded conductors, and ferrules supported

Our magnetic contactors with spring clamp terminals support solid conductors and stranded conductors, whether plated or not, for the first time in Japan.[*1] Although ferrules prevent stranded conductors from spreading out, they do not save as much work. The main wiring method used overseas does not involve ferrules, and so stranded conductors are important for global business. In addition, solid conductors are often used when installing electric facilities in buildings and they can be flexibly used for installing the growing number of electric vehicle (EV) chargers as well as for vehicle-to-home (V2H) equipment.

2.1.2 Methods to insert and remove various types of wires

Solid conductors and ferrules can be connected to our products with spring clamp terminals simply by pushing in unsheathed wires in one action, while stranded conductors can be connected in two actions using a tool. These methods eliminate the risk of losing screws and save work.

2.1.3 Higher usability thanks to 15° wiring direction

The tilted wiring direction reduces swelling in wires in ducts. In addition, the tool is operated perpendicular to the mounting surface of a control panel, which makes it easier to apply force to manipulate the springs. The

Table 1 Specifications

Models		Magnetic contactors		Magnetic relays
Operation coils	AC	S-T12SQ	S-T20SQ	SR-T5SQ
	DC	SD-T12SQ	SD-T20SQ	SRD-T5SQ
Rating (AC200V) (Same as products with screw terminals)		13A (AC-3)	18A (AC-3)	3A (AC-15)
Size of applicable wires (Main and auxiliary/operation)	Solid conductor	ϕ0.8–2		
	Stranded conductor	0.5–4 mm^2		
	Ferrule	0.25–2.5 mm^2		
External dimensions (W × H × D (mm))	AC operation	44 × 76.7 × 78 (similar to products with screw terminals) (Reference: Products with screw terminals: 44 × 75 × 78)		
	DC operation	44 × 76.7 × 100 (similar to products with screw terminals) (Reference: Products with screw terminals: 44 × 75 × 100)		
Screw installation dimensions (mm)		35 × 60, etc. (same as products with screw terminals)		

1 As of November 1, 2019, researched by Mitsubishi Electric Corporation

**Nagoya Works*

method also avoids the need to change the direction of the tool between the power source side and load side. Any terminal can be inserted and removed in a uniform direction, which greatly improves workability.

2.1.4 Wire insertion indicator

For ferrules with insulation collars, when the insulation collar section is inserted deeper from the surface of wire slots, the connection is complete. By tilting the wire insertion direction by 15° it is easier to see the insulation collar section, which speeds up checking the connection visually.

2.1.5 Push-in CAGE CLAMP*2 made by WAGO

As spring clamp terminals, the reliable Push-in CAGE CLAMP, which is made by the German spring terminal block manufacturer WAGO and has been used for many years around the world, was selected. The cage in the Push-in CAGE CLAMP holds an inserted wire firmly as if cooped up in a cage. Solid conductors and stranded conductors can be connected without crimp terminals. Specifically, a wire is surrounded with a spring on one side and with an electric conductor on the other three sides. The area of the section that is in contact with the electric conductor is reduced, which increases the pressure per unit area, ensures better contact and reduces the contact resistance.

2.2 Other advantages

2.2.1 Product types

12-A and 20-A frame types of magnetic contactors with spring clamp terminals and 5-pole magnetic relays were developed. Two types of operation coil (AC and DC) are provided for all types, making six types available in total. Regarding performance, the voltage of the operation coils, main circuit and auxiliary circuit ratings, and screw installation dimensions are similar to those of products with screw terminals. Products with spring clamp terminals have the “SQ” added to the end of the model names of products with screw terminals. They can be ordered in the same way as ordering conventional BC types of wiring streamlining terminals with screw holders. Table 1 lists the product specifications.

2.2.2 Wide range of wire types and standard wire sizes for all terminals

The developed products are compatible with a wide variety of wire types and sizes as shown in Table 2. As solid conductors, ϕ0.8 wires commonly used for communication lines up to ϕ2.0 wires often used for indoor vinyl wires in buildings are supported. As stranded conductors, 0.5-mm^2 wires often used for signal wires up to 4.0-mm^2 wires to be used on the primary side from the circuit breakers when wires are routed across multiple magnetic contactors are supported. As ferrules with insulation collars, thinner 0.25-mm^2 wires to 2.50-mm^2 wires that are also used as power lines are supported.

In addition, the same spring clamp terminal structure was applied to all terminals, making it possible to connect wires of the same size to all terminals regardless of main, auxiliary, or operation circuit, and regardless of magnetic contactor or magnetic relay.

In some cases, measures to prevent contact resistance of wires are required; for example, Company A in Table 2 instructs that only tinned wires should be used when stranded conductors are directly connected. As described in 2.1, the contact pressure per unit area of the spring clamp terminals used for these developed products is high. Therefore, even when non-plated bare copper wires are used, the contact resistance can be kept low.

As described above, the developed products support a wide variety of wire types and sizes without specific requirements or limitations on applicable size between circuits and between models, enabling flexible design of panels and equipment.

2.2.3 Electroscope slots and arrangement of coil terminals for improved usability

Regarding wiring to the developed products, two wires can be inserted per terminal and the products have

Table 2 Applicable wire sizes

Wire type	Comparison of applicable wire size between products made by Mitsubishi Electric and other companies (magnetic starters and relays)									
Solid conductor			ϕ0.8	ϕ1		ϕ1.6		ϕ2		
Stranded conductor (mm^2)			0.5 *	0.75 *	1 *	1.5	2	2.5	3.5	4
Ferrule with insulation collar (mm^2)	0.25	0.34	0.5	0.75	1	1.5	2	2.5		
Remarks	Mitsubishi Electric: All wire types in the cells enclosed by bold lines are applicable. Company A: Only the wire types in the dark- and light-gray cells are applicable. Stranded conductors require tinning. Wire sizes with asterisks* require an insulation stop. The connectable wire size varies between main circuits and auxiliary circuits. Company B: Only the wire types in the dark-gray cells are applicable.									

2 The Push-in CAGE CLAMP made by WAGO Kontakttechnik GmbH & Co. KG, Germany (“WAGO”) is used for the spring clamp terminals. “Push-in CAGE CLAMP” is a registered trademark of WAGO.

tool slots to enable each wire to be manipulated separately. Although other companies' products have the same function, our products with spring clamp terminals are easier to use than their products with screw terminals. When the screw of a product with screw terminals is loosened to remove one wire after two wires have been connected, both wires come off and so one wire needs to be tightened again. On the other hand, our products with spring clamp terminals allow individual wires to be separately manipulated, which is easier.

On our products, as shown in Fig. 1, an electroscope slot is provided for each terminal; the products of some other companies do not have such slots in which case tool slots are used instead for electrical checks. Because tool slots are intended for inserting and removing wires, when a tester pin is pushed into them for electrical checks, the wires may come off or become loose halfway, causing troubles. On the other hand, even when a tester pin is pushed into the electroscope slot of our product, there is no risk of the wire coming off. Even when electrical checks in awkward situations are needed, such as in a small space inside equipment or sequestered control panel, there is no issue of how strongly to push in the tester pin.

For products with screw terminals, the coil terminals are arranged deeper from the main terminals. On the other hand, for our products with spring clamp terminals, the coil terminals are arranged on almost the same surface as the main terminals as shown in Fig. 1. Wires are brought by hand close to the wire slots on our products with spring clamp terminals to connect them, unlike manipulating the wires on products with screw terminals. If there is a large step near a wire slot, it hinders wiring operations and makes it difficult to handle the wires. Therefore, on our products, the coil terminals are arranged on almost the same surface as the main terminals, which makes it easier to handle the wires.

2.2.4 Wire holders for smart wiring

In this development, a new wire holder was developed: wires can be routed along the magnetic contactors easily by tucking them into the wire holder. A patent for the wire holder was applied for in December 2019. The holder has the following three main functions.

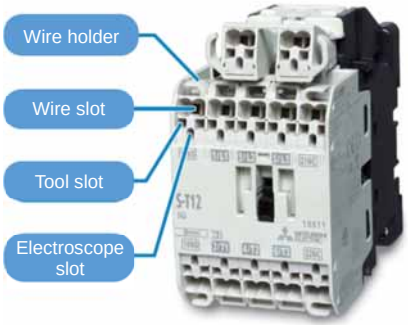


Fig. 1 S-T12SQ Magnetic contactor

(1) Gathering connected wires in one place

Because wires are connected to spring clamp terminals from the front, they are more visible compared to screw terminals, which does not look so good. Cable ties could be used to bind and gather connected wires neatly, but this involves complicated tasks such as preparing cable ties, binding wires with them, and cutting the extra cable ties. To solve this problem, new wire holders are provided to bring wires together without cable ties (Fig. 2); the holders can be used both before and after wiring.

(2) Preventing wire markers from shifting

Wires are sometimes bound together near the terminals to prevent the wire markers from shifting along the wires connected to the ducts of the mounting surfaces of control panels. Using cable ties increases the number of parts as described above, makes operations complicated, and requires treating the remnants. Wire holders are a new means of preventing wire markers from shifting simply by tucking wires into the holders.

(3) Preventing wires from breaking

Magnetic contactors themselves vibrate, and wires are connected from their wiring sections to the mounting surfaces of control panels that do not vibrate much. This causes vibrational stress to be unavoidably applied to the sections of the spring clamp terminals that hold the electric wire conductors (Fig. 3(a)). If this state continues, the conductors may break due to metal fatigue. Instead, by passing wires from the mounting surface of a control panel through the wire holders once and then connecting them to the spring clamp terminals, the sections enclosed by the dotted lines in Fig. 3(b) are united with the magnetic contactor. This greatly reduces the stress

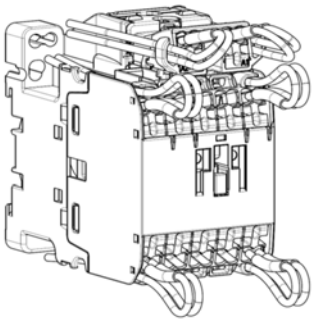
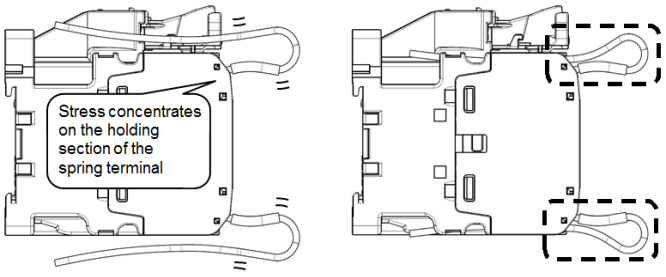
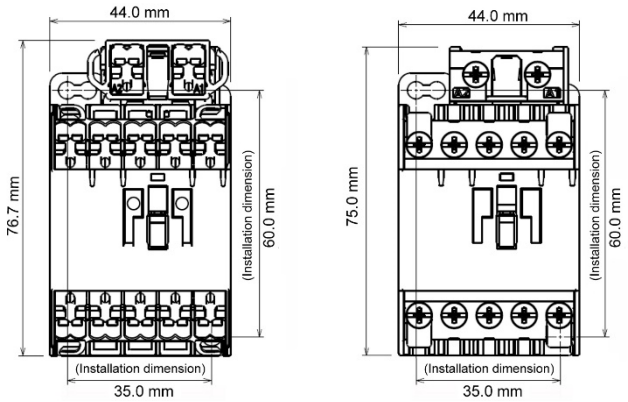


Fig. 2 Example of using the wire holder



(a) Without using wire holders (b) Using wire holders

Fig. 3 Preventing wire breakage



(a) Our product with spring clamp terminals (b) Product with screw terminals

Fig. 4 External shape

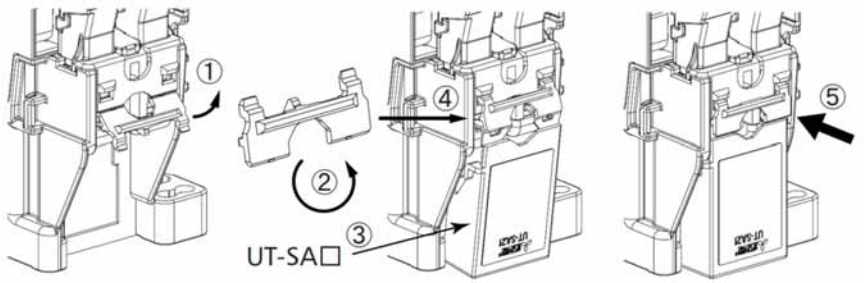


Fig. 5 Installation of surge absorber

on the holding sections of the spring clamp terminals, reducing the risk of wire breakage.

2.2.5 External shape similar to products with screw terminals

The external shape of our new products with spring clamp terminals is similar to that of magnetic contactors and magnetic relays with screw terminals which are widely used (Fig. 4), making it easy to replace existing models with the new models. In addition, when installing the developed products onto the mounting surfaces of control panels with screws, the installation dimensions are the same as those of products with screw terminals, which reduces the time for wiring of existing models and improves the quality.

In addition, because crimp terminals and other parts protrude from the top and bottom of magnetic contactors with screw terminals, devices installed above and below them need to be separated to some extent. On the other hand, wires are connected from the front of magnetic contactors with spring clamp terminals, making it more flexible to install devices above and below them, and contributing to downsizing control panels and equipment.

2.2.6 Compatibility with existing coil surge absorbers

Magnetic contactors with spring clamp terminals do not require special coil surge absorbers and the UT-SA□ series available for existing magnetic contactors with screw terminals can be used. Using the same options for the screw terminal specifications reduces the time for arrangements and stocking.

When installing a surge absorber, it is only necessary to open the cover, insert the absorber, and close the cover as shown in Fig. 5. The internal spring contact eliminates the risk of lost screws and improper installation.

3. Conclusion

This paper described magnetic starters and magnetic relays with spring clamp terminals that reduce time and effort, and improve quality. We will continue developing peripheral equipment and rating frames based on customer needs.

Reference

(1) Y. Kohi.: Circuit Breakers and Circuit Protectors with Spring Clamp Terminal Contributing to Labor Saving and Stable Quality, Mitsubishi Denki Giho, 94, No. 4, 252-255 (2020)