

# Circuit Breakers and Circuit Protectors with Spring Clamp Terminals Contributing to Labor-Saving and Stable Quality

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## 1. Introduction

Currently, the labor shortage is worsening due to the decreasing labor population and the number of skilled workers is falling. Therefore, there is growing demand for product types that can be connected by simple wiring with stable quality even when performed by young workers. Previously, the main connection method in Japan was tightening with screws. However, as the frictional force acting between the male and female threads provides the fastening power, the screws may become loose when used in environments subject to vibration or impact and while the panels are transported. Therefore, the screws need to be periodically tightened and tightened again at installation sites. To solve these problems, Mitsubishi Electric Corporation has added new small circuit breakers and circuit protectors with spring clamp terminals to the lineup.

This paper describes the small circuit breakers and circuit protectors with spring clamp terminals along with other labor-saving types of circuit breakers.

## 2. Product Types and Advantages of New Types

Mitsubishi Electric Corporation developed new small circuit breakers and circuit protectors with spring clamp terminals as 32-A or lower product types that are often used for branching for control panels and distribution boards. They have advantages of both labor-saving and downsizing.

### 2.1 Product types

Table 1 lists the product specifications. Advantages of the NF32-CVF/NV32-CVF small circuit breaker listed in the table include narrower width compared to products in the same price range with similar performance, which contributes to downsizing panels. In addition, they have openable small terminal covers as standard, securing safety and saving labor. They can be installed onto IEC 35 mm rails as standard and can be removed with one touch without tools, providing high workability. Therefore, the new products with spring clamp terminals are

Table 1 Specifications

Products		Small circuit breaker WS-V F Style								Circuit protector			
Models		NF32-CVF/ NV32-CVF		NF32-SVF/ NV32-SVF		NF63-CVF/ NV63-CVF; NF63-SVF/ NV63-SVF		NF50-SVFU/ NV50-SVFU		CP30-BA			
Appearance													
Number of poles		2	3	2	3	2	3	2	3	1	2	3	
Rated current (A)		NF: 3 – 32 NV JIS: 5 – 32 NV CE-CCC: 5 – 30		NF: 3 – 32 NV: 5 – 32		NF: 3 – 30 NV: 5 – 30		NF: 3 – 30 NV: 5 – 30		0.1 – 20			
Applicable wire size	Solid conductor	φ1.6, φ2.0		φ1.6, φ2.0		φ1.6, φ2.0		φ1.6, φ2.0 (14 – 12AWG)		φ1.6, φ2.0			
	Stranded conductor	1.0 – 10 mm <sup>2</sup>		1.0 – 10 mm <sup>2</sup>		1.0 – 10 mm <sup>2</sup>		2.0 – 10 mm <sup>2</sup> (14 – 8AWG)		0.75 – 4 mm <sup>2</sup>			
	Ferrule	1.0 – 6 mm <sup>2</sup>		1.0 – 6 mm <sup>2</sup>		1.0 – 6 mm <sup>2</sup>		2.0 – 6 mm <sup>2</sup> (14 – 10AWG)		0.75 – 2.5 mm <sup>2</sup>			
External dimensions (mm)		a	36	54	36	54	36	54	36	54	17.5	35	52.5
		b	140		140		140		140		99		
		c	52		68		68		68		65		
		ca	65		90		90		90		65		
Wire insertion port		2 ports/pole											

expected to save labor. While the length and width of small circuit breakers other than the NF32-CVF/NV32-CVF listed in the table are the same as those of the NF32-CVF/NV32-CVF, their interrupting capacity is higher and they can be applied to more types of circuits. The NF50-SVFU/NV50-SVFU comply with UL489 Listing and so can be shipped to North America. In addition, the CP30-BA circuit protector in the table is suitable for protecting equipment and its operation characteristics can be selected depending on the equipment to be connected or protected. Regarding the external shape of the products, the width is 17.5 mm for the 1-pole product and 52.5 mm for the 3-pole product, which is remarkably small.

## 2.2 Advantages of the new products

### 2.2.1 Saving time

Regarding applicable wire types, in addition to ferrules (European type rod terminals), stranded conductors and elemental solid conductors can be connected, which is the first in Japan for circuit breakers with spring clamp terminals.\*<sup>1</sup> Solid conductors and ferrules can be connected in one action by pushing them in. Connection of a stranded conductor is completed simply by opening the spring with a tool, inserting the wire, and pulling out the tool (Fig. 1). When connecting elemental wires, crimping is unnecessary and so the

total working time is shorter than when connecting ferrules. For reference, Fig. 2 compares the time required for wiring by unskilled workers according to the Japan Switchboard & control system Industries Association (JSIA).<sup>(1)</sup>

### 2.2.2 Easy wiring

Regarding ferrules, when the insulation sleeve sections have been inserted deeper from the surface of wire insertion ports, connection is completed. This wiring indicator (Fig. 3) makes it easier to visually check the connection. When wires are inserted from the front, bulges in the wires become larger compared to the screw terminal specification. With the newly developed products, the wire insertion ports are tilted at an angle of 15° to the front of the main body, thus reducing bulges in the wires (Fig. 4).

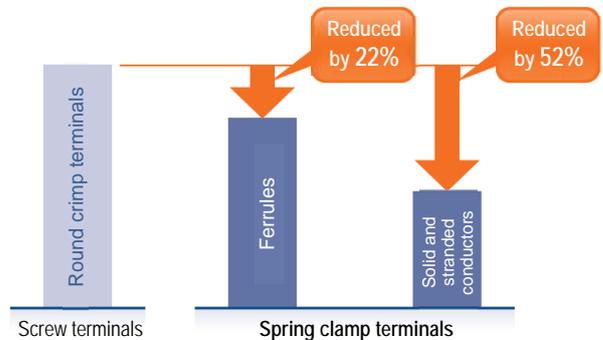
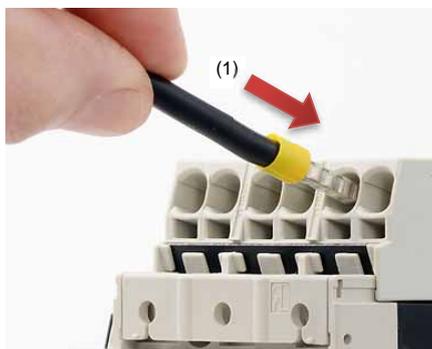
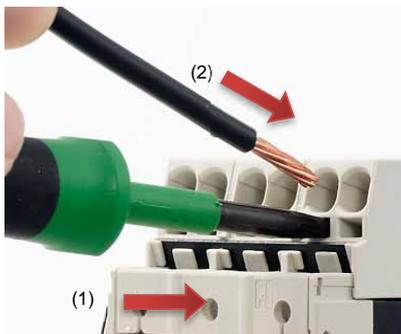


Fig. 2 Comparison of wiring time by unskilled workers (2 years of work experience)



(a) One action (ferrules and solid conductors)



(b) Two actions (stranded conductors)

Fig. 1 Two types of wiring method



(a) Connection completion



(b) Improper connection

Fig. 3 Wiring indicator

<sup>1</sup> As of April 23, 2019, researched by Mitsubishi Electric

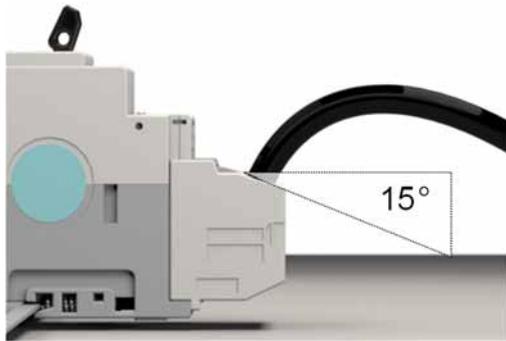


Fig. 4 Reduction of wiring bulges by tilting of wire insertion port

For the screw terminal specification, when multiple wires are connected to one pole by crossover wiring, the wires with crimp terminals need to be stacked and tightened, which increases the workload. On the other hand, our products with spring clamp terminals have two wire insertion ports for each pole terminal, making crossover wiring easy.

### 2.2.3 Stable quality

Our products with spring clamp terminals eliminate the need for skilled screwing as well as variations between workers and between tools, thus ensuring consistent connection quality. In addition, because the springs continuously apply pressure at a certain level, the terminals do not become loose due to vibration, impact, or use for a long time unlike screw terminals, making additional tightening and torque management unnecessary (maintenance-free). We have obtained third-party certification conforming to IEC60947-7-1 for the terminal sections as terminal blocks for copper conductors (screwless-type clamping units) and so our products can be used safely and securely.

### 2.2.4 Flexible specifications

In addition to the standard specification for which both line and load terminals are spring clamp terminals, we provide other specifications: only one side (line side or load side) has spring clamp terminals and the other side has screw terminals. These specifications are useful when large-diameter wires with a cross section of more than 10 mm<sup>2</sup> need to be connected to the line side and screwing is to be performed for wiring sections at the customer's site. Lead wire terminal blocks with spring clamp terminals have also been added to the lineup along with the main bodies. These terminal blocks can be installed into main bodies with screw terminals, and are ideal for various needs, for example, customers who want to try using lead wire terminal blocks because they are concerned about applying them to main circuits due to large current-carrying capacity (Fig. 5).



(a) Screws on the line side + spring clamp terminals on the load side



(b) Screws on the main body + terminal block with spring clamp terminals

Fig. 5 Examples of specification variations

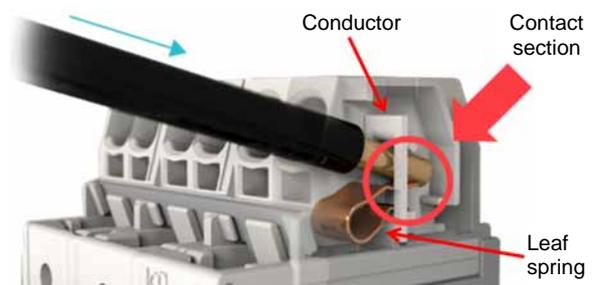


Fig. 6 Terminal structure of NF32-CVF

## 3. Technical Characteristics of Spring Clamp Terminals

Spring clamp terminals are screwless-type terminals and have long been used overseas (particularly in Europe). A terminal mainly consists of two parts (conductor and leaf spring). The leaf spring presses the wire strongly against the conductor for conducting electricity. Figure 6 shows an example of the terminal structure of the NF32-CVF circuit breaker with spring clamp terminals. An inserted wire is surrounded by a leaf spring on one side and by a conductor on the other three sides. The leaf spring applies pressure to the wire in the direction of the section that is in contact with the conductor. The contact area of the contact section

was designed to be smaller, which increases the force applied to the small area, achieving the required contact pressure and low contact resistance.

Another important point is flexibility for various types of wire. Although pushing in ferrules often saves labor, it has negative aspects, such as purchasing and managing ferrules and crimp tools and crimping operations, which take time. In addition to ferrules, elemental solid conductors and stranded conductors can be used for the new products thanks to their sufficient spring force, thus further saving labor (Fig. 7).

#### 4. Other Labor-Saving Types of Circuit Breakers

##### 4.1 Plug-in type circuit breakers for distribution boards

Plug-in type circuit breakers for distribution



Fig. 7 Applicable wire types

boards can be directly connected to bus bars (Fig. 8). They can be connected with one touch (insertion only) and no additional tightening is required. Multiple poles can be inserted at once, greatly reducing the working time. Branching conductors are not required, which saves space. The dimension from the circuit breaker installation surface to the front panel cut face has been standardized as 124 mm for the 125-A to 630-A frames, which enables standardization of the panel design. All the types come with connection indicators as standard.

##### 4.2 Molded case circuit breakers and earth leakage circuit breakers for distribution boards

###### 4.2.1 Line side plug-in type circuit breakers

As small circuit breakers for distribution boards, line side plug-in type circuit breakers that can be directly connected to bus bars have been added to our product lineup (Fig. 9). Like the plug-in type circuit breakers for distribution boards, they can be installed with one touch, reducing the working time. Because additional tightening on the line side is also unnecessary, distribution boards can be produced more quickly and the maintenance process can be omitted.

###### 4.2.2 Load side quick terminal type circuit breakers

Load side quick terminal type circuit breakers can be connected to terminals in one action by inserting wires to the terminals, as is the case with circuit breakers with spring clamp terminals (Fig. 10). Solid conductors can be used as wires and the applicable wire size is  $\phi 1.6$  to  $\phi 2.6$ . This type comes with the connection indicator as standard.

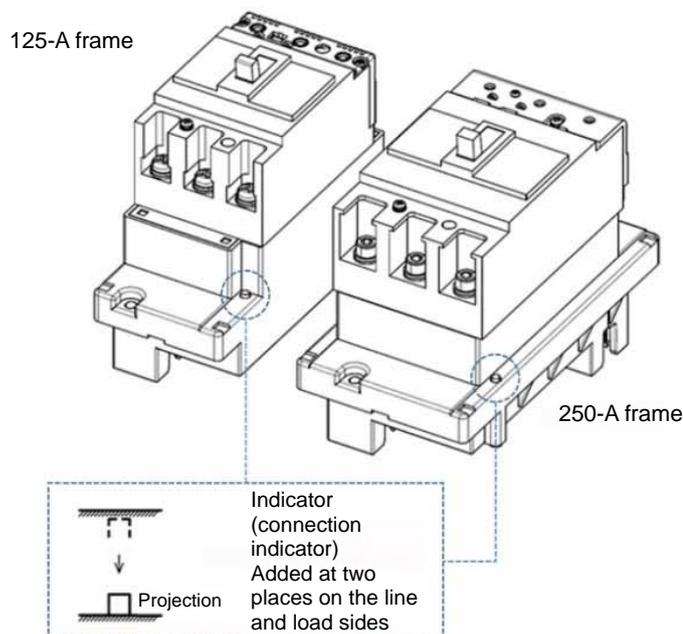


Fig. 8 Plug-in type circuit breaker for distribution board

Line side plug-in types	
Molded case circuit breakers for distribution boards	Earth leakage circuit breakers for distribution boards
 BH-CP1	 BV-CP1

Fig. 9 Line side plug-in type circuit breaker

Load side quick terminal type (QT)	
Molded case circuit breakers for distribution boards	Earth leakage circuit breakers for distribution boards
 BH-C1 QT	 BV-CP2 QT

Fig. 10 Load side quick terminal type circuit breaker

## 5. Conclusion

This paper described our circuit breakers with spring clamp terminals that help save labor and stabilize quality, along with other labor-saving types of circuit breakers. We will continue developing products that match customer needs, including expanding the number of models with spring clamp terminals and considering circuit breakers that further save labor.

## Reference

- (1) Control and Information System Committee under JSIA: Research Study on Cost Reduction of Control Panel Production, 1. Research Study on Rationalization of Wiring (2014)