Miniature Circuit-Breaker

Sizing of Suitable Miniature Circuit-Breaker

for Inverters under PV-Specific Conditions

Contents

The selection of the correct miniature circuit-breaker depends on various factors. Some factors have a stronger impact precisely with photovoltaic power-generating systems than in customary electrical installations.

Disregard of these factors increases the risk that the miniature circuit-breaker will trip during normal operating conditions. It is therefore important to specially account for these factors; only this will ensure reliable functioning of the photovoltaic power-generating system and maximum possible input.

The following pages will describe the factors that must be taken into account when selecting a miniature circuit-breaker, the special factors with photovoltaic power-generating systems, and the consequences of an incorrectly designed miniature circuit-breaker. As a clonclusion a table with an overview with maximum allowed fuses of the SMA inverters Sunny Boy, Sunny Mini Central and Sunny Tripower is presented.

1 Influencing Factors with the Selection of Suitable Miniature Circuit-Breakers

1.1 General Influencing Factors

The general requirements for the selection of a miniature circuit-breaker are established by standards and country-specific provisions.

The following will list generally applicable influencing factors that must be taken into consideration during the selection of an appropriate miniature circuit-breaker:

Factors on the capacity of the cable:

- **Type of cable used**

  The capacity of the utilized cable depends upon the cable cross-section, cable material, and the type of the cable (insulation, number of wires, etc.). The miniature circuit-breaker must therefore limit the electricity to the extent that this is not exceeded.

- **Ambient temperature around the cable**

  Increased ambient temperature around the cable leads to a reduction of capacity.

- **Laying procedure of the cable**

  If the cable is laid in insulation material, for example, its capacity is reduced. The worse the outward heat emission of the cable is, the less is its capacity.

- **Cluster of cables**

  If cables are laid close together, they heat each other. The capacity is reduced through the heating of the cables.

Other factors on the dimensioning:

- **Loop impedance**

  The loop impedance of the cable limits the electricity during a fault. This cannot have an impact on the tripping time of the miniature circuit-breaker.

- **Mutual heating of miniature circuit-breakers**

  If miniature circuit-breakers are arranged too close to each other, they will heat each other. During excessive heat impairment, they already disengage below their nominal current.

- **Ambient temperature around the miniature circuit-breaker**

  Through increased ambient temperature around the miniature circuit-breaker, less heat can be given off. The miniature circuit-breaker thereby disengages with a current that lies below its nominal current.

- **Selectivity**

  Fuses/miniature circuit-breakers must be aligned in succession to avoid unwanted trips of upstream fuse devices.

- **Type of the connected device**

  Depending upon the startup behavior of the connected device, different traits must be used to avoid false activation.

1.2 PV-Specific Influencing Factors

With PV systems, some of the previously mentioned influencing factors can affect the selection of the miniature circuit-breaker more strongly than usual.

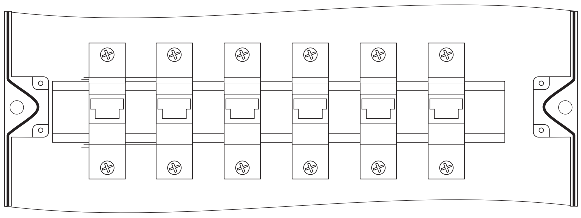
The following will list photovoltaic-specific influencing factors that must be taken into consideration during the selection of an appropriate miniature circuit-breaker:

- **Ambient temperature around the cable**

  With PV systems, cables are frequently laid outside (outdoor system, systems on flat roofs, etc.). A higher ambient temperature is usually presumed there than with an installation in buildings. The capacity is reduced through the increase of the ambient temperature.

- **Mutual heating of miniature circuit-breakers**

  With PV systems, inverters are also frequently connected to neighboring miniature circuit-breakers, which simultaneously supply their maximum current (simultaneity). The miniature circuit-breakers heat up faster through this, and premature tripping can be caused. In order to ensure sufficient heat emission and prevent premature tripping, larger spacing must be maintained between the individual miniature circuit-breakers.



  The decrease for the heat impairment is designated as an adding factor. This factor is specified in the technical data of the miniature circuit-breaker. The adding factor can be 0.77, for example, with an arrangement of new devices. The miniature circuit-breaker with a nominal current of 50 A then behaves as if its nominal current were 0.77 x 50 A = 38.5 A.

If this current is not sufficient, a miniature circuit-breaker with a higher nominal current, for example, can be used. It is to be taken into account here that the fuse is only first activated with its nominal current, depending upon the situation (no simultaneity). In this case, the cable connected to it must also possess an appropriate capacity or be replaced by one with a higher cable cross-section.

Another possibility is to increase the spacing of the miniature circuit-breaker. More heat can thus be given off and undesired tripping can be avoided.

- **Ambient temperature around the miniature circuit-breaker**

  Through the previously described simultaneity, the distributor in which the miniature circuit-breaker is installed can warm up more powerfully than is customary for ordinary installations.

  Since the electrical distributions with photovoltaic power-generating systems are often constructed outside of buildings, higher temperatures in the distributor must be reckoned with.

  Specifications on reduction factors for this factor are specified in the technical data of the miniature circuit-breaker.

- **Type of the connected device**

  The appropriate trait of the respective inverter can be extracted from the installation instructions. A circuit breaker's load disconnecting properties can be utilized to disconnect the inverter from the grid under load. A screw type fuse element, e.g. D system (Diazed) or D0 system (Neozed) has no load disconnecting properties, and thus may be used as cable protection, but **not** as a load disconnection unit.

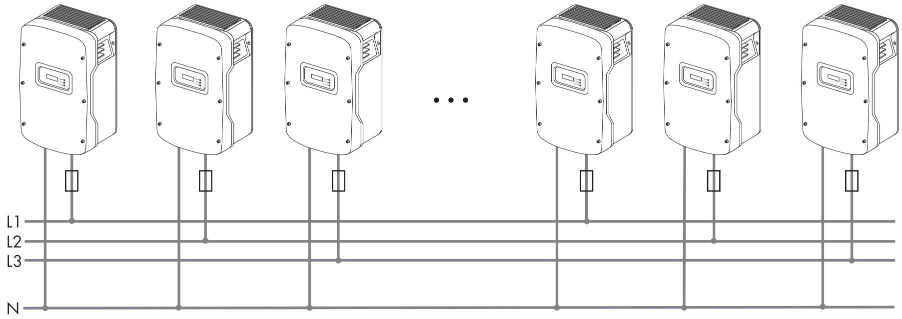
  Upon disconnection under load, the fuse element may be destroyed, or its functionality may be inhibited by contact burning.

  No additional loads may be connected between miniature circuit-breakers and inverters.

2 Worked Sample

Example for the thermal rating for a miniature circuit-breaker in a PV system operated in parallel with the low voltage grid.

PV system with nine Sunny Mini Central 7000 HV inverters and three inverters per phase.



Required technical specifications of the Sunny Mini Central 7000 HV:

- Maximum output current = 31 A
- Maximum permissible fuse protection for the Sunny Mini Central = 50 A
- The choice of cable together with the way it is routed, ambient temperatures, and other underlying conditions limit the maximum fuse protection for the cable.

  In our example we assume that the chosen cable (6 mm^2) is ideally routed and can take a nominal current of 32.2 A.

Selecting the miniature circuit-breakers

- The maximum possible nominal current for the cable used and the maximum possible fuse protection for the Sunny Mini Central limit the maximum possible nominal current for the miniature circuit-breaker.

An example for the thermal selection of a 40 A miniature circuit-breaker with B sensitivity with no gap between the circuit breakers.

- In our example, 40 A is assumed.
- Additionally, check the thermal suitability of the miniature circuit-breakers!

Load factors according to data sheet specifications:

- Reduction through permanent load >1 h = 0.9

  (Permanent loads of longer than one hour are possible in photovoltaics)
- Reduction factor when nine circuit breakers are arranged side-by-side without gaps = 0.77

  (When only one circuit breaker is used, this factor = 1)
- Increase in nominal current as a result of ambient temperatures of 40 °C in the circuit breaker panel = 1.07

  (Due to the fact that the circuit breakers are rated for 50 °C)

Result:

The nominal load current for the miniature circuit-breaker is calculated as:

Ibn = 40 A x 0.9 x 0.77 x 1.07 = 29.7 A

Summary:

The selected miniature circuit-breaker cannot be used in our example case since the maximum current-carrying capacity for fault-free operation is lower than the maximum output current of the inverter used. **It will trip under rated operating conditions!**

Solution 1:

Use a 50 A miniature circuit-breaker. As a result, the maximum current-carrying capacity will be 37.1 A (Ibn = 50 A x 0.9 x 0.77 x 1.07 = 37.1 A) and the miniature circuit-breaker will **not** trip under rated operating conditions. Bear in mind that the selected cable of 6 mm^2 may not be used with this solution. A cable with a larger cross-section must be used. The current-carrying capacity of this cable must be appropriate for the selected fuse protection.

Solution 2:

Increase the distance between the miniature circuit-breakers to 8 mm. This means that the reduction factor is 0.98 instead of 0.77. As a result, the maximum current-carrying capacity would be 33 A (Ibn = 40 A x 0.9 x 0.98 x 1.07 = 37.7 A) and the miniature circuit-breaker will **not** trip under rated operating conditions. Bear in mind that the selected cable of 6 mm^2 may not be used with this solution. The current-carrying capacity of this cable must be appropriate for the selected fuse protection.

3 Maximum allowed fuses

An overview of the maximum allowed fuses for the SMA inverters is given in the following table:

Type of inverter	Maximum fuse (Current)
Sunny Boy 1200	16 A
Sunny Boy 1700	16 A
Sunny Boy 2100TL	16 A
Sunny Boy 2500	16 A
Sunny Boy 3000	16 A
Sunny Boy 2000HF	25 A
Sunny Boy 2500HF	25 A
Sunny Boy 3000HF	25 A
Sunny Boy 3300	25 A
Sunny Boy 3800	25 A
Sunny Boy 3300TL HC	32 A
Sunny Boy 4000TL	32 A
Sunny Boy 5000TL	32 A
Sunny Mini Central 4600A	40 A
Sunny Mini Central 5000A	40 A
Sunny Mini Central 6000A	40 A
Sunny Mini Central 7000HV	50 A
Sunny Mini Central 6000TL	50 A
Sunny Mini Central 7000TL	50 A
Sunny Mini Central 8000TL	50 A
Sunny Mini Central 9000TL	80 A
Sunny Mini Central 10000TL	80 A
Sunny Mini Central 11000TL	80 A
Sunny Mini Central 9000TL RP	80 A
Sunny Mini Central 10000TL RP	80 A
Sunny Mini Central 11000TL RP	80 A
Sunny Tripower 8000TL	50 A
Sunny Tripower 10000TL	50 A
Sunny Tripower 12000TL	50 A
Sunny Tripower 15000TL	50 A
Sunny Tripower 17000TL	50 A