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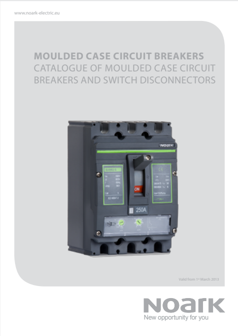

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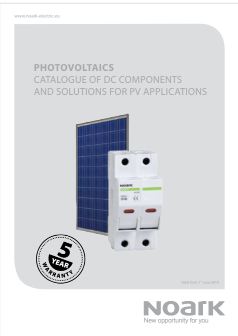

DC COMPONENTS AND PHOTOVOLTAIC SOLUTIONS

- Miniature Circuit Breakers
- Fuse Disconnectors
- Isolators
- Surge Protection Devices
- Moulded Case Circuit Breakers and Switch Disconnectors
- DC boards and Combiner Boxes

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We are determined to go further into the world market and establish and maintain strong relationships with customers. NOARK Electric cares about different areas in a local way to meet the unique requirements of each market. For this reason, our worldwide business activities are coordinated locally in the individual areas.

NOARK Electric has invested millions of Euros in development and it is equipped with the most up-to-date technologies and production facilities. The intelligent low voltage distribution and control product lines with high quality, performance and stability were developed by our highly professional and skilled R&D team.

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Remarkable technical innovations bring reliable products!

Advanced technical ideas create intelligent electrical apparatus for the future!

We are new opportunity for you!

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NOARK Electric Introduction

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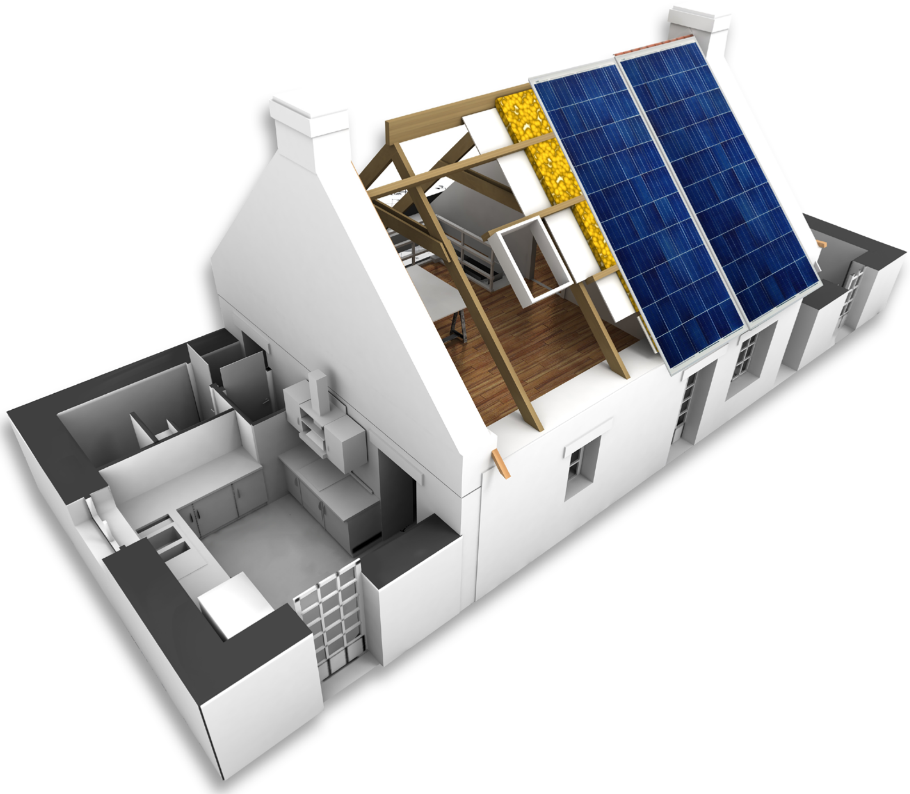
Photovoltaic applications



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Photovoltaic applications

Introduction

Photovoltaic applications have become widely used alternative source of electric energy. Because of their specific needs in comparison to other applications, they stimulated development of a new generation of DC components.

Main difference of DC part of PV installation in comparison to common DC ones lies mainly in three specific aspects. The first one is related to relatively higher voltage, typically 400 – 1000 V DC. Another follows from the fact that short circuit current of a PV panel is very close to its nominal value. The last and probably the most important one is changing of polarity of DC current on a breaker or switch during faulty operation in comparison to standard operational regime. All these three issues bring completely new requirements on design, construction and operation of DC components like circuit breakers or switches.

Basic principle of PV systems

PV systems can be divided with respect to several parameters. The fundamental division is related to connection of such power station to a (public) grid system. There are two types of solutions, plants connected to a grid and so called off grid ones. From the technology point of view, there is hardly any distinction at DC side of both types (the only one can be in requirements for grounding of the systems). Main difference is in inverter converting DC current to AC current. The off grid solutions are also typically equipped with a battery system to store energy which cannot be consumed immediately. Basic diagram of a grid connected PV system is depicted in Fig. 1.

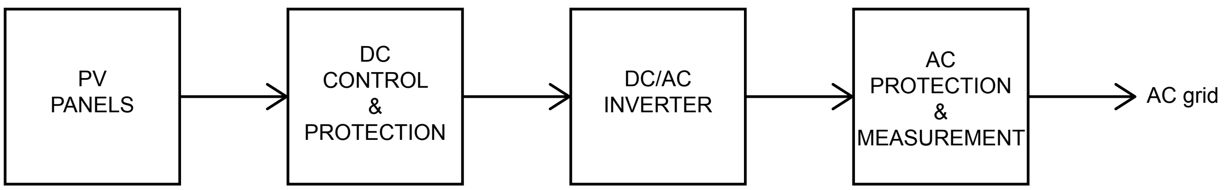


Fig. 1 Basic diagram of grid connected PV system.

The first essential part of any PV system is PV panels. With respect to the total installed power and other conditions, particular panels can be connected in series to so-called strings and strings in parallel (arrays). Nowadays, most common panels are based on polycrystalline silicon technology. This type of panels offers lowest price among the other types with very high efficiency. Another type based on crystalline slices is monocrystalline panels. Their main advantage is highest efficiency. Their price is, however, higher. The last and newest panel technology with standard commercial use is thin film one. The main advantages are minimum installation height and low weight.

Photovoltaic applications

PV panels are characterized with a set of parameters. The most important for design of a PV system are

STC rated output P_{mpp} [Wp]
Defines maximum (peak) output power (Wp) of the panel at Standard Test Conditions (STC)

Rated voltage (V_{mpp}) at STC
Rated voltage of the panel at maximum power point (MPP) measured at Standard Test Conditions (STC)

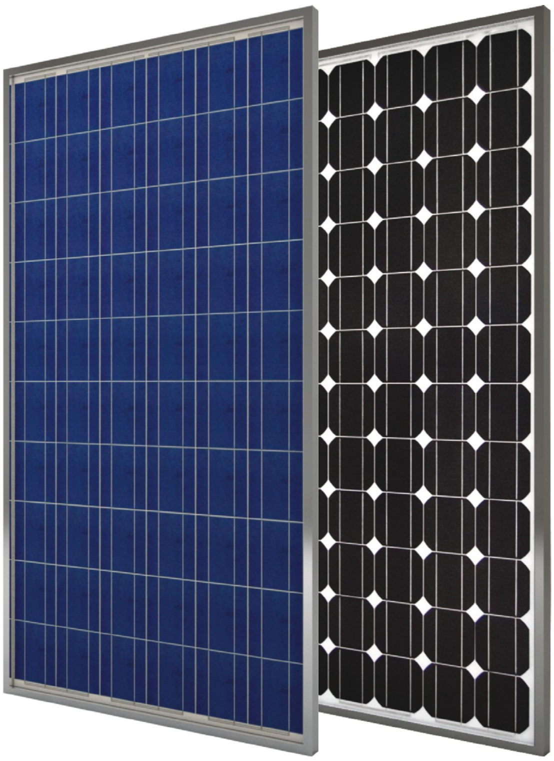
Rated current (I_{mpp}) at STC
Rated current of the panel at maximum power point (MPP) measured at Standard Test Conditions (STC)

Open circuit voltage (V_{OC}) at STC
Output voltage of the panel with zero output current definedfor Standard Test Conditions (STC), equal to maximum voltage at STC

Short circuit current (I_{SC}) at STC
Short circuit current of the panel defined for Standard Test Conditions (STC), equal to maximum output current of the panel at STC

Maximum system voltage SCII
Maximum possible voltage of the system in which the panel can be used, limits maximum voltage of a string

Maximum series fuse rating
Defines maximum back up fuse rating to avoid overload of inverse current blocking diodes and current carrying paths



Photovoltaic applications

The second block of a PV system belongs to protective and control components. This part typically consists of current protection (circuit breakers, fuses), switch disconnectors, surge protective devices. In large PV applications, there can be used also some monitoring or measuring system. Real configuration depends on a size of the system, a number of strings and arrays, or other specific requirements. This block is usually installed in a special DC board (string box, combiner box, array box, junction box), or for large systems it can be a part of the central inverter.

The last part of the system at its DC side is DC/AC inverter. It is responsible for conversion of DC current to AC one. Inverters can be sorted based on input and output power, number of output phases, type of the system they are suitable for – grounded or ungrounded, grid connected and off grid one. Main inverter parameters necessary for PV system design are

Maximum input DC Voltage
Maximum voltage of connected string given as sum of V_{OC} of all panels

MPPT Voltage Range
Range of voltages to which MPP (Maximum Power Point) Tracker can set DC working voltage of connected string to maximize its output power

Maximum input DC Current
Maximum DC current of connected strings given as sum of I_{SC} of all strings

Maximum DC Power
Maximum input DC power given as multiple of operational voltage and operational current of connected string(s)

Number of MPP Trackers
Independent MPP trackers allow optimize setting of operational maximum power point of strings separately

Number of inputs per MPP Tracker
Number of input positions, typically connectors linked to one MPP tracker

Maximum DC current per input/tracker
Maximum current of inverter input

Output Power
Maximum AC power from inverter

Grid Voltage
Range of voltages of grid which the inverter can be connected to

Number of phases / AC connection
Defines AC output, typically 1phase or 3phase

Current protection of DC part of PV systems

The first phenomena which it is necessary to keep in mind when designing a PV system is the purpose of current protection devices. It is different for protection of particular strings and for combined current from multiple strings (array protection).

Typical short circuit current of a PV panel is only about 10% above its nominal value. This fact is completely different in comparison to any other DC or AC systems. One hand, this fact would mean that it is hardly possible to protect a panel against short circuitry, because there is no suitable protective device which would trip quickly current which is only 10% above standard operating value. The key fact is that there is no risk for the panel itself to operate in short circuit current conditions. The reason is simple. A PV panel is nothing but a serial combination of blocking polarized semiconductor diodes. Thus, the short circuit current generated by a panel cannot damage the panel itself.

The only two problems will be zero output power and, based on time duration and dimensioning of connecting cables, possible overload of the cables. As PV plants are built for the purpose of production of electric energy, it is highly recommended to eliminate the short circuit fault as soon as possible.

Besides overload of connecting cables in any PV system, the main specific current protection of PV panels comes from systems with panels or more usually strings connected in parallel (PV array). An illustrative situation of two parallel strings is depicted in Fig. 2.

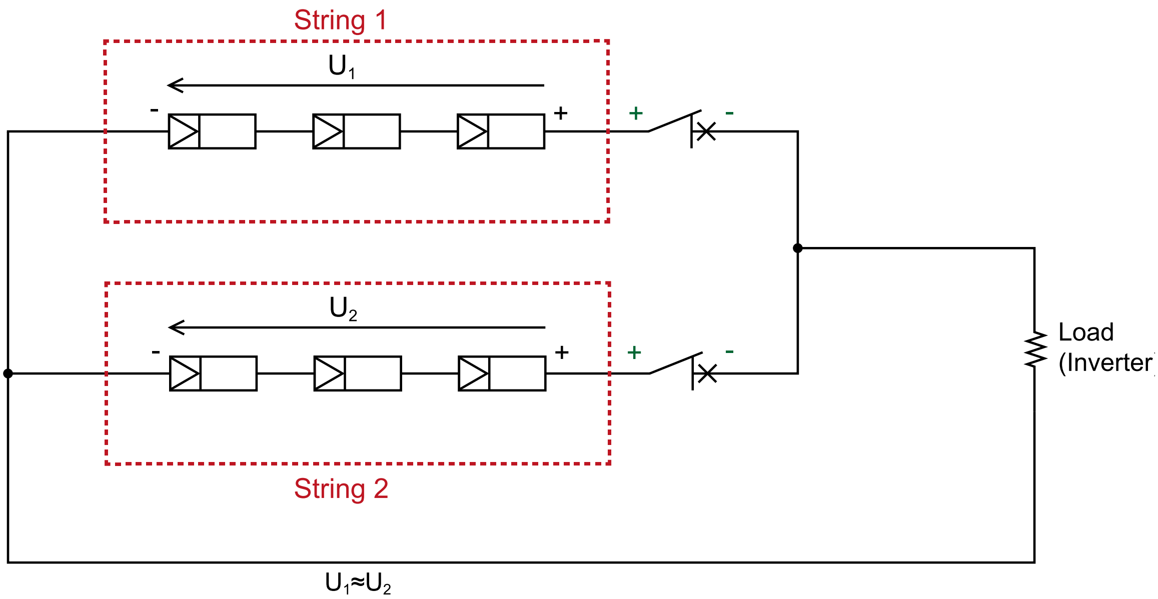


Fig. 2 Two parallel strings in standard operation mode.

The most usual reason of panel (string) short circuitry is an electric breakdown of a string. Two immediate conclusions follow from this situation. The broken panel or string does not produce electricity and serves as a conductor only. This string conductivity causes short circuitry of the other panel(s) or string(s) connected in parallel. Produced DC power comes to very low value (Voltage of the remaining strings is limited to very low value given by impedance of the broken string). Inverter produces zero output AC power because Voltage of the array is below working threshold of the inverter. Another problem, especially for large PV arrays, is significant overload of cables connecting the broken string which lead overall current of the other strings. It can cause thermal damage of them and other parts of the system.

Protection of the cables against overload and thermal damage has the same rules as for any other electric system. Design of protection against short circuitry has, however, completely different procedure. As it follows from the above description of the situation, it is clear there is necessary to install current protection into all particular strings. The first discipline of the design of appropriate protective device is selection of its rated current and breaking capacity.

Rated current and tripping characteristic of the protective device is given by parameters of the panels in the string to which the protection is connected. Parameters must ensure standard operation without unwanted tripping and limit and trip faulty currents in case of at least partial electric breakdown. Main panel parameter for this part of the design is rated current I_{mpp}. The current I_{mpp} must be below tripping current of the protective device. The question is for which current this tripping current should be set. There are two design rules. The first one comes from PV panel producers. They define parameter "Maximum series fuse rating". It is connected to the maximum permissible current of internal interconnections and blocking diodes (see below) inside of the panel. The other is given in IEC 62548-1. There is stated that tripping current should fall into range from 1.4 to 2.0 multiple of Short circuit current I_{SC} of the panel in this standard. To fulfill such requirement it is necessary to know tripping characteristic of the protective device to be used.

Let us consider an example of protection of a polycrystalline PV panel with Rated output power P_{MPP} = 245 Wp. Its typical rated current I_{mpp} is 8.2 A, and the short circuit one I_{SC} 8.62 (see e.g. Astronergy CHSM6610P panels).

First solution will be with a PV miniature circuit breaker (Ex9BP). From its product standard EN 60947-2 it follows that non tripping current I_{nf} is 1.05 x I_n and tripping one I_f = 1.30 x I_n. Based on conditions of IEC 62548-1, we have set of equations

$$I_{nf} \geq 1.4 \times I_{SC}$$
$$I_f \leq 2.0 \times I_{SC}$$

For rated current I_n of the considered circuit breaker this means

$$I_n \geq (1.4 \times I_{SC})/1.05$$

and

$$I_n \leq (2.0 \times I_{SC})/1.3$$

With the expected 245 Wp panel it means that recommended rating of the circuit breaker is 11.49 A ≤ I_n ≤ 13.26 A. Lower value can be used, but to avoid unwanted tripping of the breaker, it must be ensured that $I_{nf} > I_{SC}$ (I_{SC} can be reached even during standard operation when starting inverter MPP tracker, see below). It is important to take tolerances of all parameters into consideration. To use a breaker with higher I_n than the value given by the equation does not bring any improvement, it will only make the unwanted effect during a fault worse. In all cases, designed value has to be below the Maximum series fuse rating. In our example, its value is 15 A.

In case that a fuse is used as a protective device in our example, we need to consider I_{nf} = 1.25 x I_n and I_f = 1.6 x I_n Then the optimum recommended values lie in the interval 9.65 A ≤ I_n ≤ 10.77 A.

This way we have designed the protective device to protect the system in case of short circuitry caused by electric breakdown.

Previous calculation, however, does not show necessary breaking capacity of the protective device. It is important that this value is not given by the parameters of the panel or string to which the protective device belongs, but by parameters of the other strings connected in parallel. Maximum tripping current of the protective device is defined by maximum total current which can be supplied from the other sources. In a standard PV system, the only other sources are the other parallel strings. Then the maximum total current is defined as a sum of I_{SC} of the particular strings. In typical situation when all panels are of the same type and thus have the same I_{SC}, the maximum current to be tripped is

$$I_{trip} = (n-1) \times I_{sc}$$

, where n represents number of strings connected in parallel. Based on typical values of I_{SC} it is obvious that for a basic configuration of a PV power plant there are not requested any enormous values of breaking capacities.

Situation is different in case when there is used a battery storage system in a PV plant. It is typical for off-grid solution. This configuration is depicted in Fig. 3.

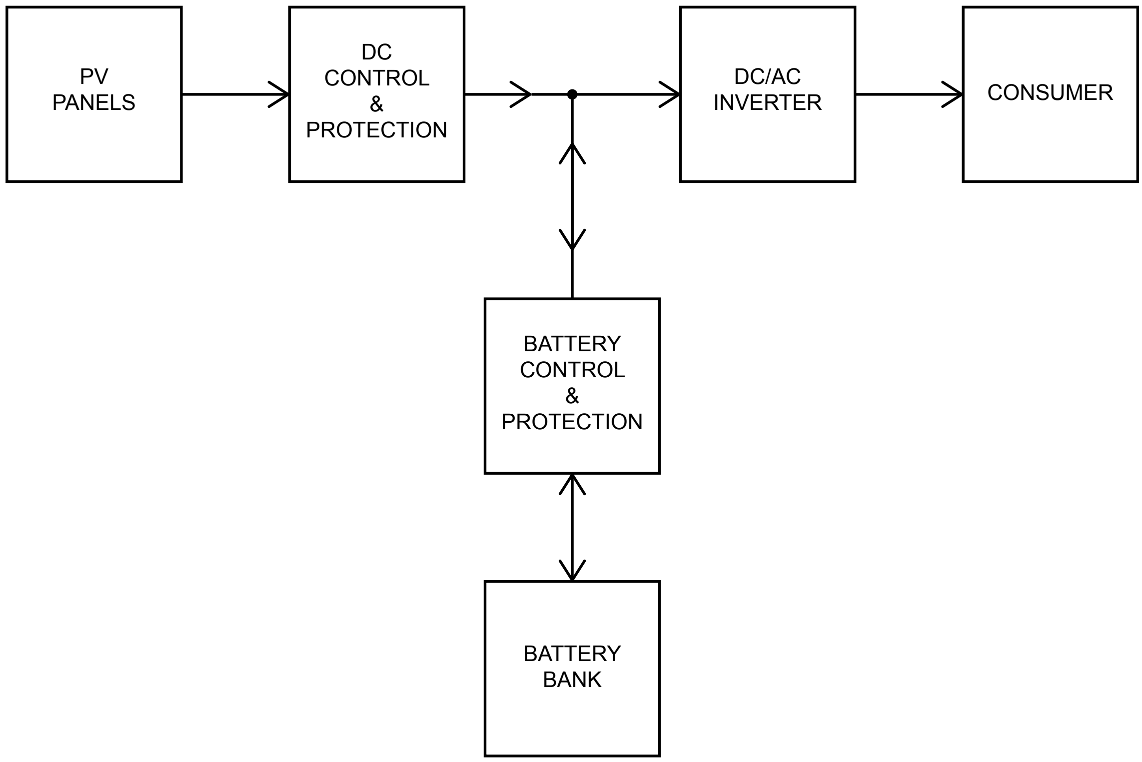


Fig. 3 An off grid solution with a battery storage system.

In contrast to PV panels, batteries are characterized with very high short circuit currents. It significantly changes the breaking capacity requirements for protective devices which can suffer and trip their short circuit current.

Arrays of strings may require another level of protection, so-called group breaker. The intention of the group breaker, i.e. a protective device which is used downstream to combiner or junction box, is just protection of the cables and devices in the box against overload. In typical applications it serves also as the main disconnector of the DC part from an inverter. DC circuits of larger systems can by typically split into several parts like string protection boxes, combiner boxes, or an array (junction) box, see Fig. 4.

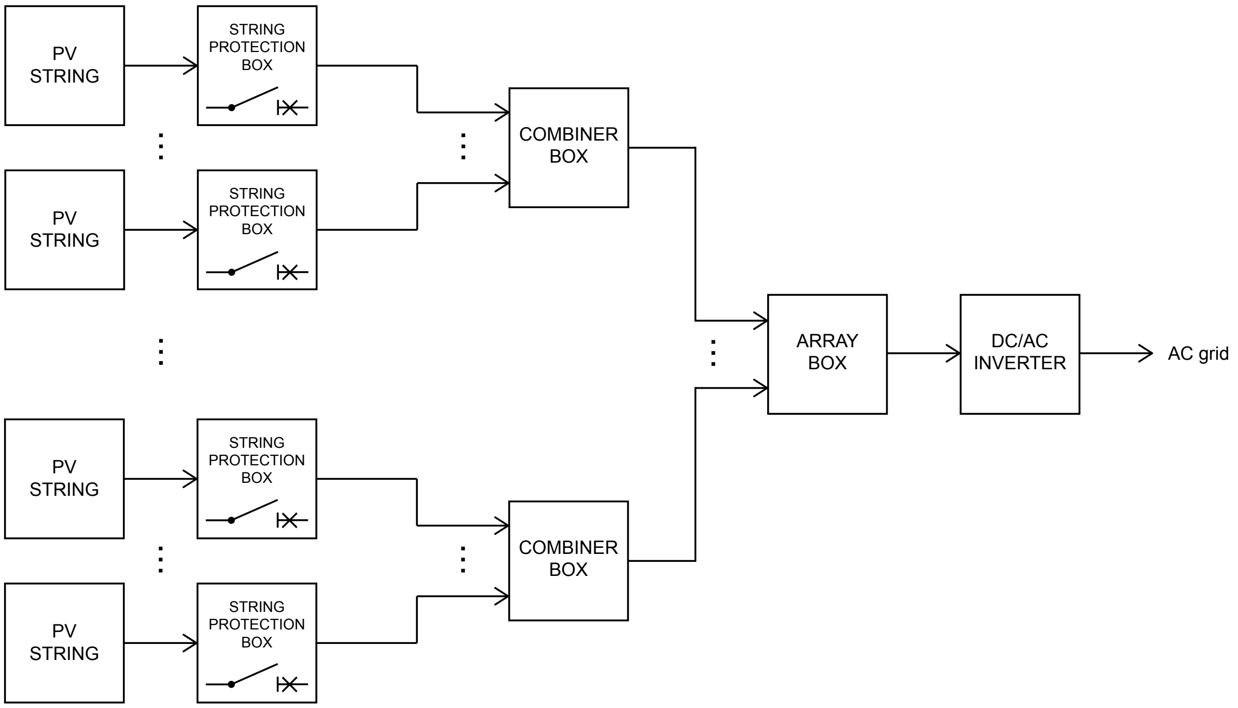


Fig. 4 A large PV system with split functionality of DC protection into string protection boxes, combiner boxes and array box.

String protection boxes contain short circuit and overload protection of strings. Usually miniature circuit breakers or fuses are used for this function. Main role of a combiner box is to combine DC current of parallel strings. There can be done simple junction of input paths. This point is also typical place of installation of surge protective devices. Output of a combiner box is either equipped with a group protection (miniature or moulded case circuit breaker), or if protection is not necessary with a group switch disconnector. Systems for monitoring of a PV plant are also usually built in in a combiner box. Array boxes are used in very large PV systems with central inverters. Their role is similar to combiner boxes. Functionality is limited just to collection of DC currents from combiner boxes and protection of connecting cables. One array box is connected to one input of inverter (there can be single input inverter, parallel input inverter, or multi MPPT inverter used). Array box can also be integrated directly into inverter boards.

For smaller and mid size systems, all functionalities can be integrated in a single DC board. Very often there are joint string protection functions with combiner box ones in small systems.

Other current protections of Photovoltaic panels

In the previous section there is described protection against consequences of short circuitry caused by a broken PV panel or string. Panels themselves need to be protected against currents as well. The problem, which can cause their damage, is reverse currents. Particular diodes in the panels are not able to lead any significant current in their direct polarization. It can happen simply when more strings are connected in parallel with slightly different output Voltage. Lower Voltage of a string can be caused also due to breakdown of some PV diode(s) in the string. If there is no protection, all PV diodes in panels in the string can be destroyed.

Protection against the reverse currents is simple. In parallel to the panel, there is connected standard power diode with the same polarization as PV diodes of the panel, see Fig. 5.

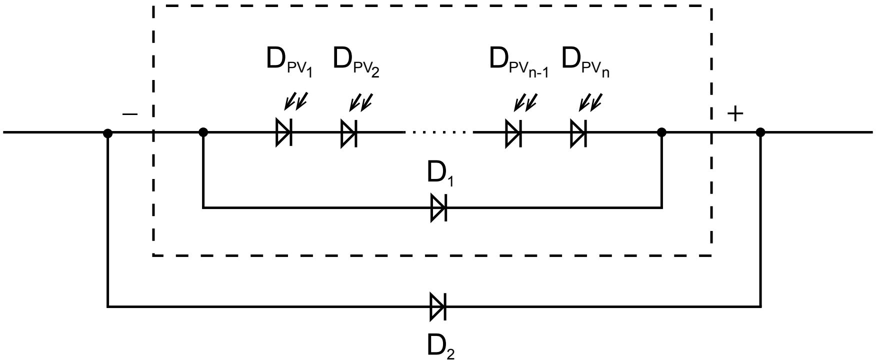


Fig. 5 Diodes to lead the reverse current of a PV panel out.

In case of a current in direct polarization, it flows through this diode (its open Voltage is lower than open Voltage of the serial combination of PV diodes in the panel). All modern polycrystalline and monocrystalline PV panels have such protection diode(s) integrated (D1 in the Figure). Maximum series fuse rating of a panel is defined also and mainly with respect to this protective diode(s). Thin film based PV panels usually do not contain such diode and thus need external protection (D2 in the Figure).

Blocking diodes could be designed also as a protection in case of short circuitry caused by electric breakdown of a string. The situation is illustrated in Fig. 6.

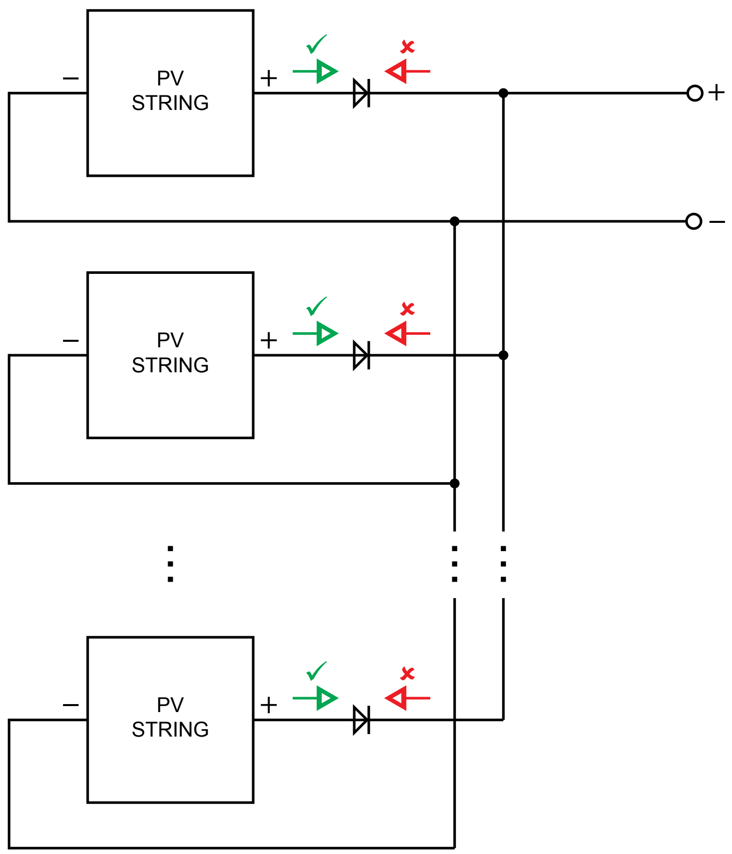


Fig. 6 Inappropriate protection against short circuitry by means of serial blocking diodes.

This type of protection is theoretically possible due to polarity change of the normal current and short circuit one. Such protection is designed if the price of the protection is the main criterion for design. As it is described below, such design does not fulfill requirements of IEC 62548-1. The main problem of this solution follows from the fact that application limits of these blocking diodes and PV diodes in panels are very similar. As a result, there is very high probability that blocking diodes will be brokendown in the same time as the diodes in the panels and the protection will not work. There should not be mixed blocking function of the diodes against reverse currents and protection against short circuit currents.

External blocking diodes are used in combination with thin film panels. They have also their use in large PV systems where they serves for blocking of inverse currents among arrays, where there are necessary higher currents diodes then those integrated in the panels. Another application is in connection with battery storage systems to block reverse current flowing to panels from the batteries.

Change of polarity of current in PV applications

Very important phenomena connected mainly with PV applications is possible change of polarity of DC current through the short circuit protective device or disconnector. In most of the standard DC applications, polarity is given by the source and remains unchanged. In PV applications with two or more strings connected in parallel, the situation is different. For the sake of brevity, let us take a case with just two strings into a consideration. Standard operation is depicted in Fig. 7.

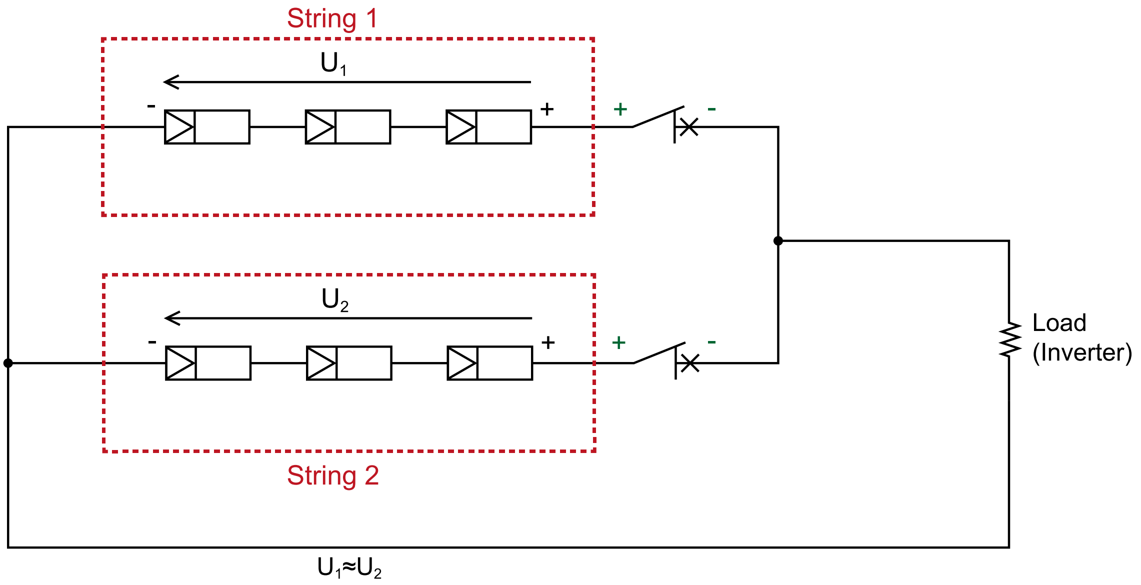


Fig. 7 Two strings in parallel during standard operation.

Polarity at circuit breakers is given by the polarity of the source, i.e. the PV strings. Situation dramatically changes in case of electrical breakdown of one string (or even one panel in the string). The circuit breaker connected to the broken string operates with opposite polarity now, see Fig. 8.

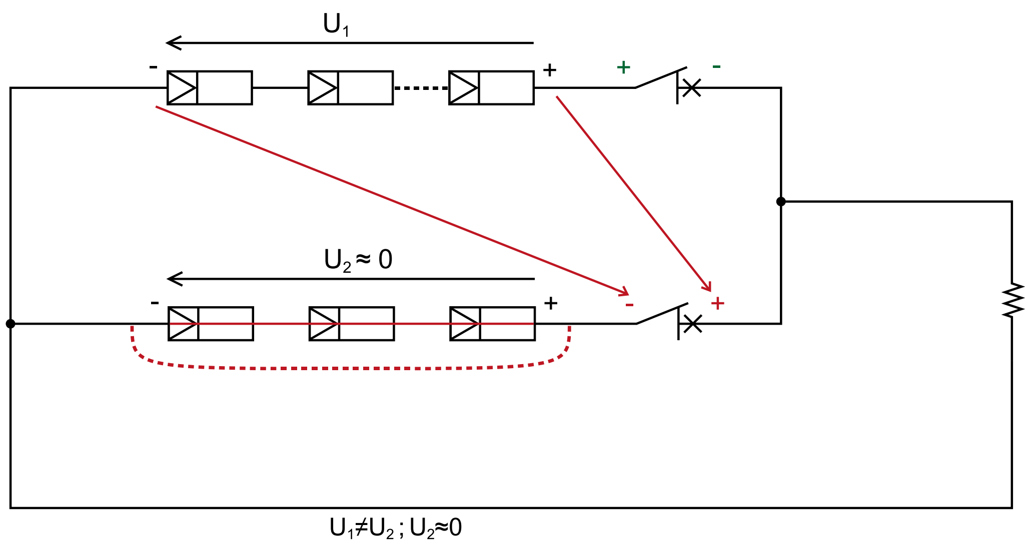


Fig. 8. Two strings in parallel in case when one is electrically brokendown.

It is important to note, that just this circuit breaker connected to the brokendown string should be tripped during the short circuitry. The same situation is also valid for a group circuit breaker protecting whole array in parallel array configuration. In other switching applications (ON and OFF operations with strings) or tripping of overload, the current polarity is given by the panel. This fact brings a new requirement on DC devices for PV in comparison to general DC applications. All such devices and theirs functionality must be polarity independent.

Similar situation is in circuit breakers protecting a battery storage system, where there is one current direction in case of charging of batteries and the other in the consumption regime. This situation is shown in Fig. 9.

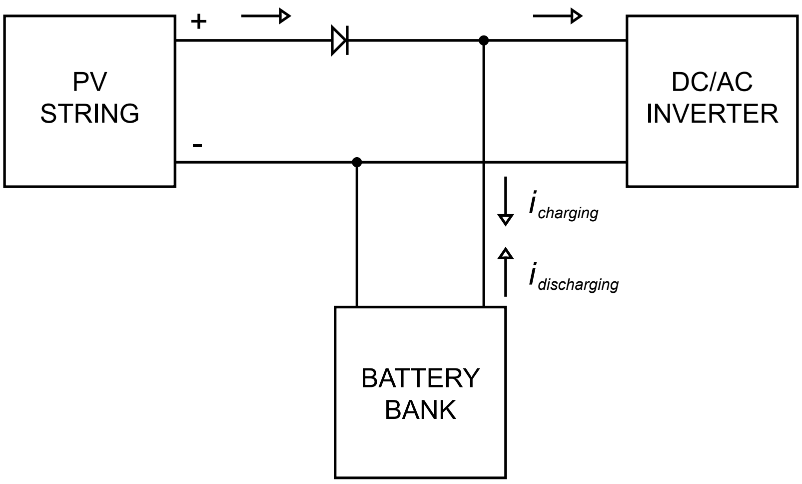


Fig. 9 Change of current direction for charging and discharging of battery storage system.

Switching and tripping of DC currents

Tripping of DC currents is much more complicated process in comparison to AC case. In AC situation, the arc between two parts of contacts can be simply interrupted when reaching zero value. This is not the case of DC. From this it follows higher requirements on tripping mechanism, its force, speed etc. The situation in PV applications is else complicated by the fact that Voltage can be typically up to 1000 V DC.

The most challenging issue for R&D engineers is distribution of the arc on the both parts of the contact. In AC case, the distribution is symmetrical between the parts. For DC circuit, it is different. The arc distribution is about 70% for one part (connected to positive pole) and 30% for the other part of the contact. Because of the permanent polarity during switching or tripping operation, the arc plasma causes electromigration of metal ions of the contact connect to positive pole of the system (or actual current). It significantly destructs the affected part of the contact system.

Solution of the problem is relatively simple. To make the arc distribution symmetrical, magnetic field can be used. Technically it can be done by permanent magnet. Its magnetic field acts against magnetic field of the positive ions of contact material and blocks their migration. Application of a permanent magnet is a typical solution in standard DC miniature circuit breakers for general applications. Such type of circuit breakers can be identified by its given polarity. When connected in wrong way, the arc distribution would not be improved but the contrary. Magnetic field amplifies the ion migration process and thus speed up the degradation of the contact. During tripping or switching, wrongly connected breaker would be destroyed. From this it is apparent that standard polarized breaker cannot be used for PV string protection, because current has different polarity in normal operation and different when a panel or string is brokendown.

Protection of PV strings requires non-polarized circuit breakers and disconnectors. Especially for installation devices, the key task is to modulate the arc distribution on the contact. The polarity independence is achieved through a design using dynamic magnetic field instead of a magnetic field from the permanent magnet. The dynamic field is generated from the operational current. It guarantees that this auxiliary magnetic field changes polarity when changing the polarity of external voltage as well as current. The complexity of the structural design of this auxiliary circuit lies in the fact that the magnitude of the magnetic field depends on the value of actual current. Unlike in permanent magnets, polarity independent DC circuit breaker design demands that the shaping magnetic field has a suitable intensity, e.g. even during manual tripping of the circuit breaker through which only a fraction of its rated current flows.

One important fact must be considered for switching of DC currents. To interrupt current at higher voltage levels typical for PV applications, more contacts connected in series are necessary. By this principle there is achieved contact distance allowing breaking of the DC arc in required short time. Installation devices are designed as combination of several single pole devices, mechanically connected in parallel. Such combination looks like a multipole AC circuit breaker, theirs operational principles are, however, very different. DC breakers are electrically connected in series. For proper functionality all contacts must operate simultaneously to split tripped voltage equally among all of them. If this criterion is not met, the fastest contact is exposed to overall system voltage and can be destroyed. To ensure the proper synchronous operation, the devices have to be combined and tested in production. Absolutely wrong application is to use two separate devices in one system, see Fig. 10.

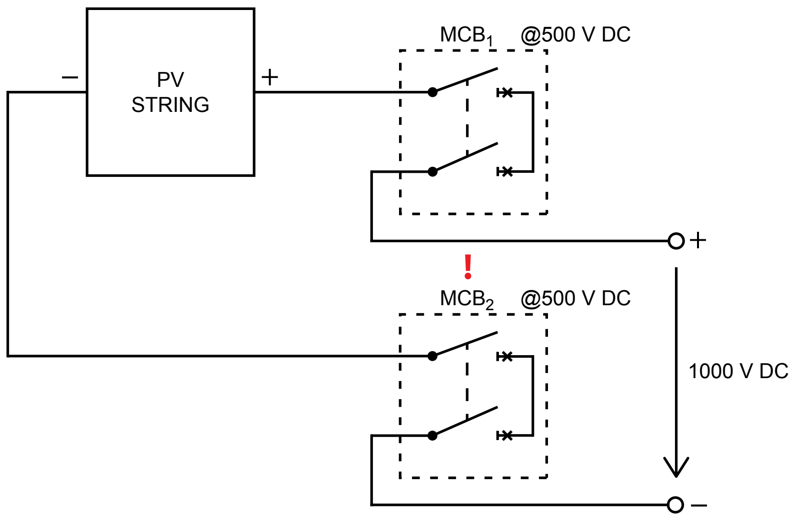


Fig. 10 Wrong application of two independent 500 V DC MCBs in 1000 V DC PV system.

Legislative requirements on PV systems

There are several legislative requirements on PV system, some of them are specialized in different countries. These are related mainly to inverter parameters and its connection to a grid. The rules are partly given by a local law and partly by Utility companies.

For DC part of a PV system, there are two general basic groups of requirements. The first one is covered with the Harmonized Document HD 60364-7-712:2005 (it is identical to IEC 60364-7-712:2002). In this document, which is adapted into local installation standards in CENELEC countries (all EU countries and some other ones), there are given main rules for PV installations with respect to their safety. As a common general requirement we can find, there is an obligation to use a disconnector in between PV panels and inverter. Especially for ungrounded systems, it is recommended to disconnect both DC poles. Drawings in this standard assume all disconnectors to be 2pole.

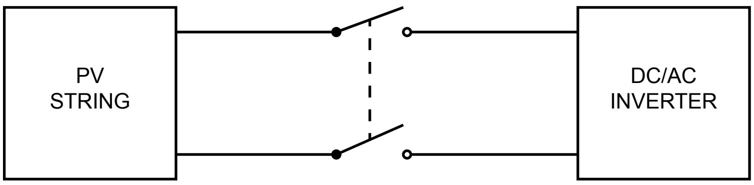


Fig. 11 Mandatory disconnection at DC side of a PV system.

Other requirements come from IEC 62548-1 standard. It handles also with design of protective devices. There is given a simple rule there, tripping current of protective device has to fall into a range from 1.4 to 2.0 of short circuit current I_{SC} of used panel. In actual design, it is necessary to calculate right with real tripping characteristics of used protective device, see the examples in previous sections of this text. An important conclusion follows from this condition. To avoid short circuitry in PV installation, a tripping protective device should be used. Blocking diodes connected in series to a string thus cannot serve as such protection.

In some countries, it is requested to have safety central off for roof top PV installation. It comes from the fact that PV panels produce electric energy when they are exposed to light. It could cause a danger situation e.g. during a fire accident when grid Voltage is disconnected from the affected building. As a solution there can be used e.g. main remote switch in the AC distribution board or undervoltage release connected to a PV panel breakers or disconnectors. The undervoltage release ensures safety disconnection even in case of some fault in the installation. Disadvantage of this approach comes from the fact that any failure of AC grid Voltage causes disconnection of the PV plant which requires manual ON operation.

Selection and design of PV panels

The first step of a design of a PV system is selection of panels and their connection. The electrical design is not affected by choice of the panel technology anyhow. The only exception is the fact than poly and mono crystalline panels are already equipped with diodes for blocking of reverse current, but thin film panels are not.

The selection of particular type of the panel depends on several aspects, including mechanical configuration of the power plant or inverter parameters. Let us assume that inverter can be adapted to the actual design and type of panels first. Then the panel parameters choice depends mainly on total installed power and possible physical configuration of the panels.

To collect total power, panels can be connected in series or in parallel, see Fig. 12.

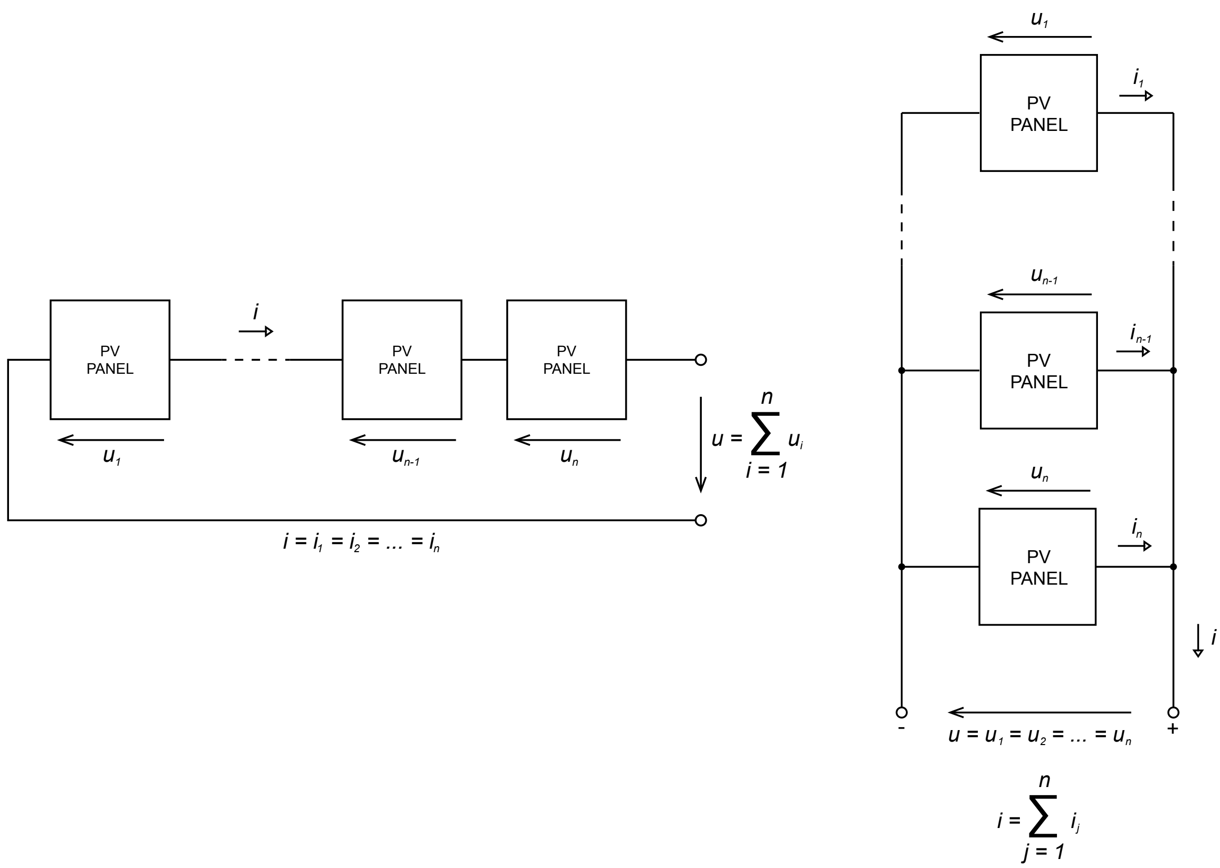


Fig. 12 Serial (left) and parallel (right) connection of panels. Schematic diagrams only.

Basic configuration is a serial connection of panels and creation of so called strings. For larger systems, particular strings can be connected in parallel – directly or via separate inputs of an inverter. The serial connection simplifies design of DC/AC inverter because it ensures DC Voltage value at level allowing direct conversion to AC only by means of switching without any circuit increasing the Voltage. An other reason for this type of connection is reduction of loss. Main part of the total loss at DC side of a PV system is directly linked to actual current – power loss at circuit breaker or fuse, cable losses etc. Limit of Voltage and thus number of panels in series is given by Maximum system Voltage. Its typical value is 1000 V DC. In real design, maximum voltage is limited by other aspects, mainly by parameters of chosen inverter. Because current through the whole string is the same, it is necessary to combine panels of the same type in order to maximize output DC power.

For larger systems more strings need to be operated. There are principally three ways of combination of output currents of parallel strings. The first one is direct combination of output currents at DC side. It is usually done in combiner boxes, or the connection can be also done inside of inverter by means of parallel input connectors. The way of connection significantly affects design of protection circuits. Important requirement for this design is the same Voltage of the connected strings.

The second way is a combination inside of a PV inverter, where there are several MPP trackers. This approach increases efficiency of the systems and allows operate particular strings at different conditions (voltage, current). It can bring significant increase of produced power e.g. in systems where particular string are not operating at the same intensity of sunshine (e.g. rooftop systems installed at rugged roofs).

The last way is to combine the produced energy at AC side. Each string or array of strings has separate inverter. Then the design of DC part is the same as for the first case.

Parallel connection of strings has its sense also for smaller systems where it would be possible to connect all panels into one string. Such situation example is shown in Fig. 13.

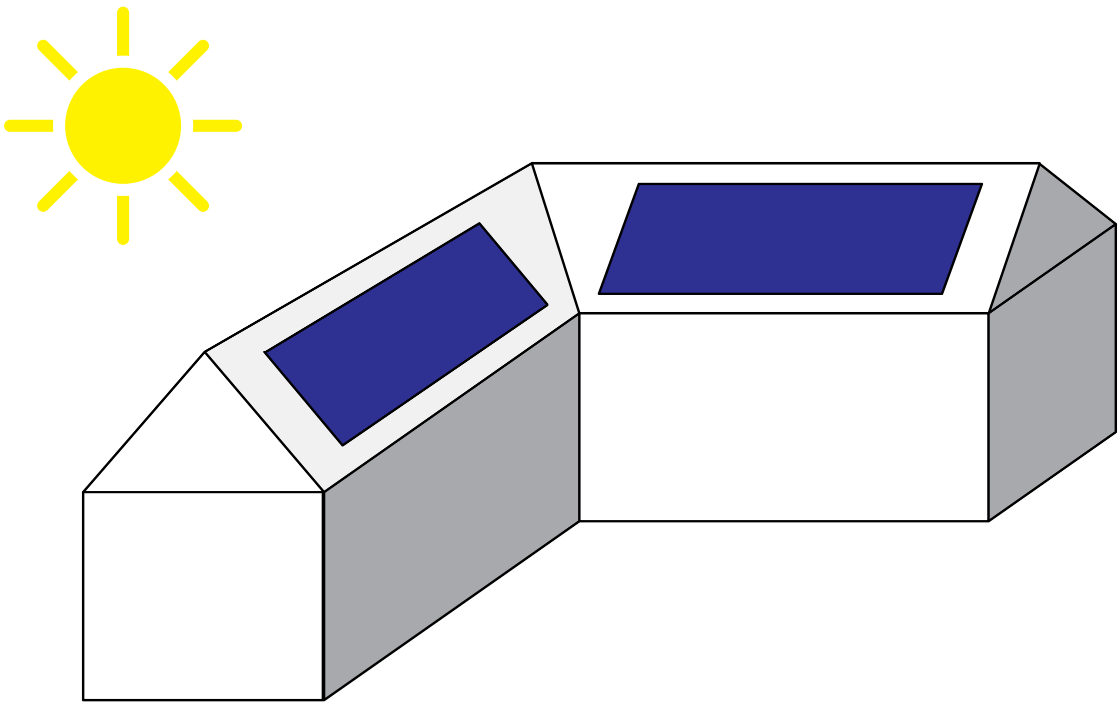


Fig. 13 A complex rooftop with different light intensity of particular parts of installation.

A string operates with the same current of all panels. The value of this current is given by minimum current among the particular panels. On the assumption that all installed panels are of the same type, their current is defined by intensity of light. Typically on rugged rooftops, intensity at their particular parts can be very different. The only way how to maximize total produced power is to split the system into several strings. If the strings contain the same number of panels, their outputs can be directly combined and there is no other investment into inverters. The parallel configuration of strings should be also considered in case that there is a smokestack on the roof or a tree close to the installation. The same issue is true also for a single panel. A single panel is nothing but serial combination of PV diodes or cells. Output current is defined by the minimum current of the diodes. A shadow on a part of the string has the same effect as if there is a shadow over the whole string, see Fig. 14.

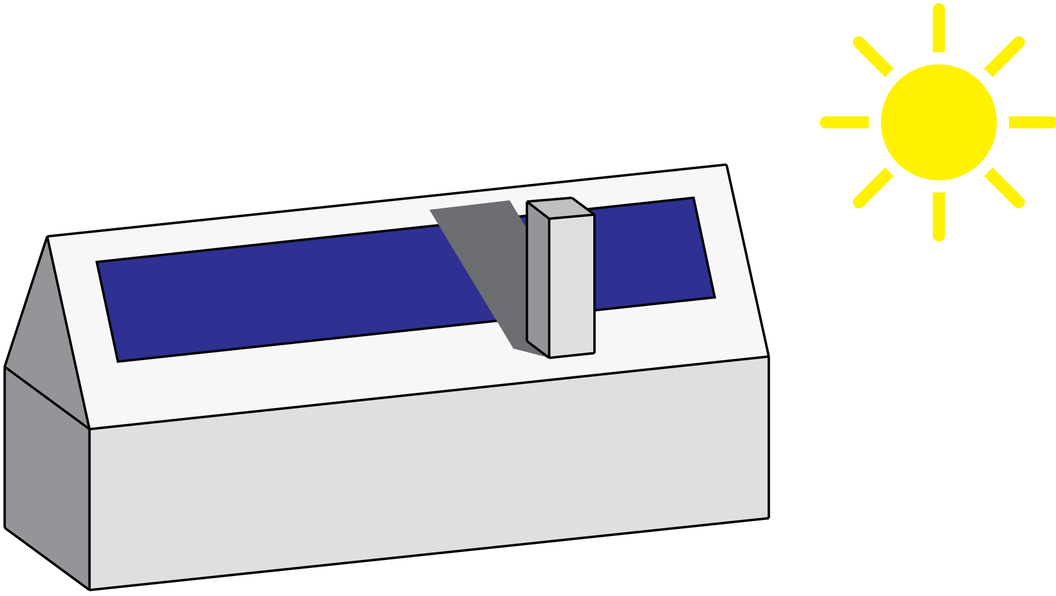


Fig. 14 A shadow on a part of a string reduces current of the whole string.

Photovoltaic applications

Design of DC protective and control circuits

Let us take protection of a single string into account at first. Based on requirements of IEC 62548-1, there should be installed a protective device for a panel or a string protection. In general, there are two possible devices to provide this functionality, miniature circuit breaker and fuse disconnector with a fuse link. Design of appropriate rated current for both devices is discussed above.

The most reliable protection of a string can be achieved with miniature circuit breaker. Due to polarity variation in different operational modes of the PV system, such DC circuit breaker has to be polarity independent (line Ex9BP, see Fig. 15).

Fig. 15 Photovoltaic DC circuit breaker Ex9BP up to 1000 V DC.

Standard DC MCBs with fixed polarity cannot provide sufficient protection and service reliability. Main advantages of MCB protection follow from three facts. In case of tripping, the circuit breaker can operate again, there are no additional costs like e.g. for a new fuse link. For applications where it is required to provide some additional remote functionality, an MCB is suitable candidate. There can be installed auxiliary contacts to see status of the device. For remote safety disconnection, undervoltage release can be used. The last issue is that MCB can be used also for disconnection function given by the standards and can be operated by unskilled persons. It is important mainly for residential rooftop applications.

Basic string protective device is cylindrical fuse disconnector with a fuse link (Ex9FP, see Fig. 16).

Fig. 16 Cylindrical fuse disconnector Ex9FP for PV applications.

Photovoltaic applications

An advantage of the fuse solution is low initial investment. Another argument to use such device is small installation width. Such disconnectors can operate at 1000 V DC as a single module device. In applications where it is necessary to ensure both pole disconnection of string by this disconnector, two pole device of two module width must be used.

There are, however, a few application limits of fuse disconnector. The lower initial investment is compensated in case of trip of a fuse link, which needs to be replaced. Another issue is that it is not possible to operate such device remotely. But there are even more important differences coming from general design of such devices. The first of them is that DC operated cylindrical fuse disconnectors are not switch disconnectors, i.e. their utilization category is DC-20. In case that the same device should fulfill also the role of the disconnector defined in HD 60364-7-712:2005, there is necessary an additional device which will interrupt current first. Other issue is that all cylindrical fuse disconnectors, including AC ones, are intended and can be operated by skilled personnel only. For this reason, they are not suitable for residential systems.

String boxes can consists also of a disconnector. In case that a circuit breaker is used for protection, the same device can provide also this functionality. Otherwise, special device must be used. DC disconnector must be also polarity independent. Its utilization category must be at least DC-21 to allow switching under load. Fig. 17 shows PV switch disconnector Ex9IP.

Fig. 17 Photovoltaic DC switch disconnector Ex9IP.

Photovoltaic applications

Special area of protection of PV system is installation of Surge Protective Devices (SPD). Because we are still in DC part of the PV plant, also the SPDs have to be designed for DC protection. Besides SPD class with respective parameters and its operating voltage, the main aspect for design is the fact if the system is grounded or ungrounded.

For effective protection, it is necessary to connect SPD system to the grounding. This fact brings the difference in design of protection for grounded and ungrounded systems. The situation is depicted in Fig. 18.

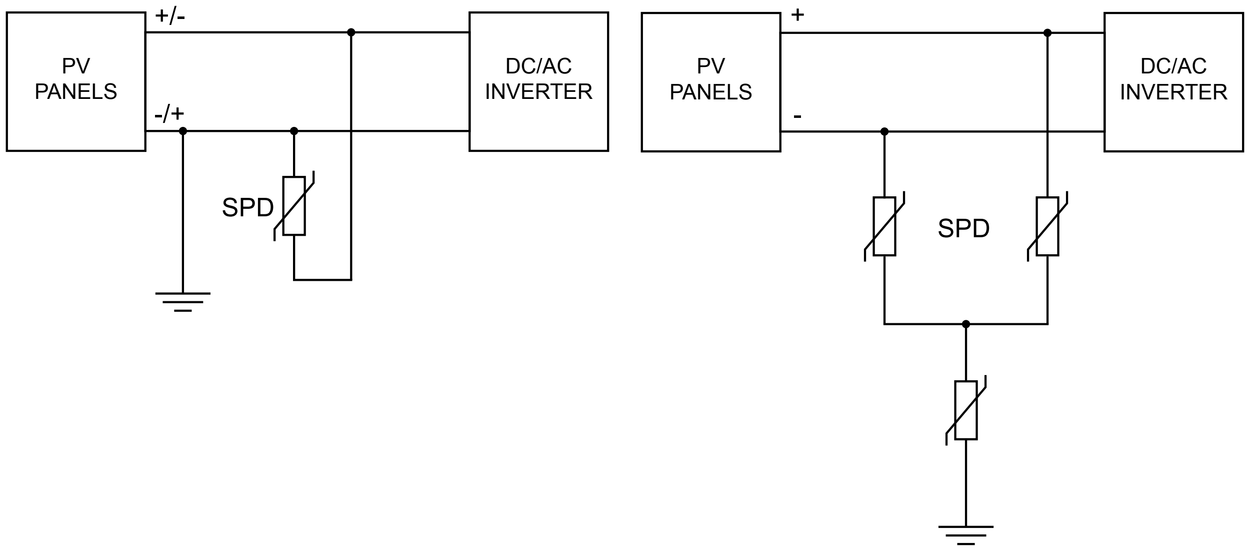


Fig. 18 Configuration of SPDs in grounded system (left) and ungrounded system (right).

To achieve better characteristics at higher DC voltages, there can be designed two MOV-based SPDs in series on a position of particular SPDs.

Some of available DC/AC inverters are declared as equipped with SPD protection. It is very important to pay attention on real SPD installed. In most of the cases, inverters contain SPD class T3 (III, D) only. It is just fine protection against residual transient overvoltage and it is not able to protect against higher energy surges.

Photovoltaic applications

For large PV systems consisting of several arrays connected in parallel, when every array consists of parallel strings, there is necessary to take into account a group protection of such system.

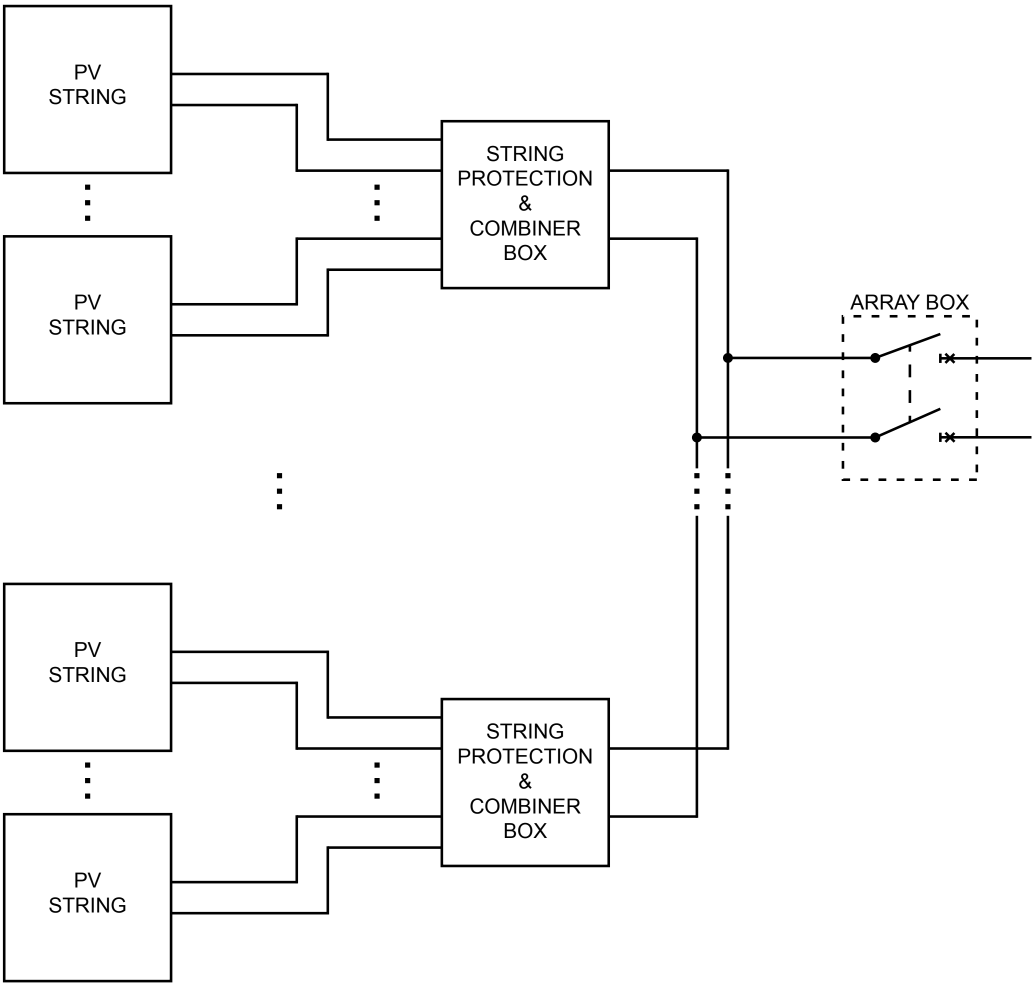


Fig. 19 Large PV system consisting of parallel arrays.

For devices used, the requirements are similar. Polarity independent ones are necessary in most of the cases. Circuit breakers and disconnectors are typical devices to be used. The intention of the circuit breakers is overload protection of the system and its wiring. When string protective devices are installed in the same box as the group (array) devices, only a disconnector can be used for this functionality. Its main role is the mandatory disconnection of PV panels from inverter.

Basic criteria for inverter selection

Inverter selection strongly depends on the size of the PV system under consideration. Besides obvious installed power, the size of the systems affects the inverter configuration at all.

One of the first inverter selection criterion is the fact if the system will be connected to a grid or not. It brings completely different solution. Off grid solution are mostly equipped also with energy storage systems (battery banks). The main difference is in the inverter technology, however. Inverters in grid connected systems are driven by the grid. Phase and frequency of produced electricity is synchronized with a grid voltage. Due to safety reasons, grid connected systems have to be equipped with automatic disconnector in case of drop of grid voltage. Such block is usually integrated directly into an inverter. Inverters designed for on grid operation thus cannot be used in off grid solution.

Very important part of any inverter is Maximum Power Point Tracker (MPPT). The key goal for any power plan is to maximize its efficiency and output power. PV panels consist of semiconductor diodes. In blocking polarization of diode voltage, a diode can produce electric current. Its value I_{el} depends directly on intensity of light I_L.

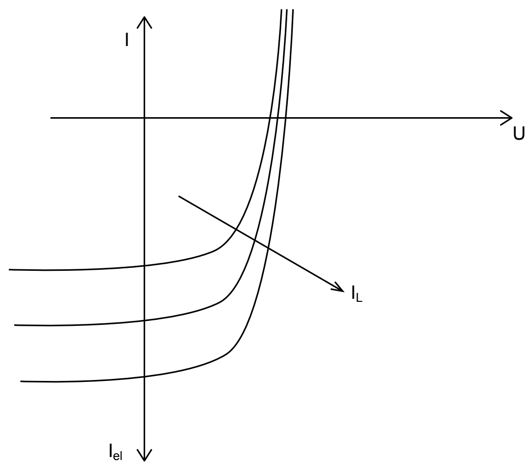


Fig. 20 Dependence of PV panel output current on intensity of light.

To reach maximum output power given as a multiple of voltage and current, it is important to find a point of the V-A characteristics with maximum value of U x I_{el}. Because this value depends also on other aspects like actual operating temperature, age of the panel etc., optimum value cannot be selected only based on supplied current. It is necessary to track the V-A characteristics during actual working conditions, see Fig. 21.

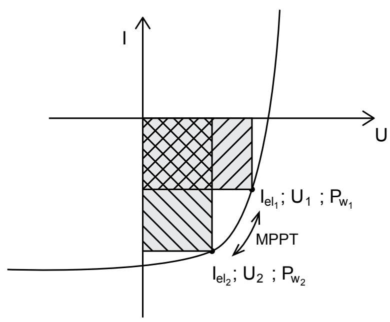


Fig. 21 Function of MPP Tracker on V-A characteristics of a PV panel.

This is achieved with Maximum Power Point Tracker MPPT. Its function partly affects also selection of string protective devices. Especially during MPPT starting, operating current close to I_{SC} can also be traced.

To one single MPP Tracker, several parallel strings up to maximum input current of the tracker can be connected. Such solution is suitable mainly for large PV systems where all the strings operate under same light conditions (green or brown field solutions, flat rooftop applications). Because MPP Tracker is the most expensive part of an inverter, such solution provides savings on investment, but does not affect power plant efficiency negatively.

Different situation is for system operating under non-uniform conditions, see e.g. situation in Fig. 13. Strings cannot be connected in parallel if they do not operate at the same voltage (i.e. there is different number of panels in particular strings). But also in situation if identical strings are designed, it can be advantageous to use separate MPP Trackers for particular ones. This is a typical situation for systems where strings operate under different light conditions (and thus with different output current). To reach maximum output power with different lighting of the strings, also different output voltages need to be traced. Light distribution over the panel installation affects optimum number of MPPT and thus also the selection of suitable inverter.

Efficiency of transmission of produced electricity is very important design parameter for large systems. Two different approaches can be used, see Fig. 22.

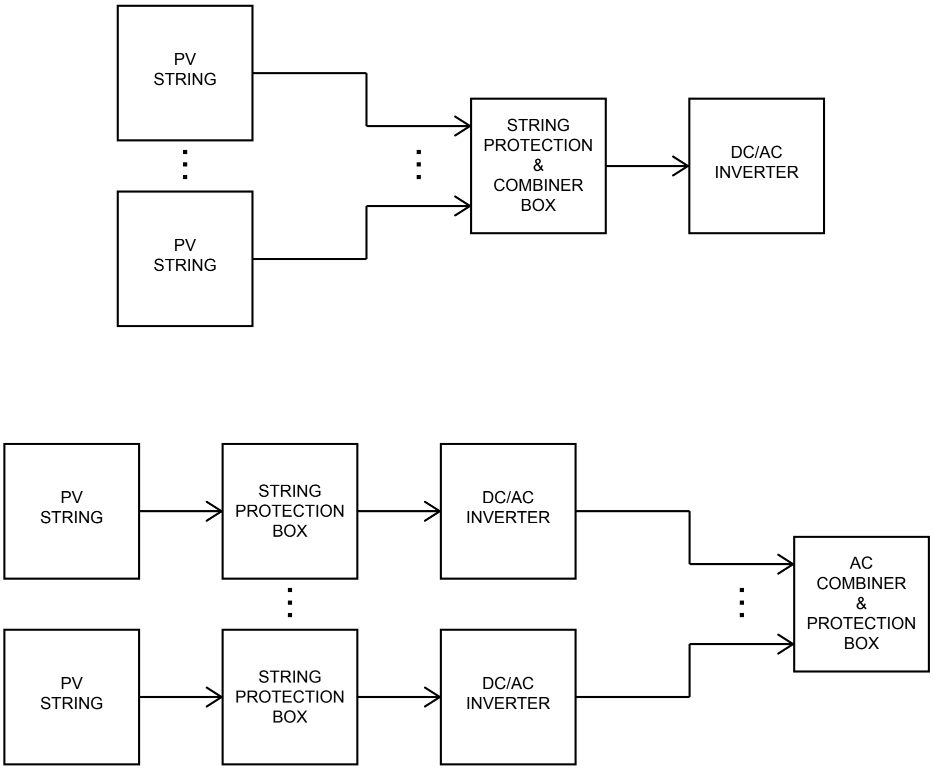


Fig. 22 Large PV system with a central inverter (above) and with distributed inverters (below).

The first style is to use a central inverter for whole power plant (or its section for very large systems). This design means to collect produced energy at DC side of the system. Such approach is advantageous for power stations localized in square or round areas, with uniform lighting of strings. This way higher efficiency of inverter and also lower investment to this part can be reached. Due to physical placement of the strings, also the overall length of higher cost DC cables is fully compensated with lower investment to the inverter.

The other approach is to use several lower power inverters for string or small arrays. This way is mostly used for systems installed in differently shaped areas, e.g. if the plant is built in a long and narrow field. Total produced electricity is combined at AC side. It brings lower investment to cables. Long DC cables in such cases could mean higher investment than higher costs per Wp for smaller inverters. Disadvantage of this decentralization lies in more difficulty service of such plant.

The biggest power plants with installed power from ca. 0.5 MWp usually use combination of both the approaches.

For small typically residential rooftop systems, one of the decisions is to choose either 1phase or 3phase inverter solution. Besides costs issues, the main argument for this decision is requirement of Utilities which grid the system will be connected to. In general, there is ca. 5 kW limit for non-three phase solutions (i.e. 1 and 2 phase ones). Utilities very often require 3phase solution even for lower installed power to ensure better balance of the grid.

Last important design point for inverter is grounding of the system. Based on HD 60364-7-712:2005, a PV system can be grounded at its DC side only on condition that there is electric separation between its DC and AC part. One hand this is additional requirement causing some investment. On the other hand grounded system can be much better and more effectively protected e.g. against overvoltage. With inverters designed to be grounded it is necessary to take care which pole of the DC side is intended for that. Grounding of the other will not only mean malfunction of the inverter but the inverter can even be destroyed.

Connection of PV system to an AC grid

Connection to a grid must follow several regulations and criteria. There have to be followed requirements given by general law as well as specific rules of the particular utility company. At AC side, there must be ensured fulfilling of general safety requirements given e.g. in HD 60364. There are also common specific rules for PV, like grounding of the system, synchronization of the frequency, phase and voltage to the system, disconnection in case of grid voltage drop etc. Local utilities can have slightly different requirements on setting of protection systems (allowed differences in voltage, phase etc.). Special care must be taken for power balance among particular phases as well as power factor. An inherent part of grid connected PV system is energy measurement.

Ordering information

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Ordering information

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Ex9MSD DC MCCB switch disconnectors 57

RC pre-wired DC boards 61

DC MCBs Ex9BP

- **DC Miniature Circuit Breakers**
- **Non-polarized, suitable for photovoltaic aplications**
- **Tested according to IEC / EN 60947-2**
- **Rated short circuit breaking capacity I_{cu} 10 kA for Ex9BP-H, 6 kA for Ex9BP-N**
- **Rated operating voltage U_e 250 V DC per pole**
- **Width 1 up to 4 modules**
- **Tripping characteristics C, K**
- **Rated current up to 63 A**
- **Wide range of accessories**

DC miniature circuit breakers Ex9BP are designed for direct current applications. Thanks to their polarity independency are suitable for photovoltaic aplications.

It can be combined with wide range of accessories including auxiliary and signal contacts, shunt trip release and undervoltage release. It is possible to create diversed combination of accessories. These combinations are only limited by total number, not by the type of accessories - all components fit together. It can be used up to three units of auxiliary or alarm contacts plus up to two units for release units.

Type Key

Ex9	BP	H	3P	C	16
Product family	Product	Breaking capacity	Module width	Tripping curve	Rated current
Ex9	DC MCBs suitable for PV	N: 6 kA H: 10 kA	1, 2, 3, 4	C, K	10 - 63 A

Certification marks

DC MCBs Ex9BP

Accessories

Aux. or signal contacts
AX, AL, AXL
Up to 3 units

Voltage or trip releases
SHT, UVT
Up to 2 units

MCB
Ex9BP
1, 2, 3, 4-module width

Auxiliary contacts AX3111, AX3122

Alarm contact AL3111

Auxiliary and alarm contact AXL31

Shunt trip releases SHT31, SHT3111

Undervoltage releases UVT31, UVT3101, UVT3110

All accessories are mounted to the MCBs Ex9BP from the left. The undervoltage release UVT in PV system is intended e.g. for safe remote disconnection of DC part from installation.

DC MCBs Ex9BP-H, 10 kA

C-Characteristic, 1-pole, 250 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	1 MU	C	101686	Ex9BP-H 1P C 10A	1/12/144
13 A	1 MU	C	102364	Ex9BP-H 1P C 13A	1/12/144
16 A	1 MU	C	101687	Ex9BP-H 1P C 16A	1/12/144
20 A	1 MU	C	101688	Ex9BP-H 1P C 20A	1/12/144
25 A	1 MU	C	101689	Ex9BP-H 1P C 25A	1/12/144
32 A	1 MU	C	101690	Ex9BP-H 1P C 32A	1/12/144
40 A	1 MU	C	101691	Ex9BP-H 1P C 40A	1/12/144
50 A	1 MU	C	101692	Ex9BP-H 1P C 50A	1/12/144
63 A	1 MU	C	101693	Ex9BP-H 1P C 63A	1/12/144

C-Characteristic, 2-pole, 500 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	2 MU	C	101694	Ex9BP-H 2P C 10A	1/6/72
13 A	2 MU	C	102365	Ex9BP-H 2P C 13A	1/6/72
16 A	2 MU	C	101695	Ex9BP-H 2P C 16A	1/6/72
20 A	2 MU	C	101696	Ex9BP-H 2P C 20A	1/6/72
25 A	2 MU	C	101697	Ex9BP-H 2P C 25A	1/6/72
32 A	2 MU	C	101698	Ex9BP-H 2P C 32A	1/6/72
40 A	2 MU	C	101699	Ex9BP-H 2P C 40A	1/6/72
50 A	2 MU	C	101700	Ex9BP-H 2P C 50A	1/6/72
63 A	2 MU	C	101701	Ex9BP-H 2P C 63A	1/6/72

C-Characteristic, 3-module, 750 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	3 MU	C	101702	Ex9BP-H 3P C 10A	1/4/48
13 A	3 MU	C	102366	Ex9BP-H 3P C 13A	1/4/48
16 A	3 MU	C	101703	Ex9BP-H 3P C 16A	1/4/48
20 A	3 MU	C	101704	Ex9BP-H 3P C 20A	1/4/48
25 A	3 MU	C	101705	Ex9BP-H 3P C 25A	1/4/48
32 A	3 MU	C	101706	Ex9BP-H 3P C 32A	1/4/48
40 A	3 MU	C	101707	Ex9BP-H 3P C 40A	1/4/48
50 A	3 MU	C	101708	Ex9BP-H 3P C 50A	1/4/48
63 A	3 MU	C	101709	Ex9BP-H 3P C 63A	1/4/48

C-Characteristic, 4-module, 1000 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	4 MU	C	101710	Ex9BP-H 4P C 10A	1/3/36
13 A	4 MU	C	102367	Ex9BP-H 4P C 13A	1/3/36
16 A	4 MU	C	101711	Ex9BP-H 4P C 16A	1/3/36
20 A	4 MU	C	101712	Ex9BP-H 4P C 20A	1/3/36
25 A	4 MU	C	101713	Ex9BP-H 4P C 25A	1/3/36
32 A	4 MU	C	101714	Ex9BP-H 4P C 32A	1/3/36
40 A	4 MU	C	101715	Ex9BP-H 4P C 40A	1/3/36
50 A	4 MU	C	101716	Ex9BP-H 4P C 50A	1/3/36
63 A	4 MU	C	101717	Ex9BP-H 4P C 63A	1/3/36

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DC MCBs Ex9BP-H, 10 kA

K-Characteristic, 1-pole, 250 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	1 MU	K	101718	Ex9BP-H 1P K 10A	1/12/144
13 A	1 MU	K	102368	Ex9BP-H 1P K 13A	1/12/144
16 A	1 MU	K	101719	Ex9BP-H 1P K 16A	1/12/144
20 A	1 MU	K	101720	Ex9BP-H 1P K 20A	1/12/144
25 A	1 MU	K	101721	Ex9BP-H 1P K 25A	1/12/144
32 A	1 MU	K	101722	Ex9BP-H 1P K 32A	1/12/144
40 A	1 MU	K	101723	Ex9BP-H 1P K 40A	1/12/144
50 A	1 MU	K	101724	Ex9BP-H 1P K 50A	1/12/144
63 A	1 MU	K	101725	Ex9BP-H 1P K 63A	1/12/144

K-Characteristic, 2-pole, 500 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	2 MU	K	101726	Ex9BP-H 2P K 10A	1/6/72
13 A	2 MU	K	102369	Ex9BP-H 2P K 13A	1/6/72
16 A	2 MU	K	101727	Ex9BP-H 2P K 16A	1/6/72
20 A	2 MU	K	101728	Ex9BP-H 2P K 20A	1/6/72
25 A	2 MU	K	101729	Ex9BP-H 2P K 25A	1/6/72
32 A	2 MU	K	101730	Ex9BP-H 2P K 32A	1/6/72
40 A	2 MU	K	101731	Ex9BP-H 2P K 40A	1/6/72
50 A	2 MU	K	101732	Ex9BP-H 2P K 50A	1/6/72
63 A	2 MU	K	101733	Ex9BP-H 2P K 63A	1/6/72

K-Characteristic, 3-module, 750 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	3 MU	K	101734	Ex9BP-H 3P K 10A	1/4/48
13 A	3 MU	K	102370	Ex9BP-H 3P K 13A	1/4/48
16 A	3 MU	K	101735	Ex9BP-H 3P K 16A	1/4/48
20 A	3 MU	K	101736	Ex9BP-H 3P K 20A	1/4/48
25 A	3 MU	K	101737	Ex9BP-H 3P K 25A	1/4/48
32 A	3 MU	K	101738	Ex9BP-H 3P K 32A	1/4/48
40 A	3 MU	K	101739	Ex9BP-H 3P K 40A	1/4/48
50 A	3 MU	K	101740	Ex9BP-H 3P K 50A	1/4/48
63 A	3 MU	K	101741	Ex9BP-H 3P K 63A	1/4/48

K-Characteristic, 4-module, 1000 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	4 MU	K	101742	Ex9BP-H 4P K 10A	1/3/36
13 A	4 MU	K	102371	Ex9BP-H 4P K 13A	1/3/36
16 A	4 MU	K	101743	Ex9BP-H 4P K 16A	1/3/36
20 A	4 MU	K	101744	Ex9BP-H 4P K 20A	1/3/36
25 A	4 MU	K	101745	Ex9BP-H 4P K 25A	1/3/36
32 A	4 MU	K	101746	Ex9BP-H 4P K 32A	1/3/36
40 A	4 MU	K	101747	Ex9BP-H 4P K 40A	1/3/36
50 A	4 MU	K	101748	Ex9BP-H 4P K 50A	1/3/36
63 A	4 MU	K	101749	Ex9BP-H 4P K 63A	1/3/36

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DC MCBs Ex9BP-N, 6 kA

C-Characteristic, 1-pole, 250 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	1 MU	C	101622	Ex9BP-N 1P C 10A	1/12/144
13 A	1 MU	C	102356	Ex9BP-N 1P C 13A	1/12/144
16 A	1 MU	C	101623	Ex9BP-N 1P C 16A	1/12/144
20 A	1 MU	C	101624	Ex9BP-N 1P C 20A	1/12/144
25 A	1 MU	C	101625	Ex9BP-N 1P C 25A	1/12/144
32 A	1 MU	C	101626	Ex9BP-N 1P C 32A	1/12/144
40 A	1 MU	C	101627	Ex9BP-N 1P C 40A	1/12/144
50 A	1 MU	C	101628	Ex9BP-N 1P C 50A	1/12/144
63 A	1 MU	C	101629	Ex9BP-N 1P C 63A	1/12/144

C-Characteristic, 2-pole, 500 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	2 MU	C	101630	Ex9BP-N 2P C 10A	1/6/72
13 A	2 MU	C	102357	Ex9BP-N 2P C 13A	1/6/72
16 A	2 MU	C	101631	Ex9BP-N 2P C 16A	1/6/72
20 A	2 MU	C	101632	Ex9BP-N 2P C 20A	1/6/72
25 A	2 MU	C	101633	Ex9BP-N 2P C 25A	1/6/72
32 A	2 MU	C	101634	Ex9BP-N 2P C 32A	1/6/72
40 A	2 MU	C	101635	Ex9BP-N 2P C 40A	1/6/72
50 A	2 MU	C	101636	Ex9BP-N 2P C 50A	1/6/72
63 A	2 MU	C	101637	Ex9BP-N 2P C 63A	1/6/72

C-Characteristic, 3-module, 750 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	3 MU	C	101638	Ex9BP-N 3P C 10A	1/4/48
13 A	3 MU	C	102358	Ex9BP-N 3P C 13A	1/4/48
16 A	3 MU	C	101639	Ex9BP-N 3P C 16A	1/4/48
20 A	3 MU	C	101640	Ex9BP-N 3P C 20A	1/4/48
25 A	3 MU	C	101641	Ex9BP-N 3P C 25A	1/4/48
32 A	3 MU	C	101642	Ex9BP-N 3P C 32A	1/4/48
40 A	3 MU	C	101643	Ex9BP-N 3P C 40A	1/4/48
50 A	3 MU	C	101644	Ex9BP-N 3P C 50A	1/4/48
63 A	3 MU	C	101645	Ex9BP-N 3P C 63A	1/4/48

C-Characteristic, 4-module, 1000 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	4 MU	C	101646	Ex9BP-N 4P C 10A	1/3/36
13 A	4 MU	C	102359	Ex9BP-N 4P C 13A	1/3/36
16 A	4 MU	C	101647	Ex9BP-N 4P C 16A	1/3/36
20 A	4 MU	C	101648	Ex9BP-N 4P C 20A	1/3/36
25 A	4 MU	C	101649	Ex9BP-N 4P C 25A	1/3/36
32 A	4 MU	C	101650	Ex9BP-N 4P C 32A	1/3/36
40 A	4 MU	C	101651	Ex9BP-N 4P C 40A	1/3/36
50 A	4 MU	C	101652	Ex9BP-N 4P C 50A	1/3/36
63 A	4 MU	C	101653	Ex9BP-N 4P C 63A	1/3/36

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DC MCBs Ex9BP-N, 6 kA

K-Characteristic, 1-pole, 250 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	1 MU	K	101654	Ex9BP-N 1P K 10A	1/12/144
13 A	1 MU	K	102360	Ex9BP-N 1P K 13A	1/12/144
16 A	1 MU	K	101655	Ex9BP-N 1P K 16A	1/12/144
20 A	1 MU	K	101656	Ex9BP-N 1P K 20A	1/12/144
25 A	1 MU	K	101657	Ex9BP-N 1P K 25A	1/12/144
32 A	1 MU	K	101658	Ex9BP-N 1P K 32A	1/12/144
40 A	1 MU	K	101659	Ex9BP-N 1P K 40A	1/12/144
50 A	1 MU	K	101660	Ex9BP-N 1P K 50A	1/12/144
63 A	1 MU	K	101661	Ex9BP-N 1P K 63A	1/12/144

K-Characteristic, 2-pole, 500 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	2 MU	K	101662	Ex9BP-N 2P K 10A	1/6/72
13 A	2 MU	K	102361	Ex9BP-N 2P K 13A	1/6/72
16 A	2 MU	K	101663	Ex9BP-N 2P K 16A	1/6/72
20 A	2 MU	K	101664	Ex9BP-N 2P K 20A	1/6/72
25 A	2 MU	K	101665	Ex9BP-N 2P K 25A	1/6/72
32 A	2 MU	K	101666	Ex9BP-N 2P K 32A	1/6/72
40 A	2 MU	K	101667	Ex9BP-N 2P K 40A	1/6/72
50 A	2 MU	K	101668	Ex9BP-N 2P K 50A	1/6/72
63 A	2 MU	K	101669	Ex9BP-N 2P K 63A	1/6/72

K-Characteristic, 3-module, 750 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	3 MU	K	101670	Ex9BP-N 3P K 10A	1/4/48
13 A	3 MU	K	102362	Ex9BP-N 3P K 13A	1/4/48
16 A	3 MU	K	101671	Ex9BP-N 3P K 16A	1/4/48
20 A	3 MU	K	101672	Ex9BP-N 3P K 20A	1/4/48
25 A	3 MU	K	101673	Ex9BP-N 3P K 25A	1/4/48
32 A	3 MU	K	101674	Ex9BP-N 3P K 32A	1/4/48
40 A	3 MU	K	101675	Ex9BP-N 3P K 40A	1/4/48
50 A	3 MU	K	101676	Ex9BP-N 3P K 50A	1/4/48
63 A	3 MU	K	101677	Ex9BP-N 3P K 63A	1/4/48

K-Characteristic, 4-module, 1000 V DC

Rated current	Width	Char.	Article No.	Type	Packing
10 A	4 MU	K	101678	Ex9BP-N 4P K 10A	1/3/36
13 A	4 MU	K	102363	Ex9BP-N 4P K 13A	1/3/36
16 A	4 MU	K	101679	Ex9BP-N 4P K 16A	1/3/36
20 A	4 MU	K	101680	Ex9BP-N 4P K 20A	1/3/36
25 A	4 MU	K	101681	Ex9BP-N 4P K 25A	1/3/36
32 A	4 MU	K	101682	Ex9BP-N 4P K 32A	1/3/36
40 A	4 MU	K	101683	Ex9BP-N 4P K 40A	1/3/36
50 A	4 MU	K	101684	Ex9BP-N 4P K 50A	1/3/36
63 A	4 MU	K	101685	Ex9BP-N 4P K 63A	1/3/36

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NOARK

DC Fuse disconnectors Ex9FP

- **DC Fuse disconnectors**
- **Suitable for PV systems**
- **Rated short-circuit breaking capacity I_{cn} with appropriate fuse-link up to 33 kA**
- **Rated current up to 30 A**
- **Optical tripping indicator**
- **Fuse-links of size 10 x 38 mm**
- **Utilization category DC-20B**

Rated operational voltage 1000 V DC

Fuse disconnectors Ex9FP for photovoltaic string protection against short circuit and overload. Suitable for cylindrical fuse-links of size 10 x 38 mm.

LED optical tripping indicator on the front side is signaling the fuse fault.

Type Key

Ex9	FP	1P	30A
Product family	Product	Poles	Max. rated current
Ex9	DC fuse disconnector	1, 2	30

Certification marks

DC Fuse disconnectors Ex9FP

1-pole

Poles	Article No.	Type	Packing
1	101766	Ex9FP 1P 30A	1/12/144

2-pole

Poles	Article No.	Type	Packing
2	101767	Ex9FP 2P 30A	1/6/72

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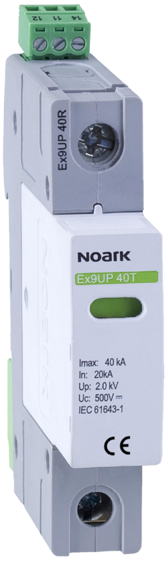
DC Surge Protection Devices Ex9UP



- **DC Surge Protection Devices class II**
- **Suitable for Photovoltaic systems**
- **Nominal discharge current I_n 20 kA (8/20 µs)**
- **Maximum discharge current I_{max} 40 kA (8/20 µs)**
- **Max. continuous operational voltage 500 V DC or 1000 V DC**
- **Meet requirements of IEC 61643-1/EN 61643-11**
- **1 and 3-pole version**
- **Plug-in module design**
- **Device status indicator**

DC Surge protection devices Ex9UP are suitable for photovoltaic applications. These SPDs are tested according Class II. Indication unit helps users to know the status of device and remote-signal port is able to provide remote indication and alarm.

Plug-in module design make it convenient to change module without device disconnection.

Type Key

Ex9	UP	40	T	R	1P	1000V
Product family	Product	Discharge current	Plug-in module	Signaling contact	Width	Operating voltage
Ex9	DC SPDs class II	I_{max}=40kA	_: Complete device T: Plug-in module only	R: Yes _: No	_: module only 1: 1P 3: 3P	500V 1000V

Certification marks

DC Surge Protection Devices Ex9UP

500 V, width 1 MU

Max continuous voltage U_c	Signaling contact	Article No.	Type	Packing
500 V	no	102312	Ex9UP 40 1P 500V	1/144
500 V	yes	102313	Ex9UP 40R 1P 500V	1/144

1000 V for grounded PV systems, width 2 MU

Max continuous voltage U_c	Signaling contact	Article No.	Type	Packing
1000 V	no	102314	Ex9UP 40 1P 1000V	1/72
1000 V	yes	102315	Ex9UP 40R 1P 1000V	1/72

1000 V for ungrounded PV systems, width 3 MU

Max continuous voltage U_c	Signaling contact	Article No.	Type	Packing
1000 V	no	103371	Ex9UP 40 3P 1000V	1/48
1000 V	yes	103372	Ex9UP 40R 3P 1000V	1/48

Plug-in module

Max continuous voltage U_c	Poles	Article No.	Type	Packing
500 V	1	102316	Ex9UP 40T 500V	1

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DC Isolators Ex9IP

- **DC modular Isolators**
- **Non-polarized, suitable for PV systems**
- **Rated current up to 63 A**
- **Rated voltage up to 1000 V DC (250 V DC per pole/module)**
- **Rated short-time withstand current I_{cw} = 12 x I_e, 1 s**
- **Meet requirements of IEC / EN 60947-3**
- **Width 1 to 4 modules**
- **Utilization category DC-22B**
- **Wide range of accessories**

DC Isolators Ex9IP can be used as a main switch in photovoltaic and similar applications. These switches are tested according to IEC / EN 60947-3 standards and fulfill also requirements for isolation function.

Ex9IP Isolators can be also combined with wide range of accessories including auxiliary and signal contacts, shunt trip releases and undervoltage.

Type Key

Ex9	IP	1P	32A
Product family	Product	Module width	Rated current
Ex9	DC Isolator	1, 2, 3, 4	16, 32, 50, 63

Certification marks

CB CE

DC Isolators Ex9IP

Accessories

Aux. or signal contacts	Voltage or trip releases	Isolator
AX, AL, AXL	**SHT, UVT**	**Ex9IP**
Up to 3 units	Up to 2 units	1, 2, 3, 4-module width

Auxiliary contacts AX3111, AX3122

Shunt trip releases SHT31, SHT3111

Undervoltage releases UVT31, UVT3101, UVT3110

All accessories are mounted to the Ex9IP isolators from the left. The undervoltage release UVT in PV system is intended e.g. for safe remote disconnection of DC part from installation.

DC Isolators Ex9IP

1-module, 250 V DC

Rated current	Width	Article No.	Type	Packing
16 A	1 MU	101750	Ex9IP 1P 16A	1/12/144
32 A	1 MU	101751	Ex9IP 1P 32A	1/12/144
50 A	1 MU	101752	Ex9IP 1P 50A	1/12/144
63 A	1 MU	101753	Ex9IP 1P 63A	1/12/144

2-module, 500 V DC

Rated current	Width	Article No.	Type	Packing
16 A	2 MU	101754	Ex9IP 2P 16A	1/6/72
32 A	2 MU	101755	Ex9IP 2P 32A	1/6/72
50 A	2 MU	101756	Ex9IP 2P 50A	1/6/72
63 A	2 MU	101757	Ex9IP 2P 63A	1/6/72

3-module, 750 V DC

Rated current	Width	Article No.	Type	Packing
16 A	3 MU	101758	Ex9IP 3P 16A	1/4/48
32 A	3 MU	101759	Ex9IP 3P 32A	1/4/48
50 A	3 MU	101760	Ex9IP 3P 50A	1/4/48
63 A	3 MU	101761	Ex9IP 3P 63A	1/4/48

4-module, 1000 V DC

Rated current	Width	Article No.	Type	Packing
16 A	4 MU	101762	Ex9IP 4P 16A	1/3/36
32 A	4 MU	101763	Ex9IP 4P 32A	1/3/36
50 A	4 MU	101764	Ex9IP 4P 50A	1/3/36
63 A	4 MU	101765	Ex9IP 4P 63A	1/3/36

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DC MCCBs Ex9MD

- **DC Moulded Case Circuit Breakers**
- **Frame size M1 with rated current up to 125 A**
  Frame size M2 with rated current up to 250 A
  Frame size M3 with rated current up to 400 A
- **3 and 4-pole versions**
- **Rated ultimate short circuit breaking capacity I_{cu} up to 100 kA**
- **I_{cs} = 100 % I_{cu}**
- **Rated voltage 750 V DC (3-pole) and 1000 V DC (4-pole)**
- **Thermomagnetic releases**
- **Fixed version**

DC Moulded Case Circuit Breakers Ex9MD TM are intended mainly for photovoltaic applications. Testing according to IEC / EN 60947-2 standards ensures functions and reliability for wide variety of applications including isolation.

These breakers are offered with breaking capacities from 25 kA up to 100 kA. Rated impulse withstand voltage U_{imp} 8 kV makes it possible to use them even in system with occurences of transient overvoltage waves of high intensity.

Utilization category A.

Type Key

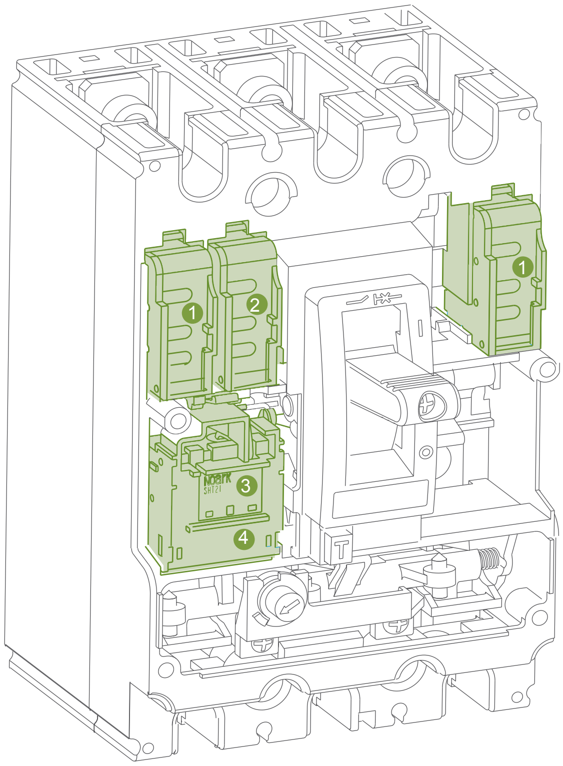
Ex9	MD	1	S	TM	DC	100	3P
Product family	Product	Frame size	Breaking capacity	Release technology	Current character	Rated current	Poles
Ex9	MD: DC MCCB	1: to 125 A 2: to 250 A 3: to 400 A	B: 25 kA S: 36 kA N: 50 kA H: 100 kA	TM: Thermo-magnetic	DC	16 — 125 125 — 250 250 — 400	3P: 3-pole 4P4T: 4-pole

Certification marks

CB CE

DC MCCBs Ex9MD

Internal accessories



1	2	3	4
Auxiliary contact **AX21** Up to 3 units	Signal contact **AL21** 1 unit	Shunt trip release **SHT2*i*** 1 unit or UVT2*i*	Undervoltage release **UVT2*i*** 1 unit or SHT2*i*

Auxiliary contact AX21

Alarm contact AL21

Shunt trip releases SHT2*i*

Undervoltage releases UVT2*i*

The undervoltage release UVT in PV system is intended e.g. for safe remote disconnection of DC part from installation.

DC MCCBs Ex9MD

External accessories

Phase barriers
PB2*i*

Terminal cover set, short
TCV2*i*

Terminal cover set, long
TCE2*i*

Box terminals
MC2*i*

Tunnel terminals
MC2*i* W

Remote operator
MOD2*i*

Direct rotary handle
RHD2*i*

Extended rotary handle
ERH2*i*

Phase barriers PB2*i*

Terminal cover set, short TCV2*i*

Terminal cover set, long TCE2*i*

Remote operators MOD2*i*

Direct rotary handles RHD2*i*

Extended rotary handles ERH2*i*

Connection terminals MC2*i*

DC MCCBs Ex9MD1 up to 125 A

Version Ex9MD1B, I_{cu} = 25 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 25 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i fixed as 10 × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
16 A	12.8—16 A	160 A	101768	Ex9MD1B TM DC16 3P	1/8
20 A	16—20 A	200 A	101769	Ex9MD1B TM DC20 3P	1/8
25 A	20—25 A	250 A	101770	Ex9MD1B TM DC25 3P	1/8
32 A	25.6—32 A	320 A	101771	Ex9MD1B TM DC32 3P	1/8
40 A	32—40 A	400 A	101772	Ex9MD1B TM DC40 3P	1/8
50 A	40—50 A	500 A	101773	Ex9MD1B TM DC50 3P	1/8
63 A	50.4—63 A	630 A	101774	Ex9MD1B TM DC63 3P	1/8
80 A	64—80 A	800 A	101775	Ex9MD1B TM DC80 3P	1/8
100 A	80—100 A	1000 A	101776	Ex9MD1B TM DC100 3P	1/8
125 A	100—125 A	1250 A	101777	Ex9MD1B TM DC125 3P	1/8
16 A	12.8—16 A	160 A	101828	Ex9MD1B TM DC16 4P4T	1/8
20 A	16—20 A	200 A	101829	Ex9MD1B TM DC20 4P4T	1/8
25 A	20—25 A	250 A	101830	Ex9MD1B TM DC25 4P4T	1/8
32 A	25.6—32 A	320 A	101831	Ex9MD1B TM DC32 4P4T	1/8
40 A	32—40 A	400 A	101832	Ex9MD1B TM DC40 4P4T	1/8
50 A	40—50 A	500 A	101833	Ex9MD1B TM DC50 4P4T	1/8
63 A	50.4—63 A	630 A	101834	Ex9MD1B TM DC63 4P4T	1/8
80 A	64—80 A	800 A	101835	Ex9MD1B TM DC80 4P4T	1/8
100 A	80—100 A	1000 A	101836	Ex9MD1B TM DC100 4P4T	1/8
125 A	100—125 A	1250 A	101837	Ex9MD1B TM DC125 4P4T	1/8

Version Ex9MD1S, I_{cu} = 36 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 36 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i fixed as 10 × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
16 A	12.8—16 A	160 A	101778	Ex9MD1S TM DC16 3P	1/8
20 A	16—20 A	200 A	101779	Ex9MD1S TM DC20 3P	1/8
25 A	20—25 A	250 A	101780	Ex9MD1S TM DC25 3P	1/8
32 A	25.6—32 A	320 A	101781	Ex9MD1S TM DC32 3P	1/8
40 A	32—40 A	400 A	101782	Ex9MD1S TM DC40 3P	1/8
50 A	40—50 A	500 A	101783	Ex9MD1S TM DC50 3P	1/8
63 A	50.4—63 A	630 A	101784	Ex9MD1S TM DC63 3P	1/8
80 A	64—80 A	800 A	101785	Ex9MD1S TM DC80 3P	1/8
100 A	80—100 A	1000 A	101786	Ex9MD1S TM DC100 3P	1/8
125 A	100—125 A	1250 A	101787	Ex9MD1S TM DC125 3P	1/8
16 A	12.8—16 A	160 A	101838	Ex9MD1S TM DC16 4P4T	1/8
20 A	16—20 A	200 A	101839	Ex9MD1S TM DC20 4P4T	1/8
25 A	20—25 A	250 A	101840	Ex9MD1S TM DC25 4P4T	1/8
32 A	25.6—32 A	320 A	101841	Ex9MD1S TM DC32 4P4T	1/8
40 A	32—40 A	400 A	101842	Ex9MD1S TM DC40 4P4T	1/8
50 A	40—50 A	500 A	101843	Ex9MD1S TM DC50 4P4T	1/8
63 A	50.4—63 A	630 A	101844	Ex9MD1S TM DC63 4P4T	1/8
80 A	64—80 A	800 A	101845	Ex9MD1S TM DC80 4P4T	1/8
100 A	80—100 A	1000 A	101846	Ex9MD1S TM DC100 4P4T	1/8
125 A	100—125 A	1250 A	101847	Ex9MD1S TM DC125 4P4T	1/8

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DC MCCBs Ex9MD1 up to 125 A

Version Ex9MD1N, I_{cu} = 50 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 50 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i fixed as 10 × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
16 A	12.8—16 A	160 A	101788	Ex9MD1N TM DC16 3P	1/8
20 A	16—20 A	200 A	101789	Ex9MD1N TM DC20 3P	1/8
25 A	20—25 A	250 A	101790	Ex9MD1N TM DC25 3P	1/8
32 A	25.6—32 A	320 A	101791	Ex9MD1N TM DC32 3P	1/8
40 A	32—40 A	400 A	101792	Ex9MD1N TM DC40 3P	1/8
50 A	40—50 A	500 A	101793	Ex9MD1N TM DC50 3P	1/8
63 A	50.4—63 A	630 A	101794	Ex9MD1N TM DC63 3P	1/8
80 A	64—80 A	800 A	101795	Ex9MD1N TM DC80 3P	1/8
100 A	80—100 A	1000 A	101796	Ex9MD1N TM DC100 3P	1/8
125 A	100—125 A	1250 A	101797	Ex9MD1N TM DC125 3P	1/8
16 A	12.8—16 A	160 A	101848	Ex9MD1N TM DC16 4P4T	1/8
20 A	16—20 A	200 A	101849	Ex9MD1N TM DC20 4P4T	1/8
25 A	20—25 A	250 A	101850	Ex9MD1N TM DC25 4P4T	1/8
32 A	25.6—32 A	320 A	101851	Ex9MD1N TM DC32 4P4T	1/8
40 A	32—40 A	400 A	101852	Ex9MD1N TM DC40 4P4T	1/8
50 A	40—50 A	500 A	101853	Ex9MD1N TM DC50 4P4T	1/8
63 A	50.4—63 A	630 A	101854	Ex9MD1N TM DC63 4P4T	1/8
80 A	64—80 A	800 A	101855	Ex9MD1N TM DC80 4P4T	1/8
100 A	80—100 A	1000 A	101856	Ex9MD1N TM DC100 4P4T	1/8
125 A	100—125 A	1250 A	101857	Ex9MD1N TM DC125 4P4T	1/8

Version Ex9MD1H, I_{cu} = 100 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 100 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i fixed as 10 × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
16 A	12.8—16 A	160 A	101818	Ex9MD1H TM DC16 3P	1/8
20 A	16—20 A	200 A	101819	Ex9MD1H TM DC20 3P	1/8
25 A	20—25 A	250 A	101820	Ex9MD1H TM DC25 3P	1/8
32 A	25.6—32 A	320 A	101821	Ex9MD1H TM DC32 3P	1/8
40 A	32—40 A	400 A	101822	Ex9MD1H TM DC40 3P	1/8
50 A	40—50 A	500 A	101823	Ex9MD1H TM DC50 3P	1/8
63 A	50.4—63 A	630 A	101824	Ex9MD1H TM DC63 3P	1/8
80 A	64—80 A	800 A	101825	Ex9MD1H TM DC80 3P	1/8
100 A	80—100 A	1000 A	101826	Ex9MD1H TM DC100 3P	1/8
125 A	100—125 A	1250 A	101827	Ex9MD1H TM DC125 3P	1/8
16 A	12.8—16 A	160 A	101878	Ex9MD1H TM DC16 4P4T	1/8
20 A	16—20 A	200 A	101879	Ex9MD1H TM DC20 4P4T	1/8
25 A	20—25 A	250 A	101880	Ex9MD1H TM DC25 4P4T	1/8
32 A	25.6—32 A	320 A	101881	Ex9MD1H TM DC32 4P4T	1/8
40 A	32—40 A	400 A	101882	Ex9MD1H TM DC40 4P4T	1/8
50 A	40—50 A	500 A	101883	Ex9MD1H TM DC50 4P4T	1/8
63 A	50.4—63 A	630 A	101884	Ex9MD1H TM DC63 4P4T	1/8
80 A	64—80 A	800 A	101885	Ex9MD1H TM DC80 4P4T	1/8
100 A	80—100 A	1000 A	101886	Ex9MD1H TM DC100 4P4T	1/8
125 A	100—125 A	1250 A	101887	Ex9MD1H TM DC125 4P4T	1/8

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DC MCCBs Ex9MD2 up to 250 A

Version Ex9MD2B, I_{cu} = 25 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 25 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
125 A	100-125 A	625-1250	101888	Ex9MD2B TM DC125 3P	1/4
160 A	128-160 A	800-1600	101889	Ex9MD2B TM DC160 3P	1/4
180 A	144-180 A	900-1800	101890	Ex9MD2B TM DC180 3P	1/4
200 A	160-200 A	1000-2000	101891	Ex9MD2B TM DC200 3P	1/4
225 A	180-225 A	1125-2250	101892	Ex9MD2B TM DC225 3P	1/4
250 A	200-250 A	1250-2500	101893	Ex9MD2B TM DC250 3P	1/4
125 A	100-125 A	625-1250	101924	Ex9MD2B TM DC125 4P4T	1/4
160 A	128-160 A	800-1600	101925	Ex9MD2B TM DC160 4P4T	1/4
180 A	144-180 A	900-1800	101926	Ex9MD2B TM DC180 4P4T	1/4
200 A	160-200 A	1000-2000	101927	Ex9MD2B TM DC200 4P4T	1/4
225 A	180-225 A	1125-2250	101928	Ex9MD2B TM DC225 4P4T	1/4
250 A	200-250 A	1250-2500	101929	Ex9MD2B TM DC250 4P4T	1/4

Version Ex9MD2S, I_{cu} = 36 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 36 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
125 A	100-125 A	625-1250	101894	Ex9MD2S TM DC125 3P	1/4
160 A	128-160 A	800-1600	101895	Ex9MD2S TM DC160 3P	1/4
180 A	144-180 A	900-1800	101896	Ex9MD2S TM DC180 3P	1/4
200 A	160-200 A	1000-2000	101897	Ex9MD2S TM DC200 3P	1/4
225 A	180-225 A	1125-2250	101898	Ex9MD2S TM DC225 3P	1/4
250 A	200-250 A	1250-2500	101899	Ex9MD2S TM DC250 3P	1/4
125 A	100-125 A	625-1250	101930	Ex9MD2S TM DC125 4P4T	1/4
160 A	128-160 A	800-1600	101931	Ex9MD2S TM DC160 4P4T	1/4
180 A	144-180 A	900-1800	101932	Ex9MD2S TM DC180 4P4T	1/4
200 A	160-200 A	1000-2000	101933	Ex9MD2S TM DC200 4P4T	1/4
225 A	180-225 A	1125-2250	101934	Ex9MD2S TM DC225 4P4T	1/4
250 A	200-250 A	1250-2500	101935	Ex9MD2S TM DC250 4P4T	1/4

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DC MCCBs Ex9MD2 up to 250 A

Version Ex9MD2N, I_{cu} = 50 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 50 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
125 A	100-125 A	625-1250	101900	Ex9MD2N TM DC125 3P	1/4
160 A	128-160 A	800-1600	101901	Ex9MD2N TM DC160 3P	1/4
180 A	144-180 A	900-1800	101902	Ex9MD2N TM DC180 3P	1/4
200 A	160-200 A	1000-2000	101903	Ex9MD2N TM DC200 3P	1/4
225 A	180-225 A	1125-2250	101904	Ex9MD2N TM DC225 3P	1/4
250 A	200-250 A	1250-2500	101905	Ex9MD2N TM DC250 3P	1/4
125 A	100-125 A	625-1250	101936	Ex9MD2N TM DC125 4P4T	1/4
160 A	128-160 A	800-1600	101937	Ex9MD2N TM DC160 4P4T	1/4
180 A	144-180 A	900-1800	101938	Ex9MD2N TM DC180 4P4T	1/4
200 A	160-200 A	1000-2000	101939	Ex9MD2N TM DC200 4P4T	1/4
225 A	180-225 A	1125-2250	101940	Ex9MD2N TM DC225 4P4T	1/4
250 A	200-250 A	1250-2500	101941	Ex9MD2N TM DC250 4P4T	1/4

Version Ex9MD2H, I_{cu} = 100 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- $I_{cs} = I_{cu}$ = 100 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
125 A	100-125 A	625-1250	101918	Ex9MD2H TM DC125 3P	1/4
160 A	128-160 A	800-1600	101919	Ex9MD2H TM DC160 3P	1/4
180 A	144-180 A	900-1800	101920	Ex9MD2H TM DC180 3P	1/4
200 A	160-200 A	1000-2000	101921	Ex9MD2H TM DC200 3P	1/4
225 A	180-225 A	1125-2250	101922	Ex9MD2H TM DC225 3P	1/4
250 A	200-250 A	1250-2500	101923	Ex9MD2H TM DC250 3P	1/4
125 A	100-125 A	625-1250	101954	Ex9MD2H TM DC125 4P4T	1/4
160 A	128-160 A	800-1600	101955	Ex9MD2H TM DC160 4P4T	1/4
180 A	144-180 A	900-1800	101956	Ex9MD2H TM DC180 4P4T	1/4
200 A	160-200 A	1000-2000	101957	Ex9MD2H TM DC200 4P4T	1/4
225 A	180-225 A	1125-2250	101958	Ex9MD2H TM DC225 4P4T	1/4
250 A	200-250 A	1250-2500	101959	Ex9MD2H TM DC250 4P4T	1/4

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DC MCCBs Ex9MD3 up to 400 A

Version Ex9MD3B, I_{cu} = 25 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 25 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar, spreaders as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
250 A	200-250 A	1250-2500	101960	Ex9MD3B TM DC250 3P	1/2
315 A	252-315 A	1575-3150	101961	Ex9MD3B TM DC315 3P	1/2
350 A	280-350 A	1750-3500	101962	Ex9MD3B TM DC350 3P	1/2
400 A	320-400 A	2000-4000	101963	Ex9MD3B TM DC400 3P	1/2
250 A	200-250 A	1250-2500	101984	Ex9MD3B TM DC250 4P4T	1/2
315 A	252-315 A	1575-3150	101985	Ex9MD3B TM DC315 4P4T	1/2
350 A	280-350 A	1750-3500	101986	Ex9MD3B TM DC350 4P4T	1/2
400 A	320-400 A	2000-4000	101987	Ex9MD3B TM DC400 4P4T	1/2

Version Ex9MD3S, I_{cu} = 36 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 36 kA at 750/1000 V AC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar, spreaders as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
250 A	200-250 A	1250-2500	101964	Ex9MD3S TM DC250 3P	1/2
315 A	252-315 A	1575-3150	101965	Ex9MD3S TM DC315 3P	1/2
350 A	280-350 A	1750-3500	101966	Ex9MD3S TM DC350 3P	1/2
400 A	320-400 A	2000-4000	101967	Ex9MD3S TM DC400 3P	1/2
250 A	200-250 A	1250-2500	101988	Ex9MD3S TM DC250 4P4T	1/2
315 A	252-315 A	1575-3150	101989	Ex9MD3S TM DC315 4P4T	1/2
350 A	280-350 A	1750-3500	101990	Ex9MD3S TM DC350 4P4T	1/2
400 A	320-400 A	2000-4000	101991	Ex9MD3S TM DC400 4P4T	1/2

Version Ex9MD3N, I_{cu} = 50 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 50 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
250 A	200-250 A	1250-2500	101968	Ex9MD3N TM DC250 3P	1/2
315 A	252-315 A	1575-3150	101969	Ex9MD3N TM DC315 3P	1/2
350 A	280-350 A	1750-3500	101970	Ex9MD3N TM DC350 3P	1/2
400 A	320-400 A	2000-4000	101971	Ex9MD3N TM DC400 3P	1/2
250 A	200-250 A	1250-2500	101992	Ex9MD3N TM DC250 4P4T	1/2
315 A	252-315 A	1575-3150	101993	Ex9MD3N TM DC315 4P4T	1/2
350 A	280-350 A	1750-3500	101994	Ex9MD3N TM DC350 4P4T	1/2
400 A	320-400 A	2000-4000	101995	Ex9MD3N TM DC400 4P4T	1/2

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DC MCCBs Ex9MD3 up to 400 A

Version Ex9MD3H, I_{cu} = 100 kA

- DC Moulded Case Circuit Breakers
- 3 and 4-pole versions
- I_{cs} = I_{cu} = 100 kA at 750/1000 V DC
- I_r can be set in steps (0.8-0.9-1.0) × I_n
- I_i variable (5-6-7-8-9-10) × I_n
- Mounting screws, interconnection busbar, spreaders as well as phase barriers in the scope of delivery

Rated current I_n	Overcurrent release I_r	Instant. release I_i	Article No.	Type	Packing
250 A	200-250 A	1250-2500	101980	Ex9MD3H TM DC250 3P	1/2
315 A	252-315 A	1575-3150	101981	Ex9MD3H TM DC315 3P	1/2
350 A	280-350 A	1750-3500	101982	Ex9MD3H TM DC350 3P	1/2
400 A	320-400 A	2000-4000	101983	Ex9MD3H TM DC400 3P	1/2
250 A	200-250 A	1250-2500	101204	Ex9MD3H TM DC250 4P4T	1/2
315 A	252-315 A	1575-3150	101205	Ex9MD3H TM DC315 4P4T	1/2
350 A	280-350 A	1750-3500	101206	Ex9MD3H TM DC350 4P4T	1/2
400 A	320-400 A	2000-4000	101207	Ex9MD3H TM DC400 4P4T	1/2

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MCCB Switch Disconnectors Ex9MSD

- **MCCB Switch Disconnectors**
- **Frame size M1 with rated current up to 125 A**
  Frame size M2 with rated current up to 250 A
  Frame size M3 with rated current up to 400 A
- **Tested according to EN 60947-3**
- **AC and DC current character types**
- **3 and 4-poles versions**
- **Rated operating voltage U_e up to 690 V AC or 1000 V DC (4-pole DC version)**
- **Fixed version**

MCCB based Switch Disconnectors Ex9MSD are used as a main switch in many various circuits. AC version are intended primarily for applications in power distribution. DC versions are suitable mainly for photovoltaic applications as a main switch of DC part of PV plant in combiner or array boxes.

These switch disconnectors have same size and design as standard Ex9M MCCBs. Therefore is there possibility to use fully compatible range of external and internal accessories including extended rotary handles, auxiliary contacts, tripping units, motor operators and terminal covers.

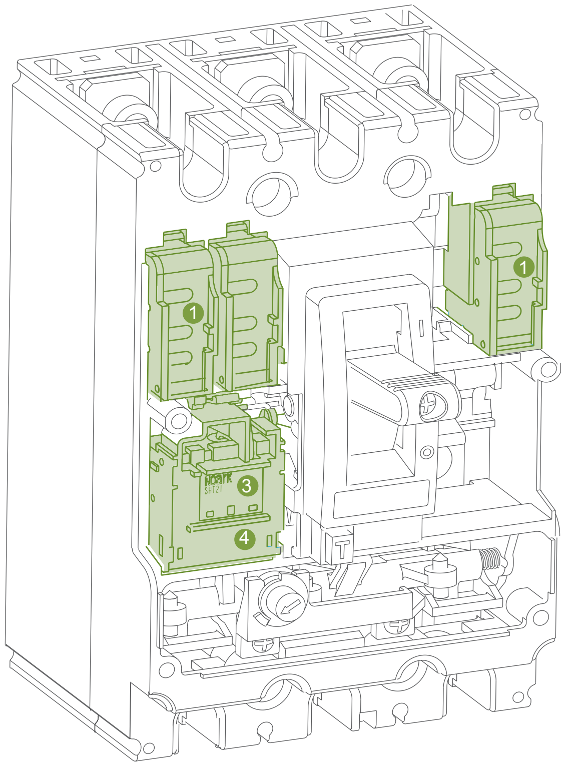
Type Key

Ex9	M	1	SD	DC	100	3P
Product family	Product	Frame size	Function	Current character	Rated current	Poles
Ex9	M: MCCB based devices	1: to 125 A 2: to 250 A 3: to 400 A	Switch Disconnector	AC DC	63 — 125 125 — 250 250 — 400	3P: 3-pole 4P: 4-pole

Certification marks

MCCB Switch Disconnectors Ex9MSD

Internal accessories



Auxiliary contact **AX21**	Shunt trip release **SHT2*i*** 1 unit or UVT2*i*	Undervoltage release **UVT2*i*** 1 unit or SHT2*i*

Auxiliary contact AX21

Shunt trip releases SHT2*i*

Undervoltage releases UVT2*i*

The undervoltage release UVT in PV system is intended e.g. for safe remote disconnection of DC part from installation.

MCCB Switch Disconnectors Ex9MSD

External accessories

Phase barriers
PB2*i*

Terminal cover set, short
TCV2*i*

Terminal cover set, long
TCE2*i*

Remote operator
MOD2*i*

Direct rotary handle
RHD2*i*

Extended rotary handle
ERH2*i*

Phase barriers PB2*i*

Short terminal cover set TCV2*i*

Long terminal cover set TCE2*i*

Remote operators MOD2*i*

Direct rotary handles RHD2*i*

Extended rotary handles ERH2*i*

Connection terminals MC2*i*

MCCB Switch Disconnectors Ex9MSD

DC versions, 750 V DC

- Mounting screws, interconnection busbars as well as phase barriers in the scope of delivery

Rated current I_n	Frame size	Article No.	Type	Packing
63 A	M1	102008	Ex9M1SD DC63 3P	1/8
100 A	M1	102009	Ex9M1SD DC100 3P	1/8
125 A	M1	102010	Ex9M1SD DC125 3P	1/8
125 A	M2	102014	Ex9M2SD DC125 3P	1/4
160 A	M2	102015	Ex9M2SD DC160 3P	1/4
200 A	M2	102016	Ex9M2SD DC200 3P	1/4
250 A	M2	102017	Ex9M2SD DC250 3P	1/4
250 A	M3	102022	Ex9M3SD DC250 3P	1/2
400 A	M3	102023	Ex9M3SD DC400 3P	1/2

DC versions, 1000 V DC

- Mounting screws, interconnection busbars as well as phase barriers in the scope of delivery

Rated current I_n	Frame size	Article No.	Type	Packing
63 A	M1	102011	Ex9M1SD DC63 4P	1/8
100 A	M1	102012	Ex9M1SD DC100 4P	1/8
125 A	M1	102013	Ex9M1SD DC125 4P	1/8
125 A	M2	102018	Ex9M2SD DC125 4P	1/4
160 A	M2	102019	Ex9M2SD DC160 4P	1/4
200 A	M2	102020	Ex9M2SD DC200 4P	1/4
250 A	M2	102021	Ex9M2SD DC250 4P	1/4
250 A	M3	102024	Ex9M3SD DC250 4P	1/2
400 A	M3	102025	Ex9M3SD DC400 4P	1/2

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DC boards for PV applications RC

- **Fully assembled and wired DC boards for Photovoltaic roof top applications up to 5 kW**
- **Plug-and-Play solution, MC4 connections**
- **Type Tested according to EN 60439-3**
- **Rated operational voltage 500 or 1000 V DC**
- **Rated string current I_{sc} up to ca. 8.65 A**
- **Output test protocol for every piece**
- **NOARK devices installed**
- **PHS line of consumer units, degree of protection IP65**

Assembled pre-wired DC boards for PV roof top applications up to 5 kW. The configuration of devices is designed to cover the offer of the most common 1phase inverters up to ca. 5 kW on the market. Design of the boards is suitable for outdoor surface mounting with IP65 degree of protection.

They are prepared for easy use in small residential PV systems. It is necessary only to mount the unit to designated place, assemble and connect input and output cables throught standard photovoltaic MC4 connectors. The only one duty of electrician is to supplement swichboard with marking according to local legislative requirements.

In the scope of delivery, there is assembled and wired consumer unit (devices, wires, PE terminals, busbars, type label, output test protocol, mounting material and instructions, multilanguage stickers, cable glands and MC4 connectors).

Other variants of configurations than offered are possible upon a request, based on a quantity required.

Type Key

RC	5	B	1	3	U	422	B	U	X
Product family	Consumer unit size	Board function	Input protection	Number of PV strings	PV system type	Number of poles of used devices	Output device	Release type	Auxiliary contacts
Fully assembled pre-wired DC boards for PV apps. up to 5kW	1: 4MU 2: 8MU 3: 12MU 4: 24MU 5: 36MU	A: protected string box B: protected combiner box	1: MCB 2: fuse	1 2 3	U: ungrounded G: grounded	MCBs or Isolators	_: none B: MCB I: isolator	_: none U: undervoltage S: shunt-trip	_: none X: auxiliary L: alarm

Certification marks

CE

DC boards for PV applications RC

Solutions for ungrounded PV systems

- Rated string input current (I_{sc}) up to ca. 8.65 A
- Installed MCBs 10A, characteristic C
- IP65 consumer unit usable also for outdoor mounting
- In the scope of delivery: assembled and wired consumer unit with transparent door (devices, wires, PE terminals, type label, output test protocol, mounting material and instructions, multilanguage stickers, cable glands and MC4 connectors).

Max.input power	Input strings	Outputs	Input voltage	Article No.	Type	Packing
3.1 kW	1	1	500 V	S101004	RC2-A1-1-U-2	1
3.1 kW	1	1	500 V	S101005	RC2-A1-1-U-2-S	1
3.1 kW	1	1	500 V	S101006	RC2-A1-1-U-2-U	1
2x3.1 kW	2	1	2x500 V	S101010	RC3-B1-2-U-22-I	1
2x3.1 kW	2	1	2x500 V	S101011	RC3-B1-2-U-22-ISX	1
2x3.1 kW	2	1	2x500 V	S101012	RC3-B1-2-U-22-IUX	1
2x6.2 kW	2	2	2x1000 V	S101016	RC4-A1-2-U-44	1
2x6.2 kW	2	2	2x1000 V	S101017	RC4-A1-2-U-44-S	1
2x6.2 kW	2	2	2x1000 V	S101018	RC4-A1-2-U-44-U	1
6.2+2x3.1 kW	3	3	1000+2x500 V	S101022	RC4-A1-3-U-422	1
6.2+2x3.1 kW	3	3	1000+2x500 V	S101023	RC4-A1-3-U-422-S	1
6.2+2x3.1 kW	3	3	1000+2x500 V	S101024	RC4-A1-3-U-422-U	1

Solutions for grounded PV systems

- Rated string input current (I_{sc}) up to ca. 8.65 A
- Installed MCBs 10A, characteristic C
- IP65 consumer unit usable also for outdoor mounting
- In the scope of delivery: assembled and wired consumer unit with transparent door (devices, wires, PE terminals, type label, output test protocol, mounting material and instructions, multilanguage stickers, cable glands and MC4 connectors).

Max.input power	Input strings	Outputs	Input voltage	Article No.	Type	Packing
3.1 kW	1	1	500 V	S101001	RC2-A1-1-G-2	1
3.1 kW	1	1	500 V	S101002	RC2-A1-1-G-2-S	1
3.1 kW	1	1	500 V	S101003	RC2-A1-1-G-2-U	1
2x3.1 kW	2	1	2x500 V	S101007	RC3-B1-2-G-22-I	1
2x3.1 kW	2	1	2x500 V	S101008	RC3-B1-2-G-22-ISX	1
2x3.1 kW	2	1	2x500 V	S101009	RC3-B1-2-G-22-IUX	1
2x6.2 kW	2	2	2x1000 V	S101013	RC4-A1-2-G-44	1
2x6.2 kW	2	2	2x1000 V	S101014	RC4-A1-2-G-44-S	1
2x6.2 kW	2	2	2x1000 V	S101015	RC4-A1-2-G-44-U	1
6.2+2x3.1kW	3	3	1000+2x500 V	S101019	RC4-A1-3-G-422	1
6.2+2x3.1kW	3	3	1000+2x500 V	S101020	RC4-A1-3-G-422-S	1
6.2+2x3.1kW	3	3	1000+2x500 V	S101021	RC4-A1-3-G-422-U	1

Other variants or configurations are possible upon a request, based on a quantity required.

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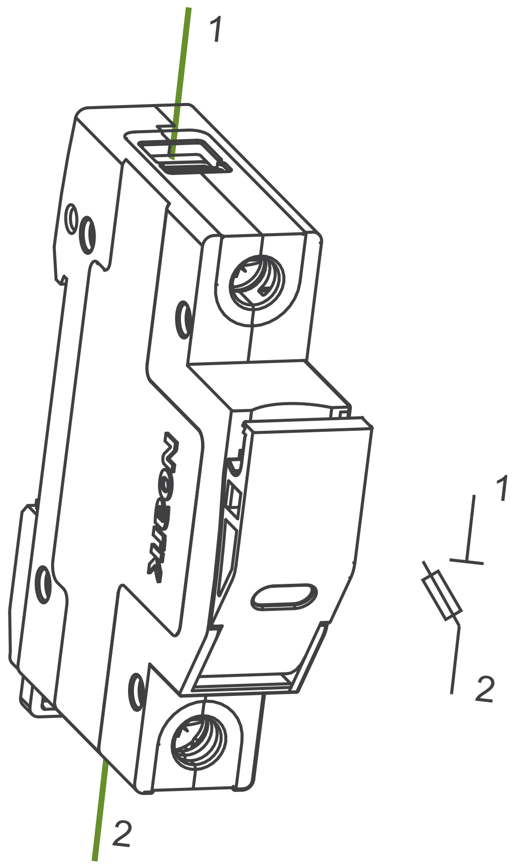
Technical information



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RC pre-wired DC boards 92

Technical Data Ex9BP

DC Miniature Circuit Breakers up to 63 A

General parameters

Non-polarized, suitable for general DC as well as Photovoltaic applications		
Accessories		
Auxiliary contacts	AX3111, AX3122	100540, 100542
Alarm contact	AL3111	100541
Auxiliary and alarm contact	AXL31	100543
Shunt trip releases	SHT31, SHT3111	100544-100546, 100547-100549
Undervoltage releases	UVT31, UVT3101, UVT3110	100550-100551, 100552-100553, 100554-100555
Max. number of installed accessories is 3 pcs of one contact units (AX3111, AL3111) or 2 pcs of two contact units (AX3122, AXL31) and 2 pcs of releases (SHT31, UVT31)		

Electrical parameters

Tested according to	IEC / EN 60947-2
Rated op. voltage U_e	250 (1P), 500 (2P), 750 (3P), 1000 V DC (4P)
Rated breaking capacity I_{cu}	6 kA (Ex9BP-N), 10 kA (Ex9BP-H)
Rated current I_n	10 — 63 A
Tripping characteristics	C, K
Rated impulse withstand voltage U_{imp}	4 kV
Rated insulation voltage U_i	1000 V DC
Mechanical service life	20 000 operation cycles
Electrical service life	10 000 operation cycles
Selectivity class	3
Line voltage connection	arbitrary above or below

Mechanical parameters

Device width	18 mm (per pole/module)
Device height	83 mm (89 mm including rail clip)
Frame size	45 mm
Mounting	easy fastening onto 35 mm device rail (DIN)
Degree of protection	IP40, IP20 terminals
Terminals	combined lift + open mouthed
Terminal capacity	1 — 35 mm^2
Fastening torque of terminals	2 — 3.5 Nm
Busbar thiskness	0.8 — 2 mm
Ambient temperature	-20 — +70 °C
Altitude	≤ 5000 m
Relative humidity	≤ 95 %
Resistance to humidity and heat	class 2
Pollution degree	3
Installation class	III
Weight	0.12 kg (per pole/module)

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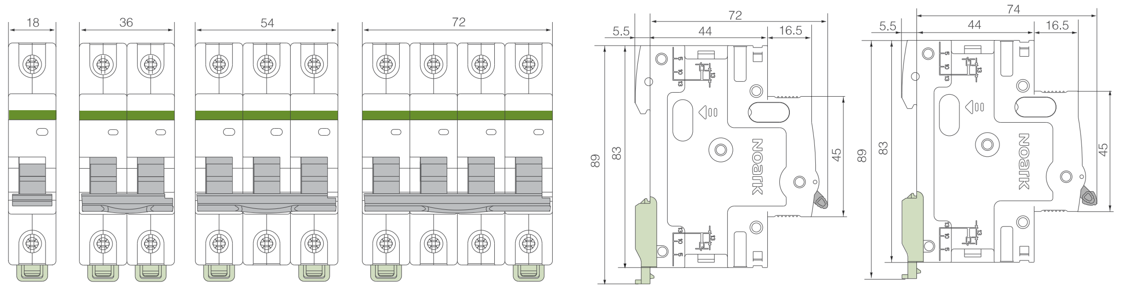
Technical Data Ex9BP

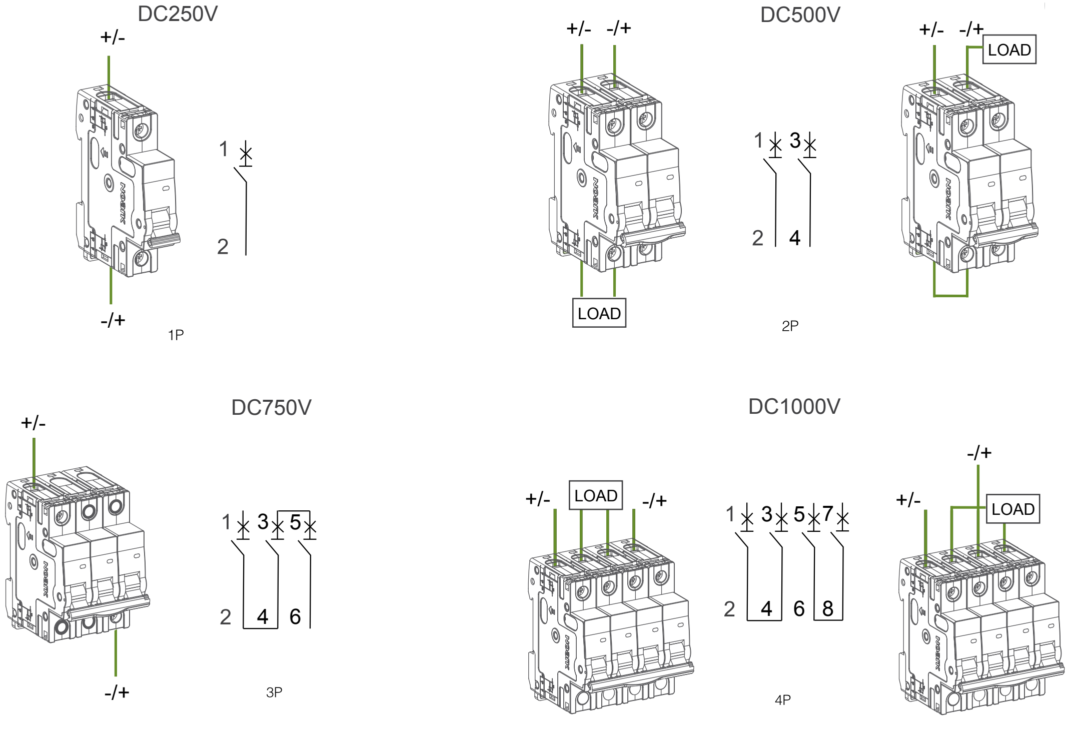
DC Miniature Circuit Breakers up to 63 A

Dimensions



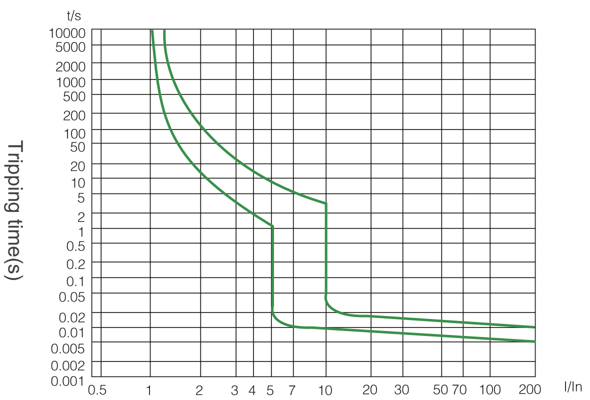
1P 2P 3P 4P 1P 2P, 3P, 4P

Wiring diagrams

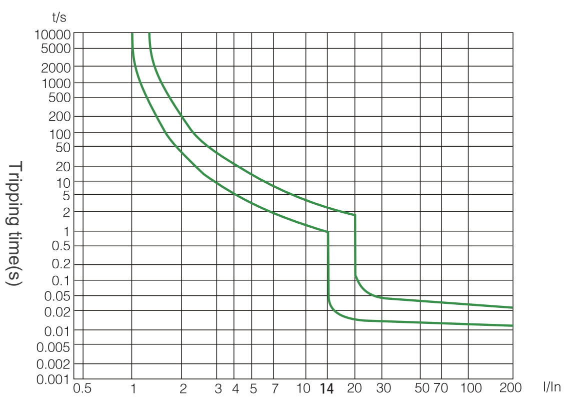


Tripping characteristics

Characteristic C



Characteristic K



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Technical Data Ex9BP

DC Miniature Circuit Breakers up to 63 A

Dependence of Tripping Characteristics on Ambient Temperature

T [°C]	10 A	13 A	16 A	20 A	25 A	32 A	40 A	50 A	63 A
-20	13.5	17	20	24.5	29.8	39.5	50.5	60	77.5
-15	13.3	16.8	19.8	24.3	29.7	39.3	50.4	59.8	76.3
-10	13	16.5	19.5	24	29.5	39	50.2	59.5	75
-5	12.7	16.1	19.2	23.8	29.3	38.8	50	59.2	73
0	12.5	15.8	19.1	23.7	29.2	38.6	48.8	59	71.8
5	12.3	15.5	18.8	23.5	29	38.4	48.6	58.8	70.6
10	12.1	15.2	18.6	23.3	28.8	38.2	48.4	56.5	69
15	12	14.9	18.5	23.1	28.6	38	48.1	55	67.5
20	11.8	14.7	18.3	22.8	28.4	37.8	47.8	54.5	66.2
25	11.5	14.1	18	22.6	28.2	37.5	47	52.5	64.5
30	10	13	16	20	25	32	40	50	63
35	9.9	12.8	15.7	19.7	24.6	31.5	39.2	48.8	61.5
40	9.8	12.5	15.4	19.3	24.3	31.1	38.8	47	58.7
45	9.8	12.2	15.1	18.8	24	30.8	38.3	45.5	55.8
50	9.6	11.7	14.9	18.5	23.8	30.1	38	44	53.5
55	9.5	11.5	14.7	18.2	23.5	29.5	36.5	42.5	51.7
60	9	11.2	14.5	17.8	23	28.5	35	41.5	49.2
65	8.6	11	14	17.5	22	27.5	34	40.5	47.9
70	8	10.8	13.8	17.3	21.5	27	32.5	38	46.8

Ordering data p. 33

Technical Data Ex9FP

DC Fuse Disconnectors

General parameters

For protecting against overload and short-circuit current in direct current and PV applications
Modular design, width 1 MU per pole
Fuse fault indicator
Fuse disconnector cannot be operated by unskilled person (EN 60947-3)

Electrical parameters

Tested according to	IEC/EN 60947-3
Rated operating voltage U_e	1000 V DC
Rated current I_e DC-20B 1000 V DC	up to 30 A
Number of poles	1, 2
Rated insulation voltage U_i	1000 V DC
Rated impulse withstand voltage U_{imp}	6 kV
Utilization category	DC-20B
Rated short-time breaking capacity	33 kA (30 kA from 20A)
Rated conditional short-circuit current	20 kA
Maximum power loss of fuse link	4 W

Mechanical parameters

Device width	18 mm (per pole)
Device height	83 mm (89 mm including rail clip)
Frame size	45 mm
Mounting	easy fastening onto 35 mm device rail (DIN)
Degree of protection	IP20
Terminal capacity	2.5 — 10 mm^2
Ambient temperature	-30 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 95 %
Resistance to humidity and heat	class 2
Pollution degree	3
Installation class	III
Fuse dimension	10 x 38 mm
Weight	0.07 kg per pole

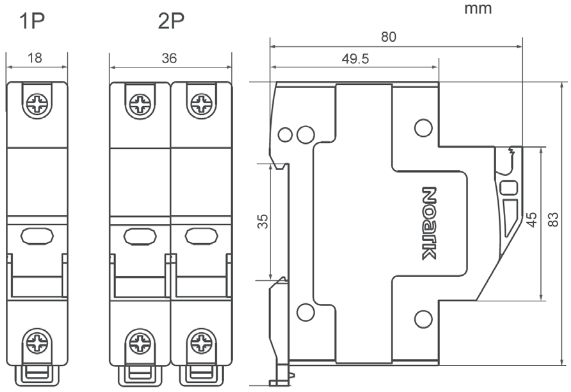
Ordering data p. 39

NOARK

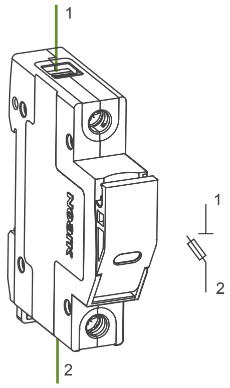
Technical Data Ex9FP

DC Fuse Disconnectors

Dimensions



Wiring diagrams



Ordering data p. 39

Technical Data Ex9UP

DC SPDs class II

General parameters

Suitable for photovoltaic applications
Modular device, plug-in module design
Indication window help users to know the status of device
Optional remote-signaling contact

Electrical parameters

	Ex9UP 40(R) 1P 500V	Ex9UP 40(R) 1P/3P 1000V
Open voltage $U_{oc\ max}$	500 V DC	1000 V DC
SPD class according to	IEC 61643-1 / EN 61643-11	
Classified test	II (C, T2)	
Max continuous operational voltage U_c	500 V DC	1000 V DC
Rated nominal discharge current I_n	20 kA (8/20 µs)	
Max impulse current I_{max}	40 kA (8/20 µs)	
Protection voltage U_p	2.0 kV	3.8 kV
Remote contact op. voltage	250 V AC / 30 V DC	
Remote contact op. current	1 A	

Mechanical parameters

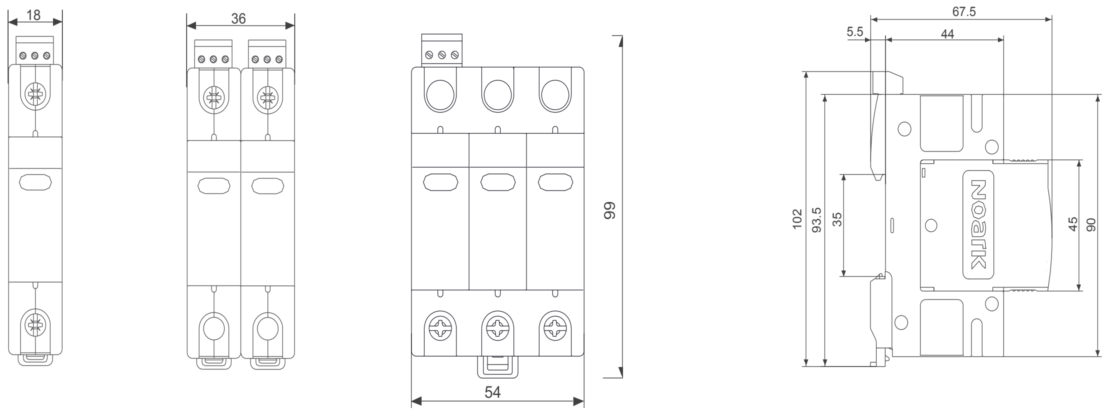
Device width	18 mm (per pole/module)
Device height	83 mm (89 mm including rail clip)
Frame size	45 mm
Mounting	easy fastening onto 35 mm device rail (DIN)
Degree of protection	IP40, terminals IP20
Terminals	M5 screws
Terminal capacity	4 — 25 mm^2
Fastening torque of terminals	3.5 Nm
Ambient temperature	-30 — +70 °C
Altitude	≤ 2000 m
Relative humidity	30 — 90 %
Weight	0.12 kg (per pole/module)

Ordering data p. 41

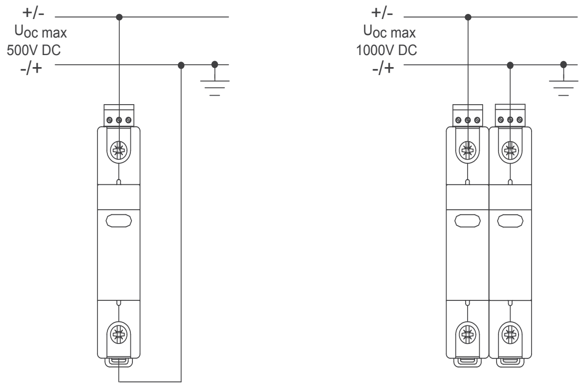
Technical Data Ex9UP

DC SPDs class II

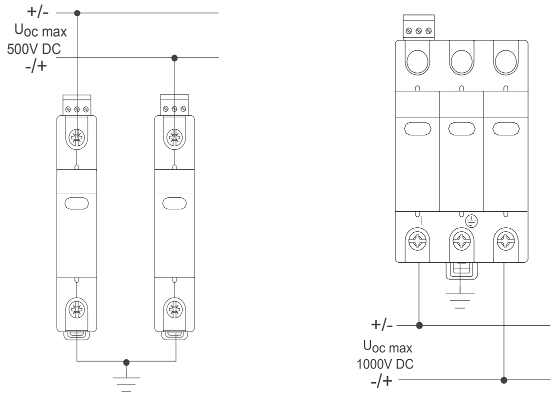
Dimensions



Wiring diagrams - grounded systems



Wiring diagrams - ungrounded systems



Ordering data p. 41

Technical Data Ex9IP

Modular DC isolators up to 63 A

General parameters

Main switches with isolation function suitable for direct current and Photovoltaic applications
Non-polarized
Modular design, DIN-rail mounting
Max. number of installed accessories is 3 pcs of one contact units (AX3111) or 2 pcs of two contact units (AX3122) and 2 pcs of releases (SHT31, UVT31)

Electrical parameters

Tested according to	IEC/EN 60947-3
Rated operating voltage U_e	250 (1P), 500 (2P), 750 (3P), 1000 V DC (4P)
Rated current I_e	16, 32, 50, 63 A
Module width	1, 2, 3, 4
Utilization category	DC-22B
Rated insulation voltage U_i	1000 V
Rated impulse withstand voltage U_{imp}	6 kV
Rated short-time withstand current I_{cw}, 1 s	12 x I_e
Rated short-circuit making capacity I_{cm}	20 x I_e
Mechanical service life	20 000 operation cycles
Electrical service life	2 000 operation cycles

Mechanical parameters

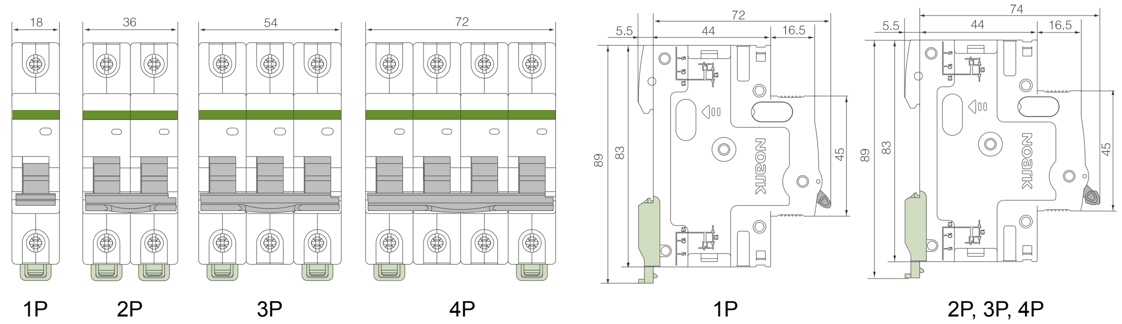
Device width	18 mm (per pole/module)
Device height	83 mm (89 mm including rail clip)
Frame size	45 mm
Mounting	easy fastening onto 35 mm device rail (DIN)
Degree of protection	IP40, terminals IP20
Terminals	combined lift + open mouthed
Terminal capacity	10 — 35 mm^2
Fastening torque of terminals	2 — 3.5 nm
Busbar thiskness	0.8 — 2 mm
Ambient temperature	-30 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 95 %
Resistance to humidity and heat	class 2
Pollution degree	3
Installation class	III
Weight	0.12 kg (per pole/module)

Ordering data p. 43

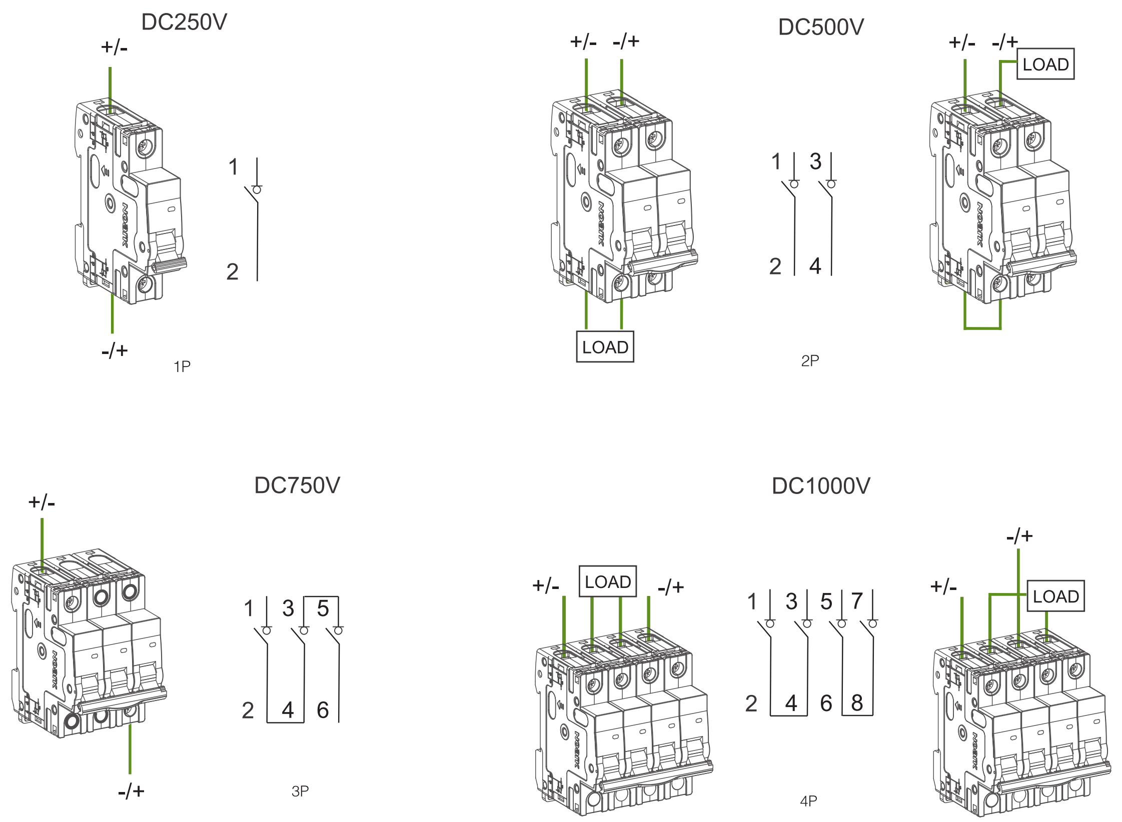
Technical Data Ex9IP

Modular DC isolators up to 63 A

Dimensions



Wiring diagrams



Ordering data p. 43

Technical Data Ex9MD1

DC Moulded Case Circuit Breakers up to 125 A

General parameters

Suitable for PV and similar applications		
Thermal release adjustable (0.8-0.9-1) x I_n		
Instantaneous short-circuit current release fixed 10 x I_n		
Internal accessories		
Auxiliary contact unit	AX21	101395
Alarm contact unit	AL21	101396
Shunt trip releases	SHT21	101397-101405
Undervoltage releases	UVT21	101406-101407
Max. number of installed internal accessories is 2 pcs of AX21, 1 pc of AL21 and 1 pc of a release (SHT21 or UVT21)		
External accessories		
Direct rotary handle	RHD21	101410
Extended rotary handle	ERH21	101409
Remote motor operators	MOD21	101411-101415
Terminal cover set, short	TCV21 3P, TCV21 4P	101439, 102372
Terminal cover set, long	TCE21 3P, TCE21 4P	101440, 102373
Phase barrier set	PB21 3P, PB21 4P	101441, 102398
Connection terminals	MC21	103705-103708
Mounting screws, interconnection busbars as well as phase barriers in the scope of delivery		

Electrical parameters

	Ex9MD1B	Ex9MD1S	Ex9MD1N	Ex9MD1H
Tested according to	IEC/EN 60947-2			
Rated op. voltage U_e	750 (3P),1000 V DC (4P)			
Rated insulation voltage U_i	1000 V			
Rated impulse withstand voltage U_{imp}	8 kV			
Rated ultimate short-circuit breaking capacity I_{cu}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated service short-circuit breaking capacity I_{cs}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated short-circuit making capacity I_{cm}	52.5 kA / 1000 V DC	75.6 kA / 1000 V DC	105 kA / 1000 V DC	220kA / 1000 V DC
Rated current	16 — 125 A			
Overvoltage category	III			
Utilization category	A			
Mechanical service life	15 000 operation cycles			
Electrical service life	5 000 operation cycles			
Maximum frequency of switch. cycles	120 cycles pes hour			
Total disconnection time at short circuit	< 2 ms			
Power loss per pole at 125 A	12.5 W			

Ordering data p. 47

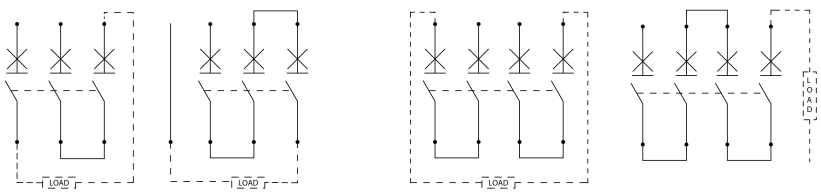
Technical Data Ex9MD1

DC Moulded Case Circuit Breakers up to 125 A

Mechanical parameters

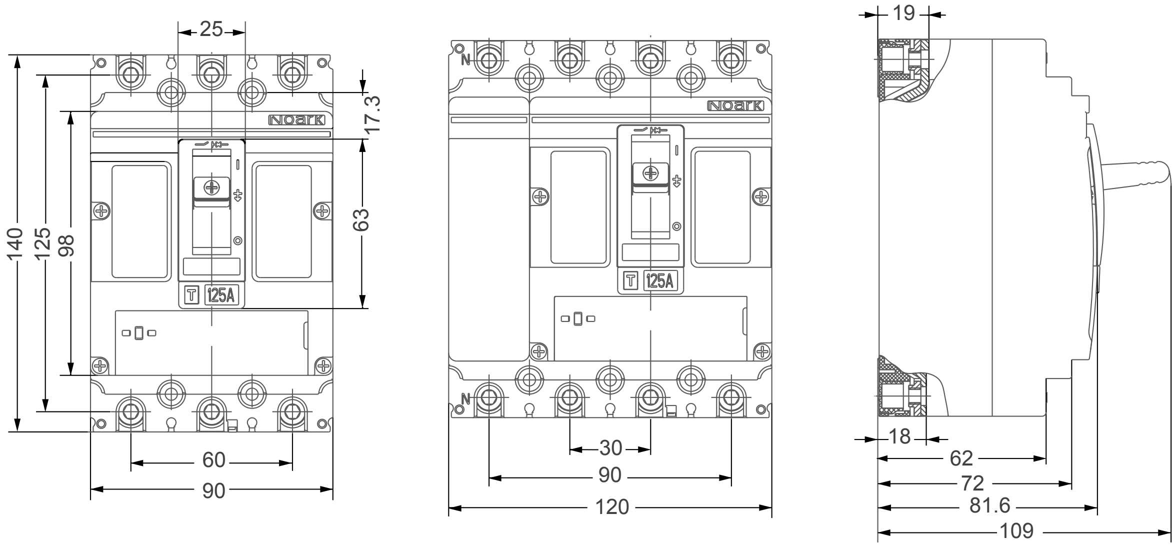
Device width (3P / 4P)	90 mm / 120 mm
Device height	140 mm
Device depth	81.6 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M6 screws
Busbar thickness	≤ 4 mm
Busbar width	≤ 14.2 mm
Cable lug width	≤ 14.2 mm
Fastening torque of terminals	8 — 10 Nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	1.2 kg / 1.7 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram



3P 4P

Dimensions

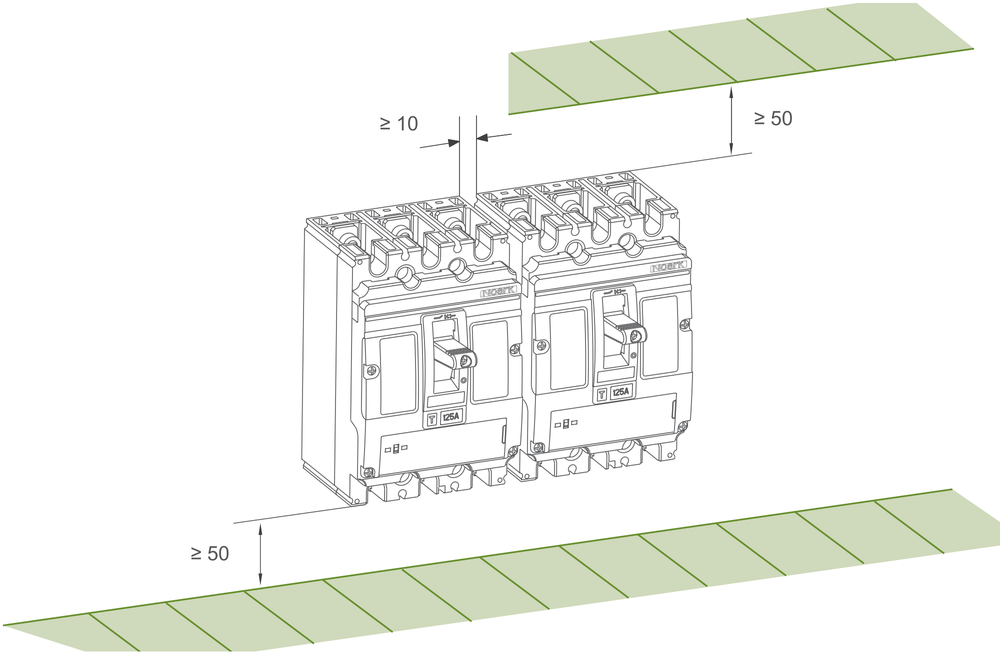


Ordering data p. 47

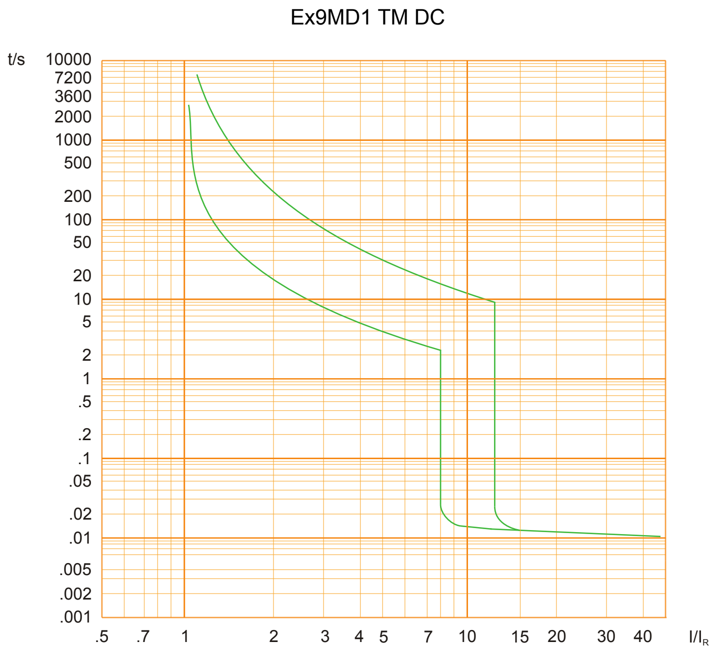
Technical Data Ex9MD1

DC Moulded Case Circuit Breakers up to 125 A

Installation space



Tripping characteristic



Ordering data p. 47

Technical Data Ex9MD2

DC Moulded Case Circuit Breakers up to 250 A

General parameters

Suitable for PV and similar applications		
Thermal release adjustable (0.8-0.9-1) x I_n		
Instantaneous short-circuit current release (5-6-7-8-9-10) x I_n		
Internal accessories		
Auxiliary contact unit	AX21	101395
Alarm contact unit	AL21	101396
Shunt trip releases	SHT22	101416-101424
Undervoltage releases	UVT22	101425-101426
Max. number of installed internal accessories is 2 pcs of AX21, 1 pc of AL21 and 1 pc of a release (SHT22 or UVT22)		
External accessories		
Direct rotary handle	RHD22	101429
Extended rotary handle	ERH22	101428
Remote motor operators	MOD22	101430-101434
Terminal cover set, short	TCV22 3P, TCV22 4P	101442, 102374
Terminal cover set, long	TCE22 3P, TCE22 4P	101443, 102375
Phase barrier set	PB22 3P, PB22 4P	101444, 102399
Connection terminals	MC22	103709-103714
Mounting screws, interconnection busbars as well as phase barriers in the scope of delivery		

Electrical parameters

	Ex9MD2B	Ex9MD2S	Ex9MD2N	Ex9MD2H
Tested according to	IEC/EN 60947-2			
Rated op. voltage U_e	750 (3P), 1000 V DC (4P)			
Rated insulation voltage U_i	1000 V			
Rated impulse withstand voltage U_{imp}	8 kV			
Rated ultimate short-circuit breaking capacity I_{cu}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated service short-circuit breaking capacity I_{cs}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated short-circuit making capacity I_{cm}	52.5 kA / 1000 V DC	75.6 kA / 1000 V DC	105 kA / 1000 V DC	220kA / 1000 V DC
Rated current	125 — 250 A			
Overvoltage category	III			
Utilization category	A			
Mechanical service life	15 000 operation cycles			
Electrical service life	5 000 operation cycles			
Maximum frequency of switch. cycles	120 cycles per hour			
Total disconnection time at short circuit	< 2 ms			
Power loss per pole at 250 A	25 W			

Ordering data p. 52

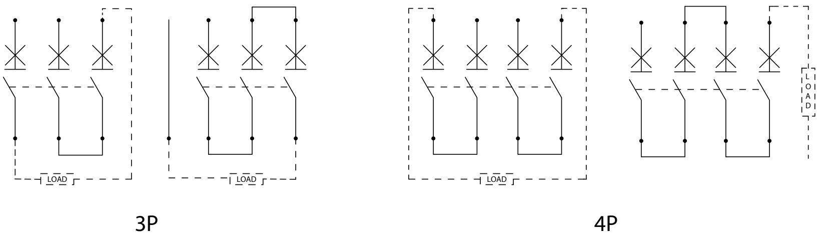
Technical Data Ex9MD2

DC Moulded Case Circuit Breakers up to 250 A

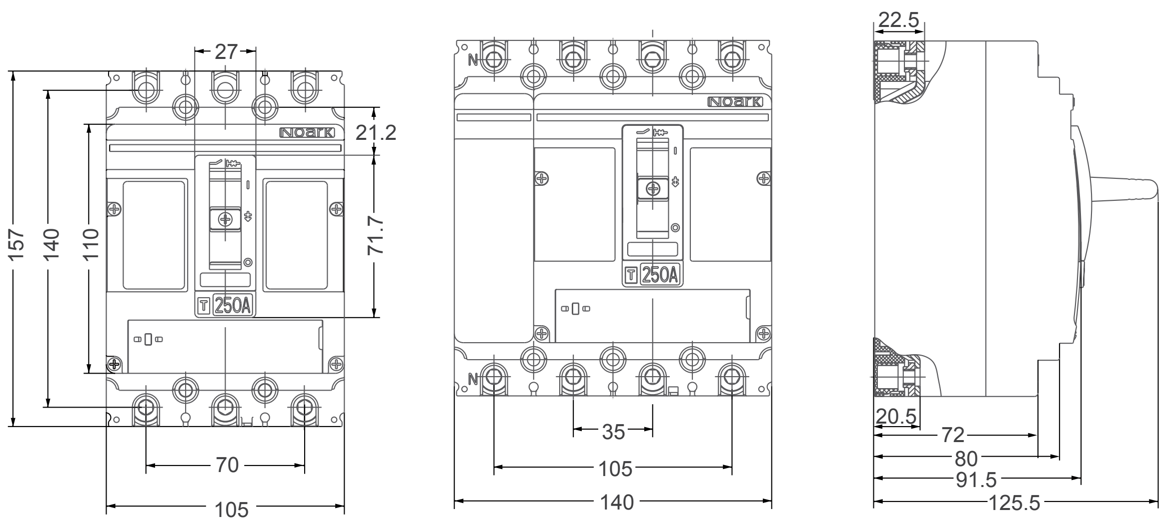
Mechanical parameters

Device width (3P / 4P)	105 mm / 140 mm
Device height	157 mm
Device depth	91.5 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M8 screws
Busbar thickness	≤ 6 mm
Busbar width	≤ 25 mm
Cable lug width	≤ 25 mm
Fastening torque of terminals	8 — 10 Nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	1.7 / 2.2 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram



Dimensions

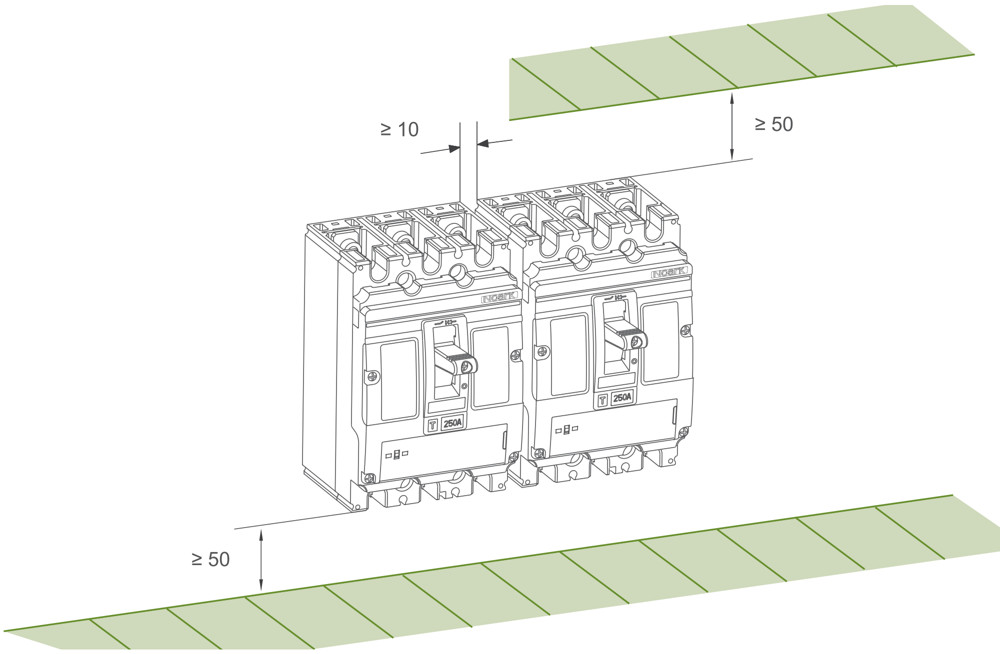


Ordering data p. 52

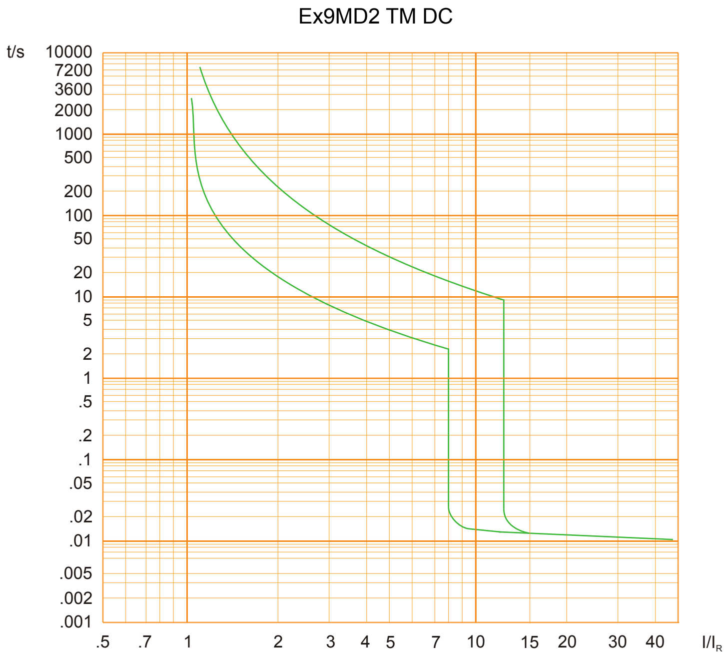
Technical Data Ex9MD2

DC Moulded Case Circuit Breakers up to 250 A

Installation space



Tripping characteristic



Ordering data p. 52

Technical Data Ex9MD3

DC Moulded Case Circuit Breakers up to 400 A

General parameters

Suitable for PV and similar applications		
Thermal release adjustable (0.8-0.9-1) x I_n		
Instantaneous short-circuit current release (5-6-7-8-9-10) x I_n		
Internal accessories		
Auxiliary contact unit	AX21	101395
Alarm contact unit	AL21	101396
Shunt trip releases	SHT22	101416-101424
Undervoltage releases	UVT22	101425-101426
Max. number of installed internal accessories is 3 pcs of AX21, 1 pc of AL21 and 1 pc of a release (SHT22 or UVT22)		
External accessories		
Direct rotary handle	RHD23	101429
Extended rotary handle	ERH23	101428
Remote motor operators	MOD23	101430-101434
Terminal cover set, short	TCV23 3P, TCV23 4P	101442, 102376
Terminal cover set, long	TCE23 3P, TCE23 4P	101443, 102377
Phase barrier set	PB23 3P, PB23 4P	101444, 102340
Connection terminals	MC23	103715-103722
Mounting screws, interconnection busbars, spreaders as well as phase barriers in the scope of delivery		

Electrical parameters

	Ex9MD3B	Ex9MD3S	Ex9MD3N	Ex9MD3H
Tested according to	IEC/EN 60947-2			
Rated op. voltage U_e	750 (3P), 1000 V DC (4P)			
Rated insulation voltage U_i	1000 V			
Rated impulse withstand voltage U_{imp}	8 kV			
Rated ultimate short-circuit breaking capacity I_{cu}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated service short-circuit breaking capacity I_{cs}	25 kA / 1000 V DC	36 kA / 1000 V DC	50 kA / 1000 V DC	100 kA / 1000 V DC
Rated short-circuit making capacity I_{cm}	52.5 kA / 1000 V DC	75.6 kA / 1000 V DC	105 kA / 1000 V DC	220kA / 1000 V DC
Rated current	250 — 400 A			
Overvoltage category	III			
Utilization category	A			
Mechanical service life	10 000 operation cycles			
Electrical service life	2 000 operation cycles			
Maximum frequency of switch. cycles	60 cycles per hour			
Total disconnection time at short circuit	< 2 ms			
Power loss per pole at 400 A	24 W			

Ordering data p. 54

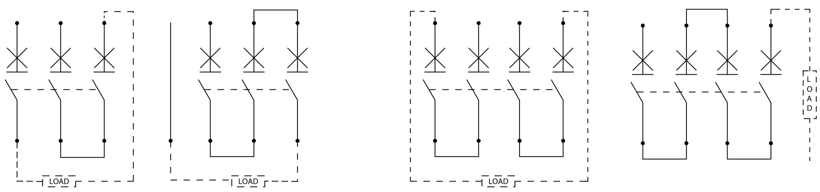
Technical Data Ex9MD3

DC Moulded Case Circuit Breakers up to 400 A

Mechanical parameters

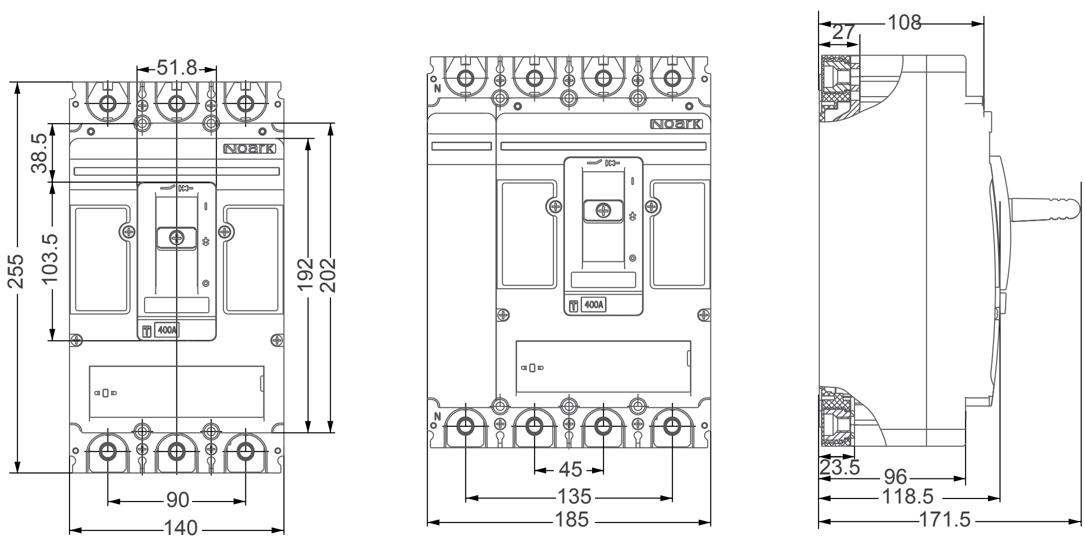
Device width (3P / 4P)	140 mm / 185 mm
Device height	255 mm
Device depth	118.5 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M10 screws
Busbar thickness	≤ 8 mm
Busbar width	≤ 30 mm
Cable lug width	≤ 30 mm
Fastening torque of terminals	70 nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	5 kg / 6.6 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram



3P 4P

Dimensions

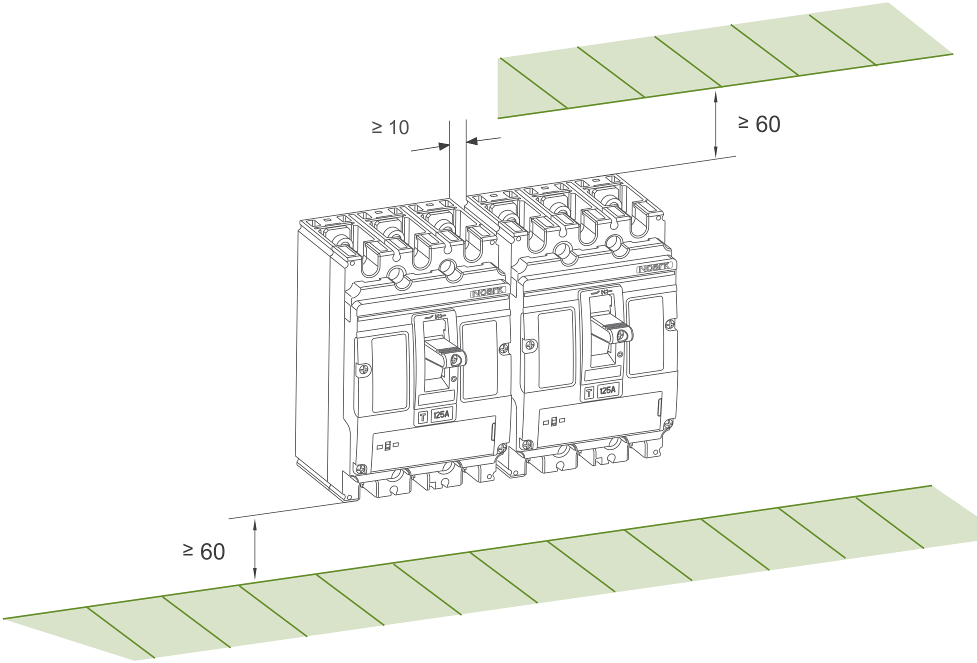


Ordering data p. 54

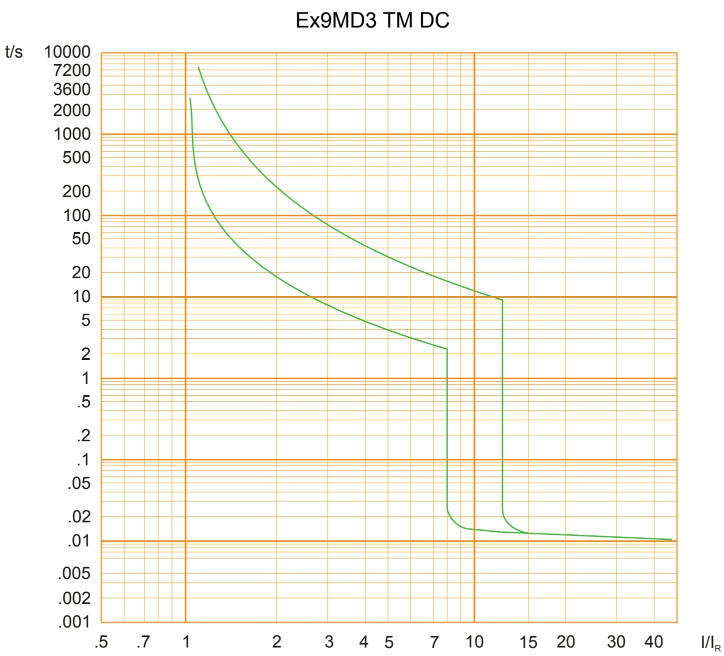
Noark

DC Moulded Case Circuit Breakers up to 400 A

Installation space



Tripping characteristics



Ordering data p. 54

Technical Data Ex9M1SD

MCCB Switch Disconnectors up to 125 A

General parameters

Suitable for PV and similar applications		
Internal accessories		
Auxiliary contact unit	AX21	101395
Shunt trip releases	SHT21	101397-101405
Undervoltage releases	UVT21	101406-101407
Max. number of installed internal accessories is 2 pcs of AX21 and 1 pc of a release (SHT21 or UVT21)		
External accessories		
Direct rotary handle	RHD21	101410
Extended rotary handle	ERH21	101409
Remote motor operators	MOD21	101411-101415
Terminal cover set, short	TCV21 3P, TCV21 4P	101439, 102372
Terminal cover set, long	TCE21 3P, TCE21 4P	101440, 102373
Phase barrier set	PB21 3P, 4P	101441, 104852
Connection terminals	MC21	103705-103708
Mounting screws as well as phase barriers in the scope of delivery		

Electrical parameters

Tested according to	IEC/EN 60947-3
Rated operating voltage U_e	415 / 690 V AC (AC versions) 750 V DC (3P DC version) 1000 V DC (4P DC version)
Rated insulation voltage U_i	1000 V
Rated impulse withstand voltage U_{imp}	8 kV
Rated current I_n	63 — 125 A
Rated short time withstand current I_{cw} 1 s 3 s 20 s	 1800 A 1800 A 700 A
Overvoltage category	III
Utilization category	A
Mechanical service life	15 000 operation cycles
Electrical service life	5 000 operation cycles
Maximum frequency of switch. cycles	120 cycles per hour

Ordering data p. 57

Technical Data Ex9M1SD

MCCB Switch Disconnectors up to 125 A

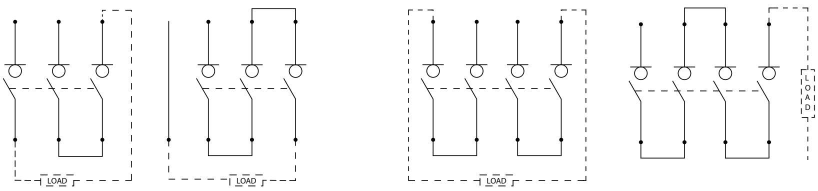
Mechanical parameters

Device width (3P / 4P)	90 mm / 120 mm
Device height	140 mm
Device depth	81.6 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M6 screws
Busbar thickness	≤ 4 mm
Busbar width	≤ 14.2 mm
Cable lug width	≤ 14.2 mm
Fastening torque of terminals	8 — 10 Nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	1.0 kg / 1.5 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram - AC versions

3P 4P

Wiring diagram - DC versions



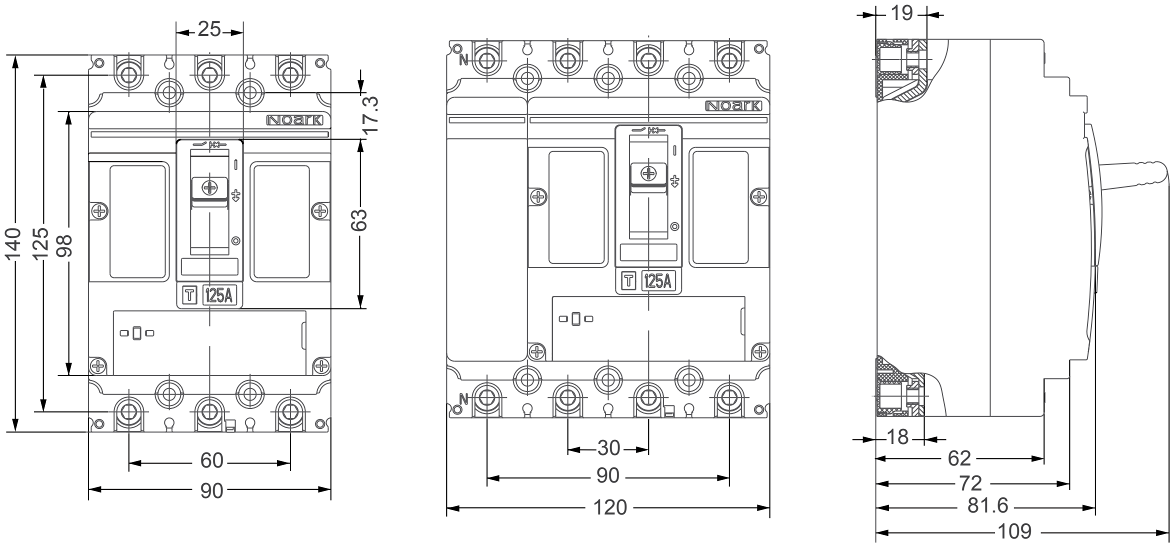
3P 4P

Ordering data p. 57

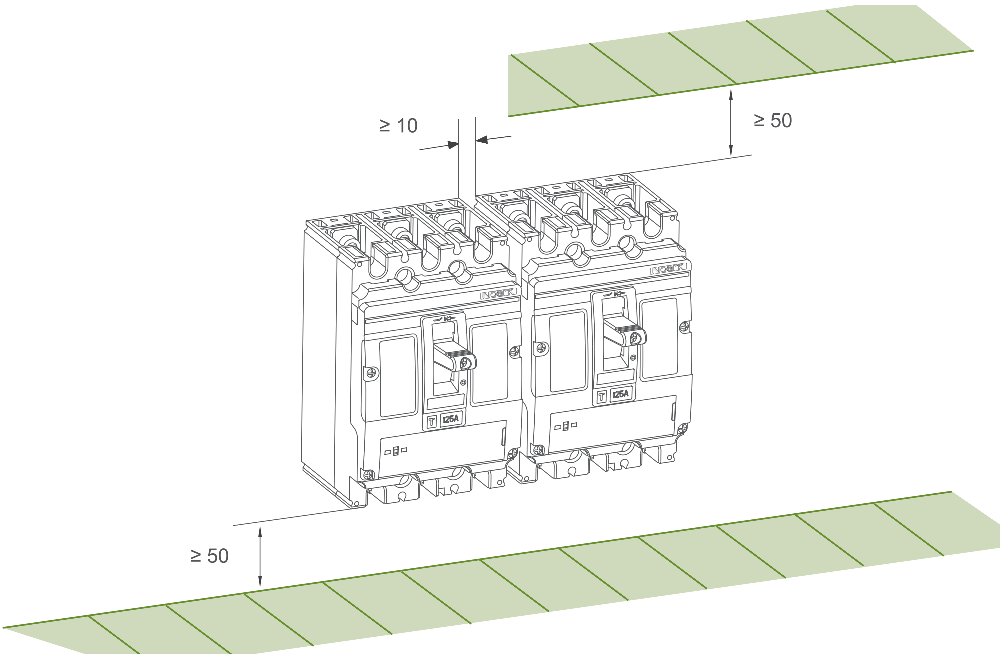
Technical Data Ex9M1SD

MCCB Switch Disconnectors up to 125 A

Dimensions



Installation space



Ordering data p. 57

Technical Data Ex9M2SD

MCCB Switch Disconnectors up to 250 A

General parameters

Suitable for PV and similar applications		
Internal accessories		
Auxiliary contact unit	AX21	101395
Shunt trip releases	SHT22	101416-101424
Undervoltage releases	UVT22	101425-101426
Max. number of installed internal accessories is 2 pcs of AX21 and 1 pc of a release (SHT22 or UVT22)		
External accessories		
Direct rotary handle	RHD22	101429
Extended rotary handle	ERH22	101428
Remote motor operators	MOD22	101430-101434
Terminal cover set, short	TCV22 3P, TCV22 4P	101442, 102374
Terminal cover set, long	TCE22 3P, TCE22 4P	101443, 102375
Phase barrier set	PB22 3P, 4P	101444, 104853
Connection terminals	MC22	103709-103714
Mounting screws as well as phase barriers in the scope of delivery		

Electrical parameters

Tested according to	IEC/EN 60947-3
Rated operating voltage U_e	415 / 690 V AC (AC versions) 750 V DC (3P DC version) 1000 V DC (4P DC version)
Rated insulation voltage U_i	1000 V
Rated impulse withstand voltage U_{imp}	8 kV
Rated current i_n	125 — 250 A
Rated short time withstand current I_{cw} 1 s 3 s 20 s	 3200 A 3200 A 1350 A
Overvoltage category	III
Utilization category	A
Mechanical service life	15 000 operation cycles
Electrical service life	5 000 operation cycles
Maximum frequency of switch. cycles	120 cycles per hour

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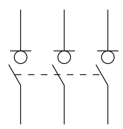
Technical Data Ex9M2SD

MCCB Switch Disconnectors up to 250 A

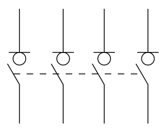
Mechanical parameters

Device width (3P / 4P)	105 mm / 140 mm
Device height	157 mm
Device depth	91.5 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M8 screws
Busbar thickness	≤ 6 mm
Busbar width	≤ 25 mm
Cable lug width	≤ 25 mm
Fastening torque of terminals	8 — 10 Nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	1.5 / 2.0 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram - AC versions

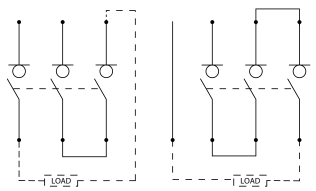


3P

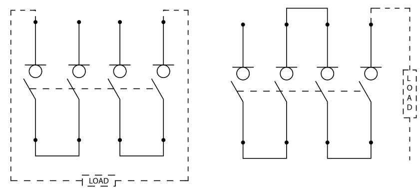


4P

Wiring diagram - DC versions



3P



4P

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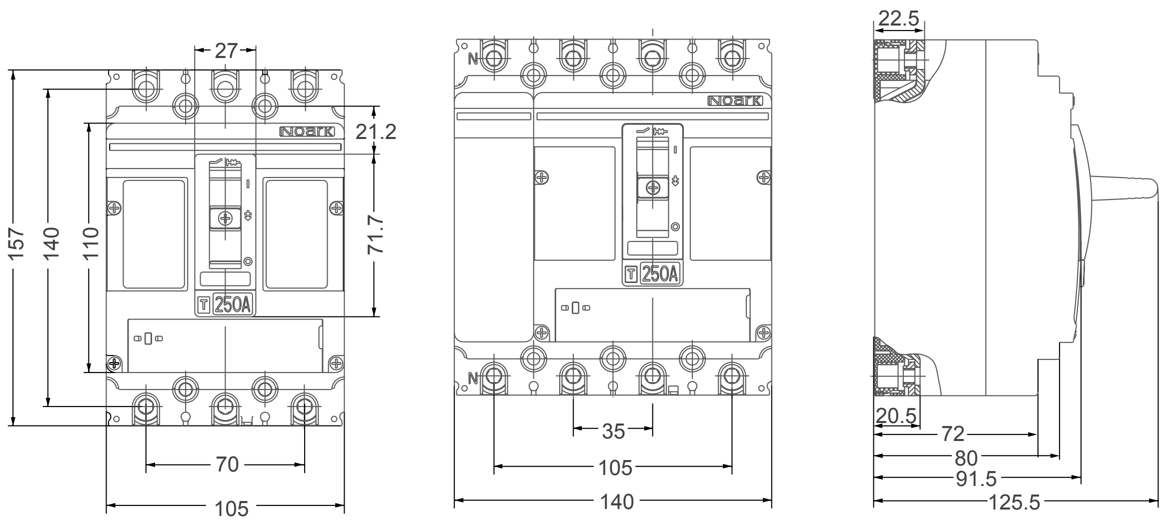
NOARK

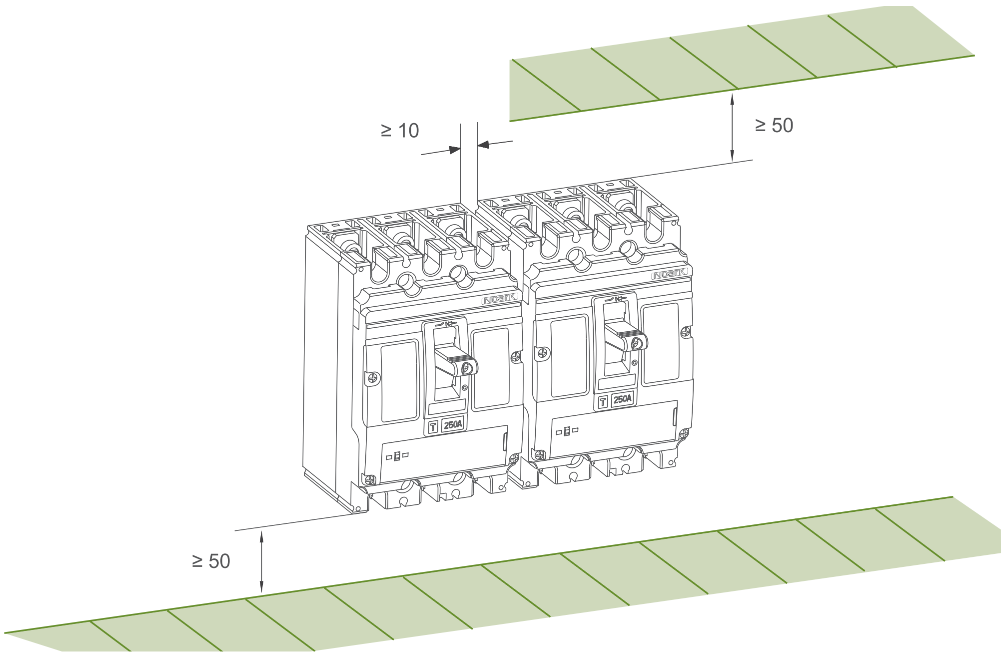
Technical Data Ex9M2SD

MCCB Switch Disconnectors up to 250 A

Dimensions



Installation space



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Technical Data Ex9M3SD

MCCB Switch Disconnectors up to 400 A

General parameters

Suitable for industrial and photovoltaic applications		
Internal accessories		
Auxiliary contact unit	AX21	101395
Shunt trip releases	SHT22	101416-101424
Undervoltage releases	UVT22	101425-101426
Max. number of installed internal accessories is 3 pcs of AX21 and 1 pc of a release (SHT22 or UVT22)		
External accessories		
Direct rotary handle	RHD23	101483
Extended rotary handle	ERH23	101482
Remote motor operators	MOD23	101484-101488
Terminal cover set, short	TCV23 3P, TCV23 4P	101489, 102376
Terminal cover set, long	TCE23 3P, TCE23 4P	101490, 102377
Phase barrier set	PB23 3P, 4P	101491, 104854
Connection terminals	MC23	103715-103722
Mounting screws as well as phase barriers (and interconnection busbars for DC version) in the scope of delivery		

Electrical parameters

Tested according to	IEC/EN 60947-3
Rated operating voltage U_e	415 / 690 V AC (AC versions) 750 V DC (3P DC version) 1000 V DC (4P DC version)
Rated insulation voltage U_i	1000 V
Rated impulse withstand voltage U_{imp}	8 kV
Rated current I_n	250 — 400 A
Rated short time withstand current I_{cw} 1 s 3 s 20 s	 5000 A 5000 A 2400 A
Overvoltage category	III
Utilization category	A
Mechanical service life	10 000 operation cycles
Electrical service life	2 000 operation cycles
Maximum frequency of switch. cycles	60 cycles per hour

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Technical Data Ex9M3SD

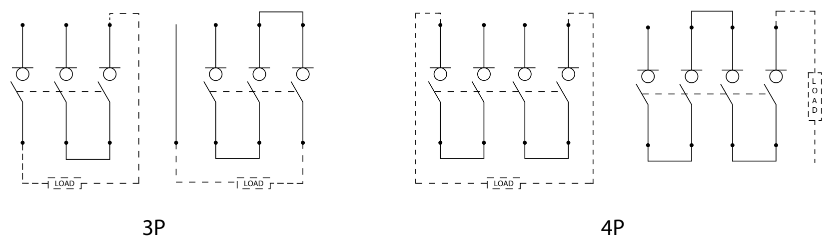
MCCB Switch Disconnectors up to 400 A

Mechanical parameters

Device width (3P / 4P)	140 mm / 185 mm
Device height	255 mm
Device depth	118.5 mm
Mounting	onto panel
Degree of protection	IP40, IP20 terminals
Terminals	M10 screws
Busbar thickness	≤ 8 mm
Busbar width	≤ 30 mm
Cable lug width	≤ 30 mm
Fastening torque of terminals	70 Nm
Ambient temperature	-25 — +70 °C
Altitude	≤ 2000 m
Relative humidity	≤ 50 % at 40 °C, ≤ 90 % monthly average
Resistance to humidity and heat	class 2
Pollution degree	3
Weight (3P / 4P)	4.5 kg / 6 kg
Mounting position	vertical, can be rotated by 90° in each axis

Wiring diagram - AC versions

Wiring diagram - DC versions



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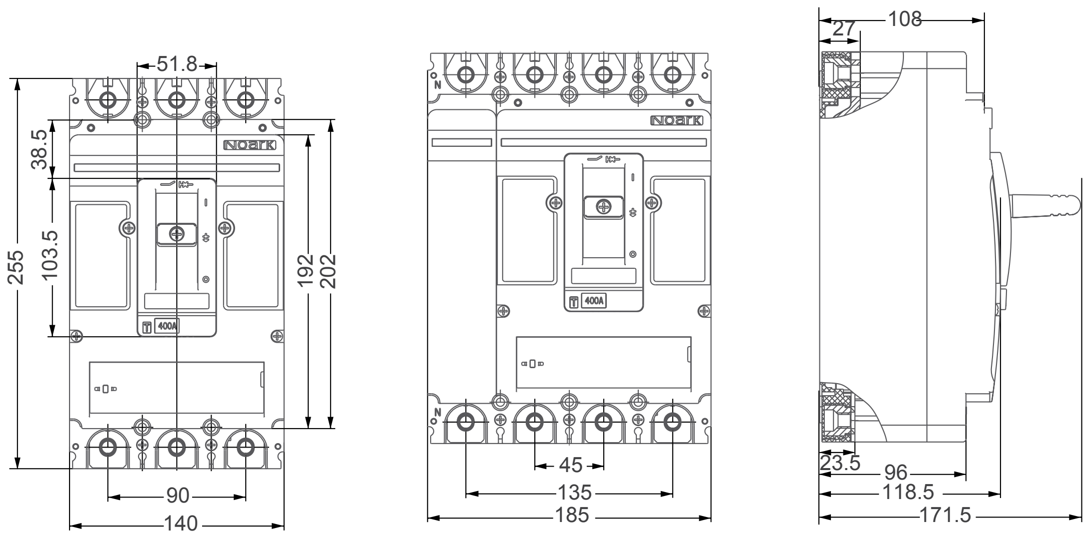
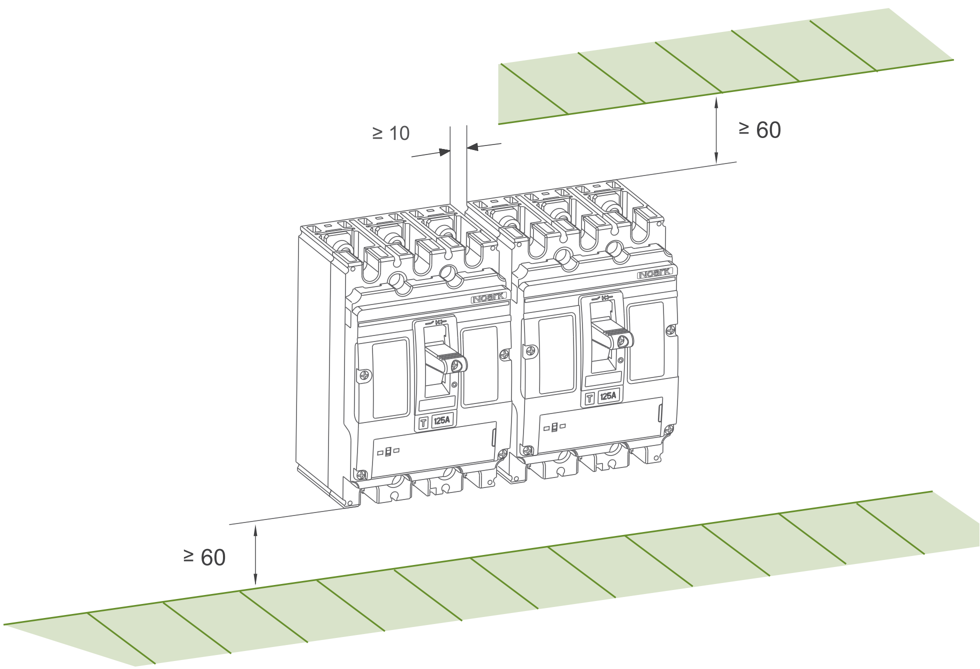
Technical Data Ex9M3SD

MCCB Switch Disconnectors up to 400 A

Dimensions



Installation space



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Technical Data RC

DC boards for PV applications up to 5 kW

General parameters

Assembled pre-wired DC boards for Photovoltaic applications
Surface mounted version of consumer units with transparent door
Output test protocol for every piece
Scope of delivery: assembled and wired consumer unit (devices, busbars, wires, PE terminals, type label), mounting material, mounting instructions, output test protocol, multilanguage stickers, cable glands and MC4 connectors

Electrical parameters

Tested according to	EN 60439-3
Maximum rated current I_n	63 A
Protection class	II
Rated insulating voltage U_i	1000 V DC

Mechanical parameters

Degree of protection	IP 65
Mechanical impact resistance	IK08

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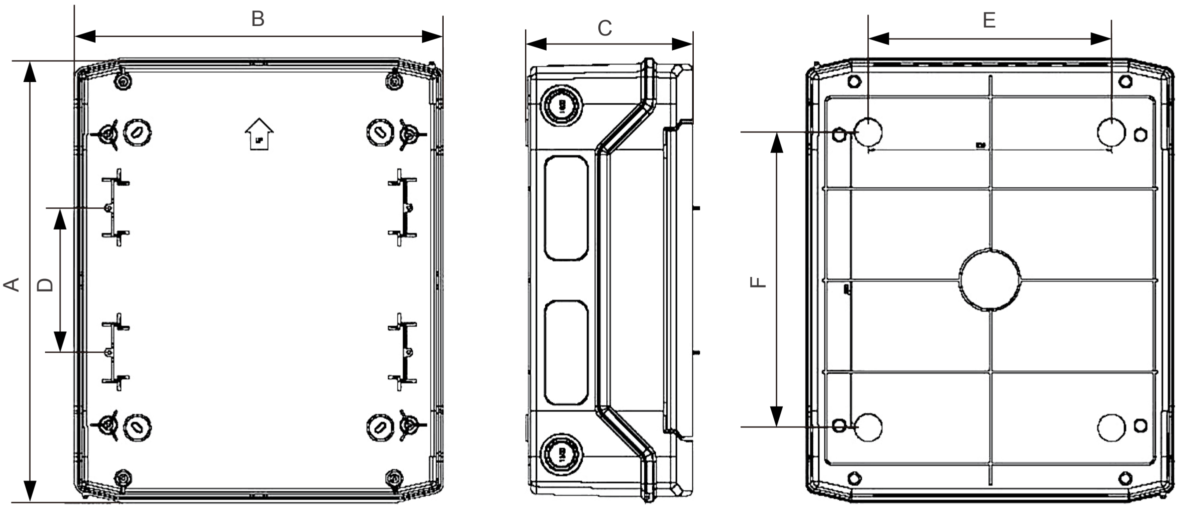
Technical Data RC

DC boards for PV applications up to 5 kW

Dimensional drawings



* all MC4 connectors are mounted on the bottom side of the board

Dimensions

Type	Dimensions [mm]					
	A	B	C	D	E	F
PHS 4T	201	128	120	—	78	111
PHS 8T	201	202	120	—	100	140
PHS 12T	256	319	144	—	210	130
PHS 24T	384	319	144	125	210	255
PHS 36T	535	319	144	125	210	380

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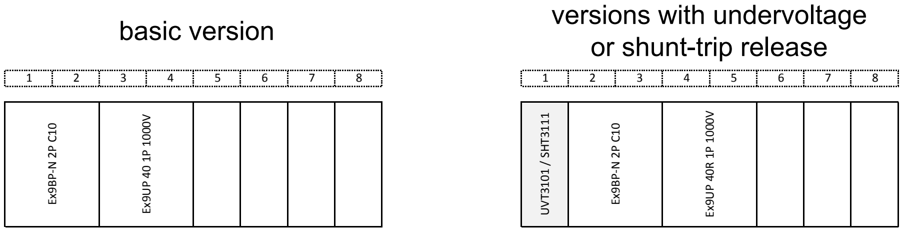
Technical Data RC

DC boards for PV applications up to 5 kW (versions RC2-A1-1)

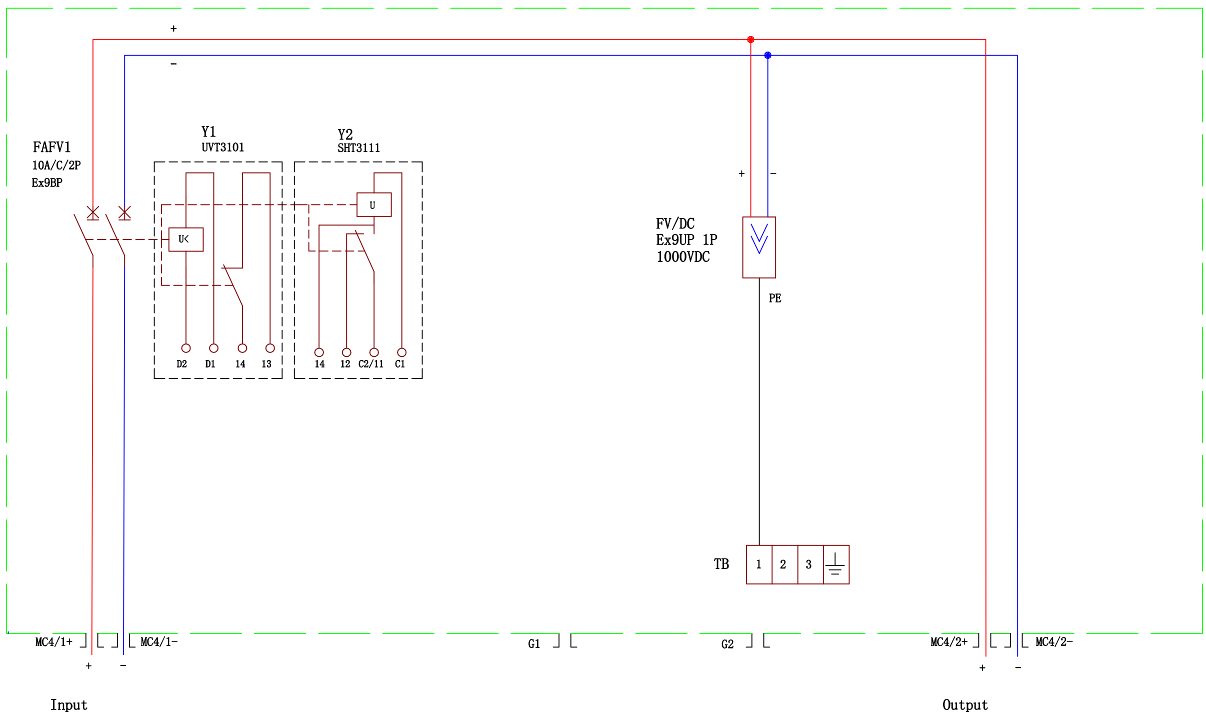
Electrical parameters

Designed for 1 phase inverters	up to 3 kW
Max. input power	3.15 kW (with 230-260 Wp panels)
Input strings	1
Used protection	1x MCB, C characteristic, 10 A
Max. number of panels	approx. 12 per string (based on panel rated voltage)
Outputs	1
Max. input voltage	1x 500 V DC

Block diagram and position of devices



Wiring diagram - RC2-A1-1-U-2. - ungrounded system



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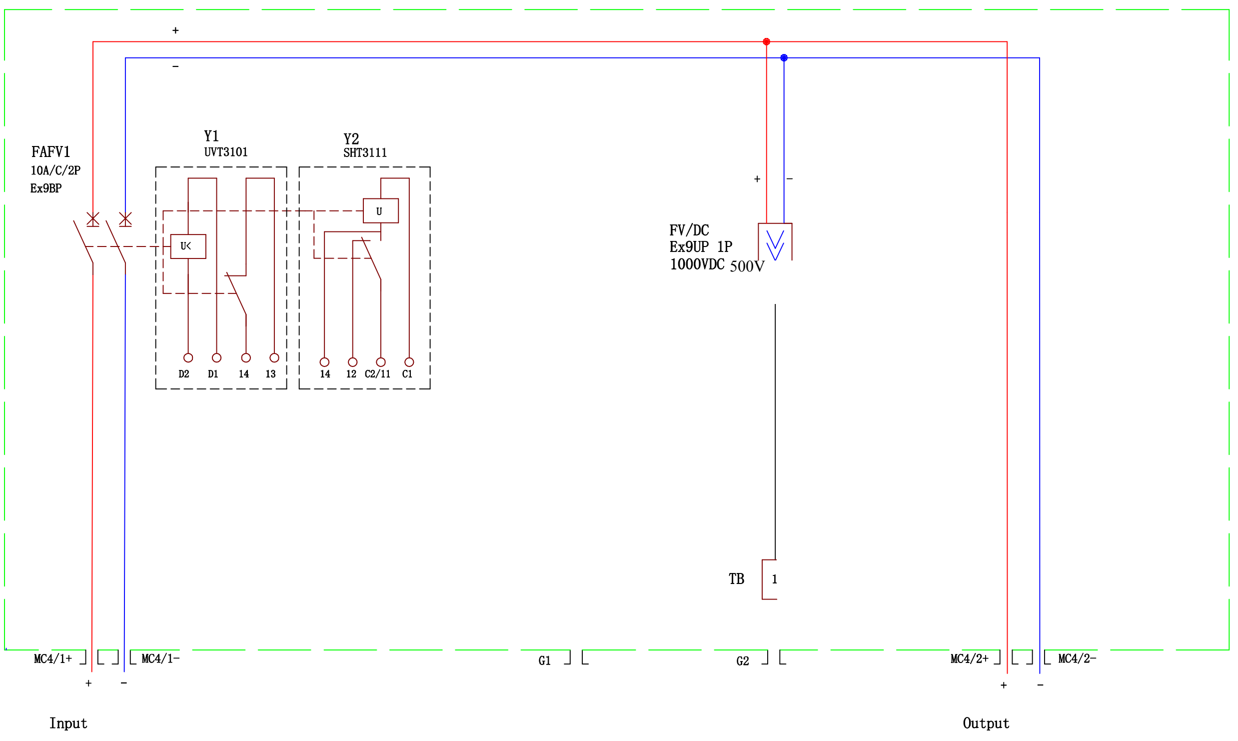
DC boards for PV applications up to 5 kW (versions RC2-A1-1)

Wiring diagram - RC2-A1-1-G-2. - grounded system



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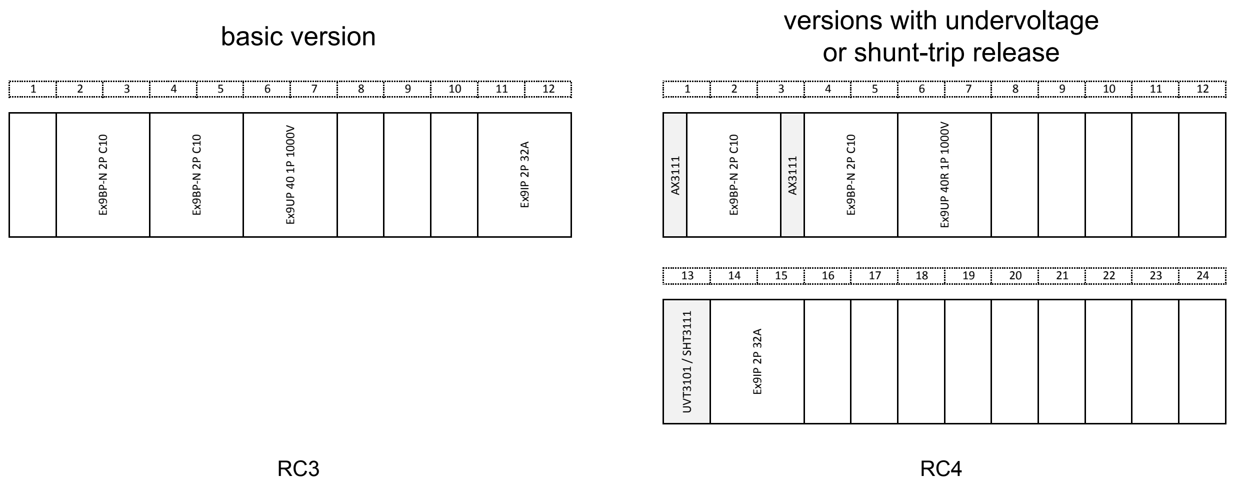
Technical Data RC

DC boards for PV applications up to 5 kW (versions RC.-B1-2)

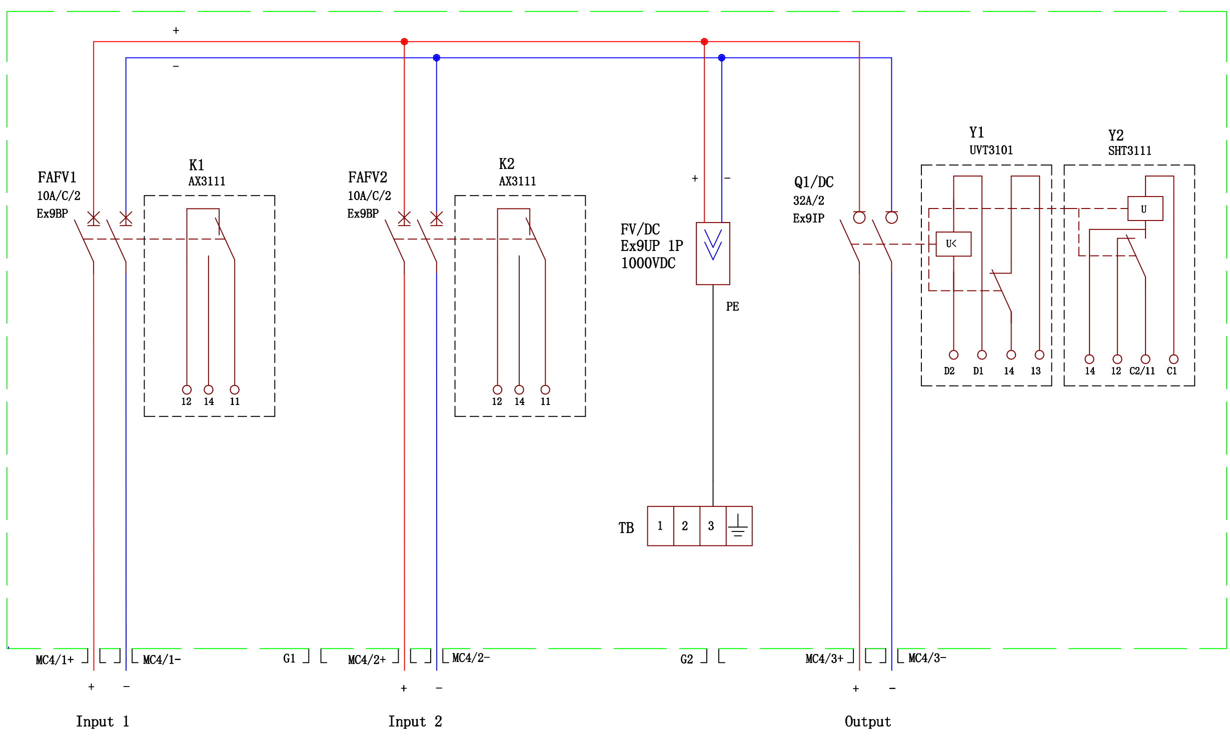
Electrical parameters

Designed for 1 phase inverters	up to 4 kW
Max. input power	3.15 kW per string (with 230-260 Wp panels)
Input strings	2
Used protection	2x MCB, C characteristic, 10 A
Max. number of panels	approx. 12 per string (based on panel rated voltage)
Outputs	1
Max. input voltage	2x 500 V DC

Block diagram and position of devices



Wiring diagram - RC.-B1-2-U-22-I. - ungrounded system



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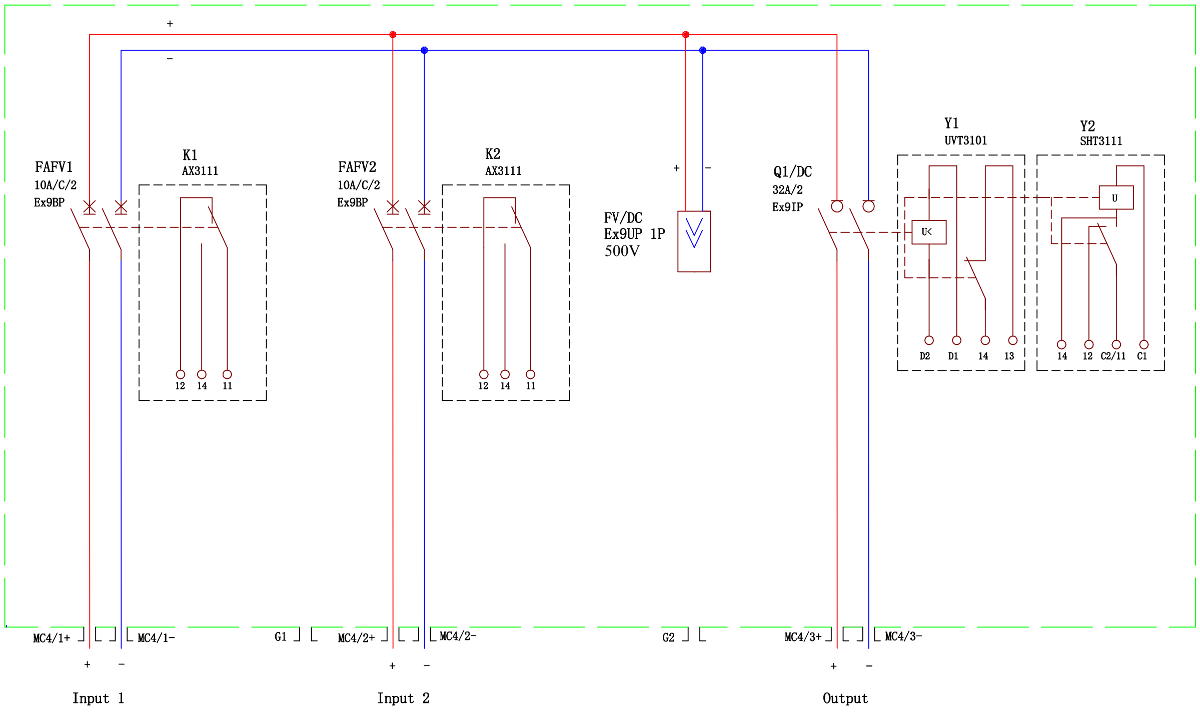
DC boards for PV applications up to 5 kW (versions RC.-B1-2)

Wiring diagram - RC.-B1-2-G-22-I. - grounded system



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DC boards for PV applications up to 5 kW (versions RC4-A1-2)

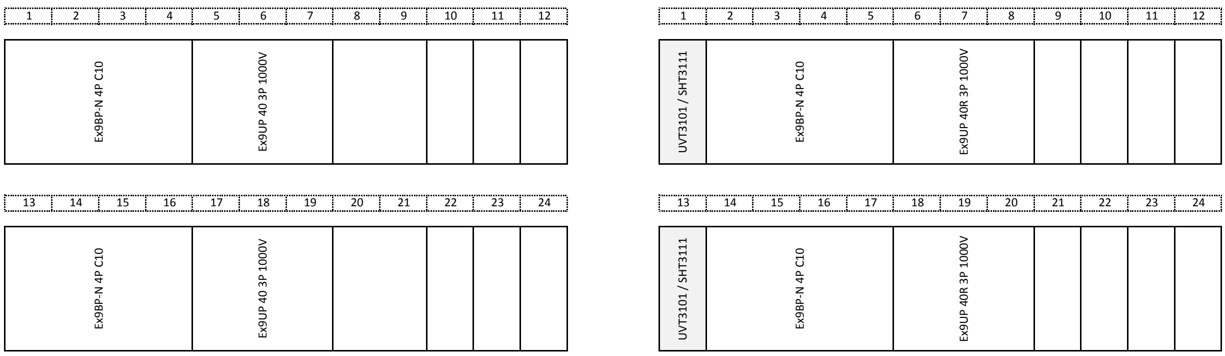
Electrical parameters

Designed for 1 phase inverters	up to 5 kW
Max. input power	6.2 kW per string (with 230-260 Wp panels)
Input strings	2
Used protection	2x MCB, C characteristic, 10 A
Max. number of panels	approx. 24 per string (based on panel rated voltage)
Outputs	2
Max. input voltage	2x 1000 V DC

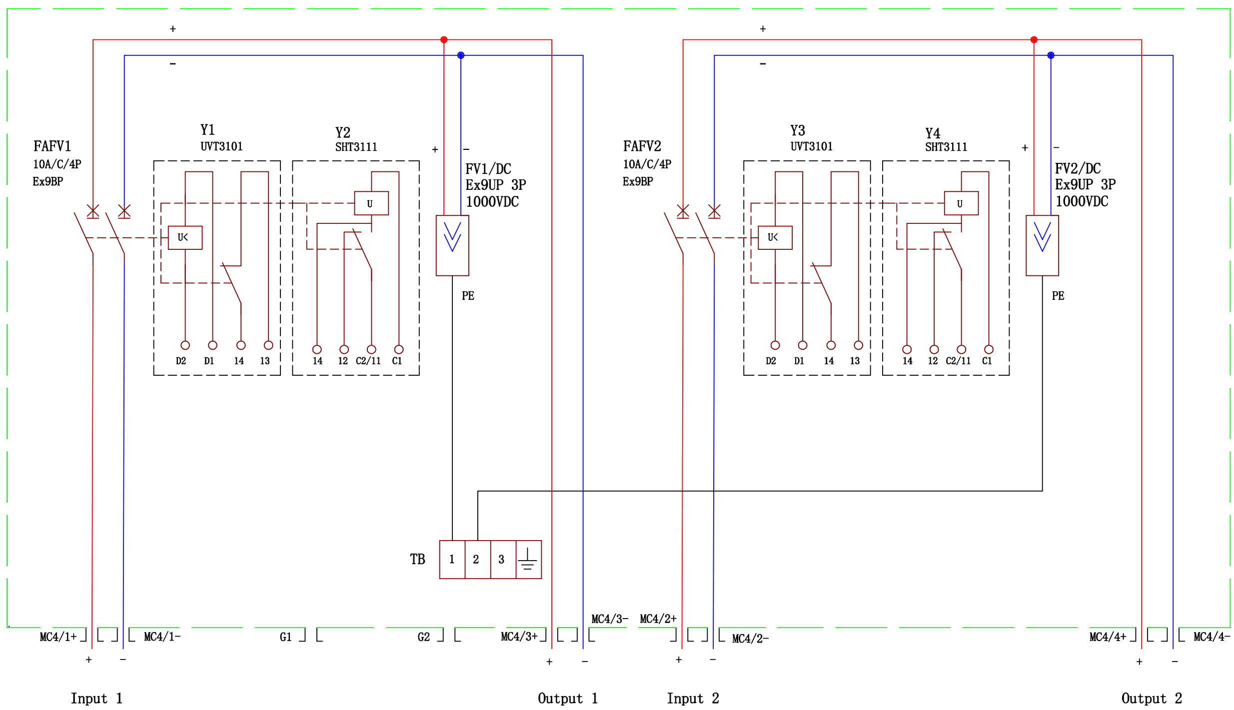
Block diagram and position of devices

basic version

versions with undervoltage
or shunt-trip release



Wiring diagram - RC4-A1-2-U-44. - ungrounded system



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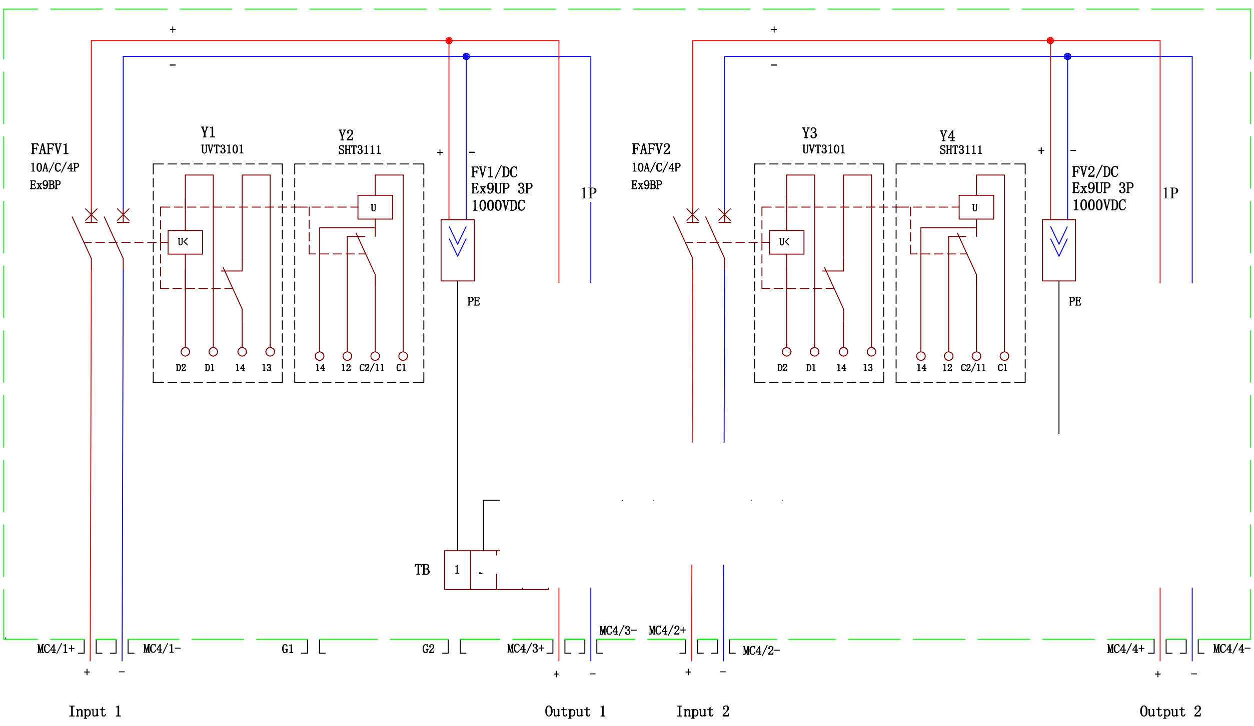
DC boards for PV applications up to 5 kW (versions RC4-A1-2)

Wiring diagram - RC4-A1-2-G-44. - grounded system



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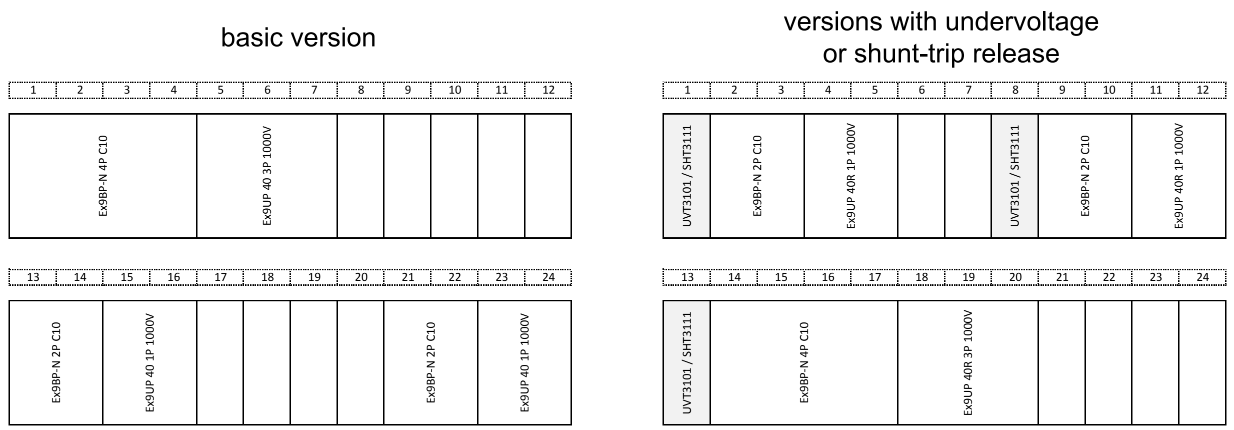
Technical Data RC

DC boards for PV applications up to 5 kW (versions RC4-A1-3)

Electrical parameters

Designed for 1 phase inverters	up to 5 kW
Max. input power	1x 6.2 kW + 2x 3.15 kW (with 230-260 Wp panels)
Input strings	3
Used protection	3x MCB, C characteristic, 10 A
Max. number of panels	approx. 1x 24 + 2x 12 (based on panel rated voltage)
Outputs	3
Max. input voltage	1x 1000 V + 2x 500 V DC

Block diagram and position of devices



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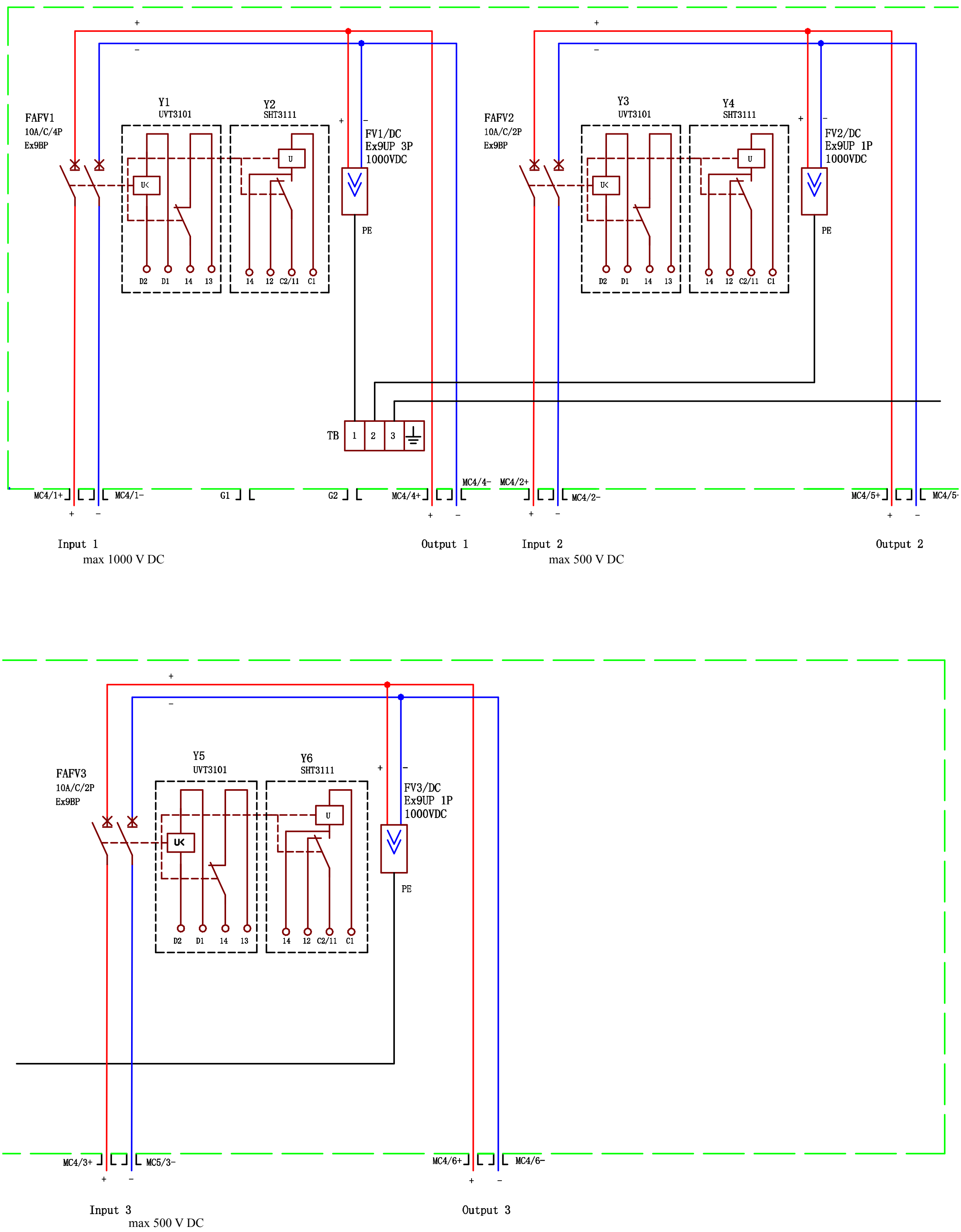
DC boards for PV applications up to 5 kW (versions RC4-A1-3)

Wiring diagram - RC4-A1-3-U-422. - ungrounded system



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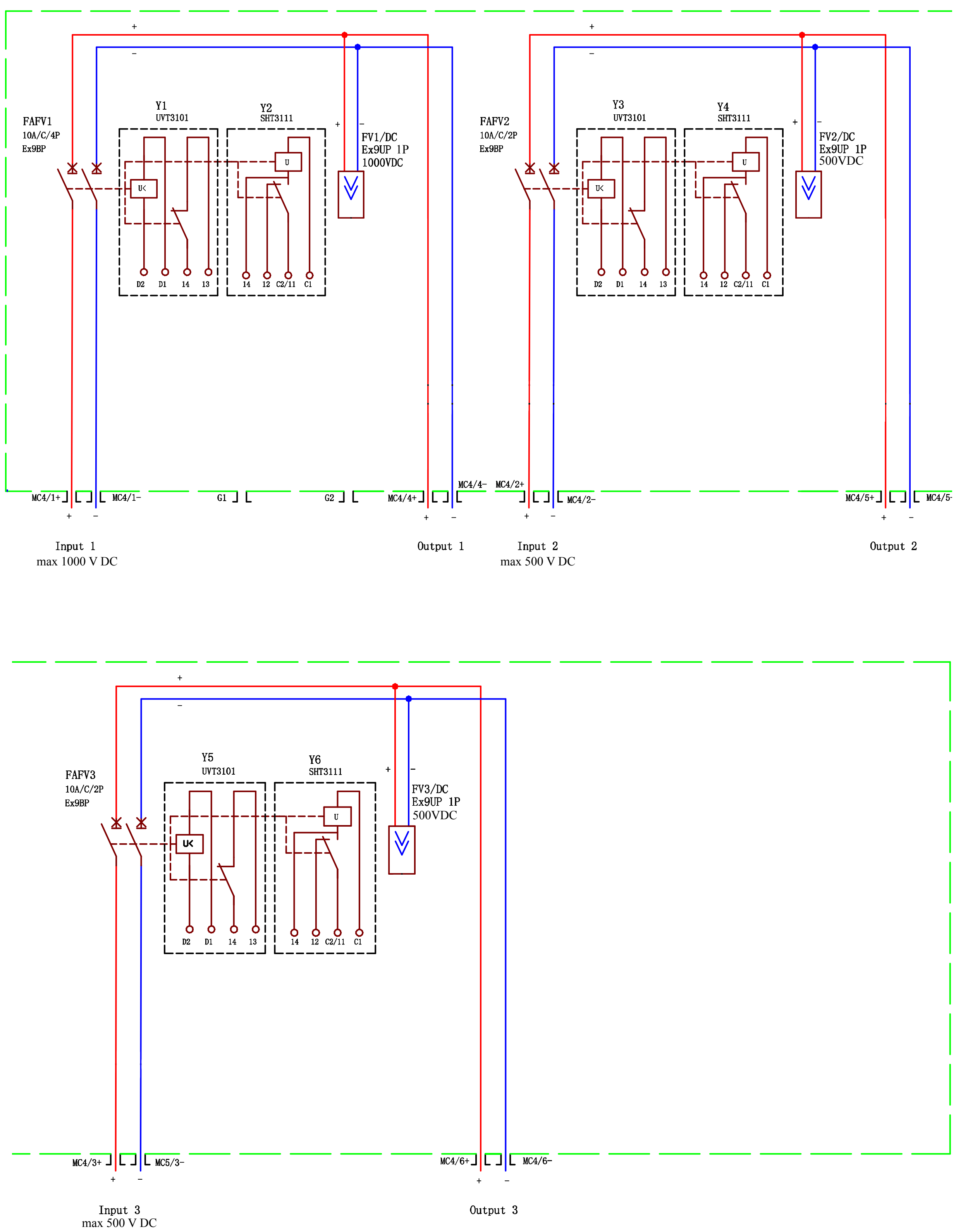
DC boards for PV applications up to 5 kW (versions RC4-A1-3)

Wiring diagram - RC4-A1-3-G-422. - grounded system



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