

Discussion Paper on the Correct Wiring of Double Pole DC Circuit Breakers

AS/NZS5033:2005 requires a double pole disconnection device on the PV array cable on the DC side of a grid-connected inverter.

In grid-connected PV systems (i.e. without batteries attached), this device is required only to be a load breaking isolator, but many installers are using double pole DC circuit breakers because they are more easily available. These DC circuit breakers can either be polarised or non-polarised breakers. It is anticipated that the new version of AS/NZS5033 will not allow polarised breakers, but currently they are commonly used.

Polarised breakers present a concern because if they are wired incorrectly, they are a potential hazard. If wired incorrectly and turned off under load, (e.g. middle of day with DC current flowing) the circuit breakers might not be able to extinguish the arc and the circuit breaker will burn out.

Polarised DC circuit breakers use a small magnet to direct the arc away from the contacts and up into the arc shoot and arc disrupter cage. If the direction of current flow through the unit is reversed, then the magnet directs the arc away from the arc shoot and into the mechanism of the unit thus destroying it.

This discussion paper details: (i) the common mistakes installers are making when wiring the polarised breakers; (ii) how the polarised breakers work and how they are wired correctly.

The main difference between polarised and non-polarised breakers is that the polarised breakers will typically have a marking on them showing a '+' and '-' symbol.

Common mistakes installers are making when wiring polarised breakers

Polarised Breakers: Marking only on the terminals at bottom of the circuit breaker.

The manufacturer of the circuit breaker product intends that the PV array is connected at the bottom of the circuit breaker hence the '+' and '-' markings are shown there. Many in the industry are connecting to the top of the circuit breaker but matching the markings at the bottom as shown in Figure 1.

THIS IS WRONG.

Some installers have stated that they thought the inverter was the 'source' and therefore that is why they connect the '+' and '-' from the inverter to the respective '+' and '-' on the circuit breaker.

THIS IS WRONG. The PV array is the source.

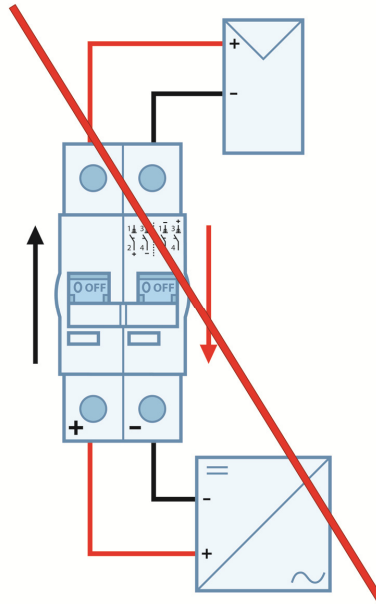


Figure 1: Incorrect wired polarised breaker (markings at bottom)

Polarised Breakers –Markings shown on every terminal of circuit breaker.

The intention with this type of breaker is that the '+' and '-' of the solar array is connected to the poles marked '+' and '-' on the circuit breaker regardless of whether it is connected at the top or bottom. Many of the industry are connecting the inverter to the poles marked + and - on the circuit breaker.

THIS IS WRONG.

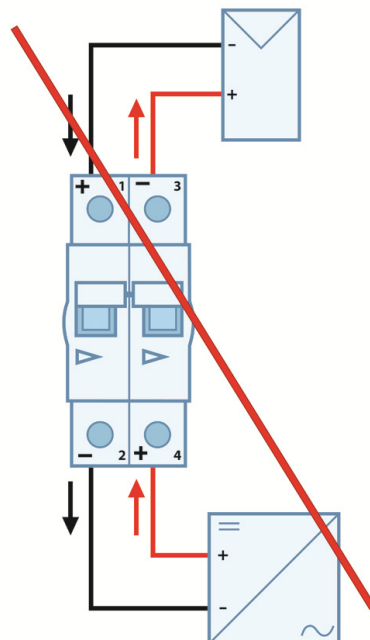


Figure 2: Incorrect wired polarised breaker (markings top and bottom)

How to wire the breakers correctly

Polarised Breakers – Marking only on the terminals at bottom of circuit breaker.

A number of the breakers on the market (e.g. ABB, GE and Terasaki) only have the ‘+’ and ‘-’ symbols on one side. (See figure 3) and typically they are at the bottom of the circuit breaker.

It is intended that the energy source, in a solar system this will be the PV array, is to be connected to the side with the ‘+’ and ‘-’ symbols: the array output positive is connected to the positive and array negative connected to the negative as shown in Figure 4.



Figure 3: Polarised ABB Breaker

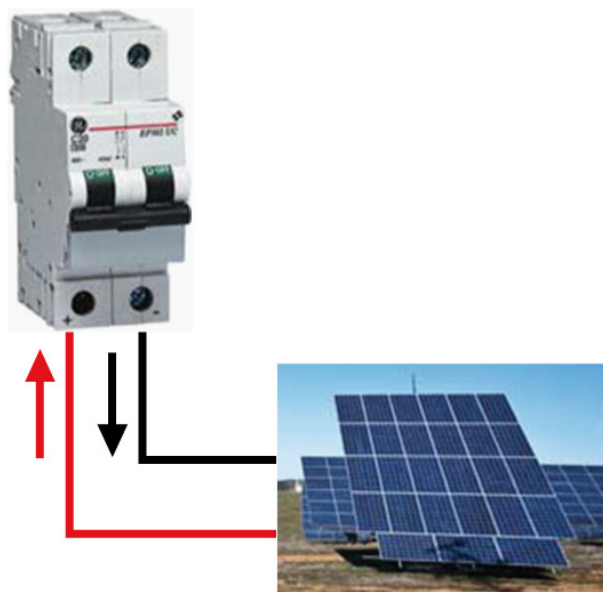


Figure 4: Preferred connection of array to a polarised double pole DC Circuit Breaker with markings on bottom of circuit breaker

The preferred method of connection of the array is at the bottom as shown in figure 4. However, all manufacturers of this equipment provide drawings on how to connect the array to the circuit breaker if the array is connected to the top of the breaker and the inverter at the bottom of the breaker.

NOTE: For all connections, **the direction of the current flow is to be the same whether the array is connected to the top or the bottom.** Figure 5 can be best used to explain this.

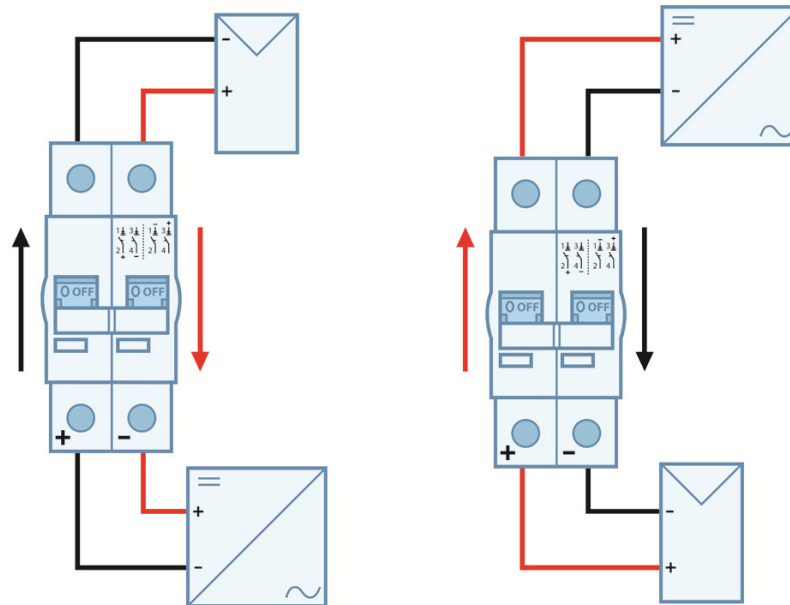


Figure 5: Two Ways of Connecting to a Polarised DC Breaker with markings only on bottom side.

Figure 5 shows that the two ways of connecting the array to the breaker the direction of current flow is identical. The conventional current flow is from the positive of the solar array through the load (inverter) and back to the negative of the solar array. In Figure 5 – right hand side diagram - where the array is connected to the bottom of the circuit breaker the conventional current flow will be as follows:

- From the positive of the array the current flows through the bottom of the left hand circuit breaker and then out through the top.
- The current then flows from the top of the left hand side of the breaker through the inverter and then back into the top of the right hand side of the breaker.
- The current then flows down through the right hand side breaker and back to negative of the module.

In the diagram on the left, the array is connected to the top of the breaker while the inverter is connected at the bottom.

Initially this drawing can appear to be incorrect because the positive of the inverter connects to the negative marking on the circuit breaker while the negative of the inverter connects to the positive marking on the circuit breaker, *however, this is correct and will ensure that the breaker operates correctly under load.* If you study the two diagrams the current direction is the same.

- From the positive of the array, the current flows through the top of the right hand circuit breaker and then out through the bottom.

- The current then flows from the bottom of the right hand side of the breaker through the inverter and then back into the bottom of the left hand side of the breaker.
- The current then flows down through the left hand side breaker and back to negative of the module.

Polarised Breakers – Markings at every terminal of circuit breaker.

A number of the breakers on the market (e.g. Clipsal, Klockner Moeller) have the + and – symbols on the top terminals. (See figure 6) and then the symbol – and + on the bottom terminals. These can cause confusion because one side of the single breaker has the + symbol while the same single breaker then has the ‘–’ symbol at the other end. Again this is implying direction of current flow.



Figure 6: Polarised breaker with markings at both ends of the breaker

It is important to follow the respective drawing which shows the source (in solar systems the PV array) and how its polarity is connected to the circuit breaker. Typically the connection is such that:

Whichever end of the circuit breaker the array is connected to, the positive and negative outputs of the array shall be connected to the respective ‘+’ and ‘–’ terminals on the circuit breaker.

This can be seen in figure 7, the connection diagram for a Clipsal breaker and then in figure 8 which shows the interconnections for a Klockner Moeller breaker. If you study both these drawings and follow the description used above for the polarised breaker with markings only on one end, you will see that the current flows in the same direction through the circuit breaker regardless of whether the array is connected at the top or bottom.

Connection at 500V d.c., 2 pole (2 examples shown)

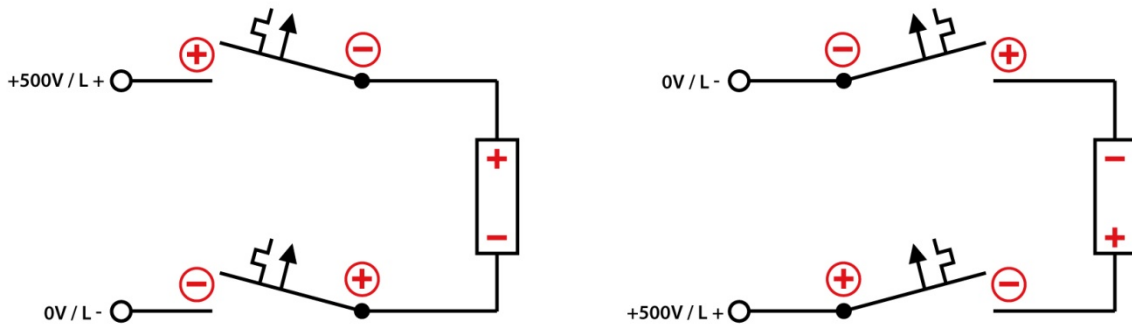


Figure 7: Interconnection diagram for Clipsal Breaker

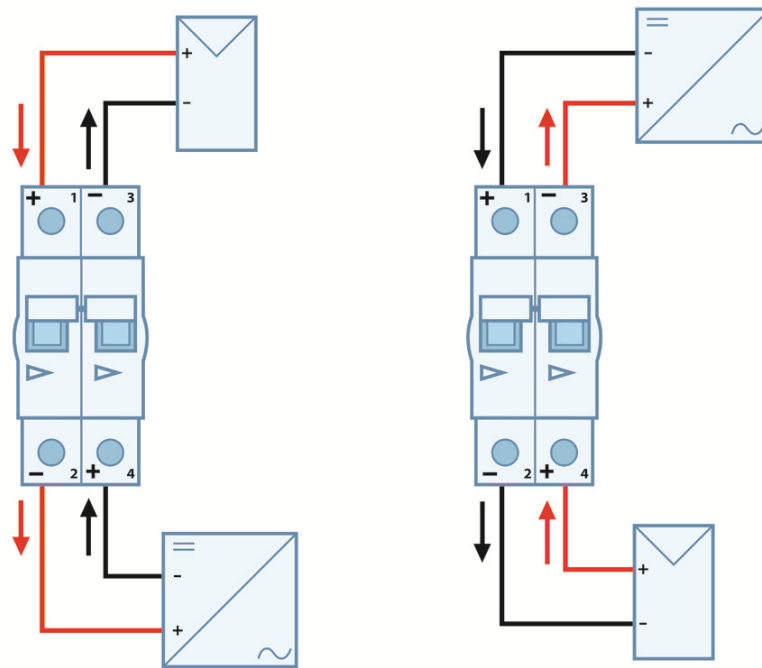


Figure 8: Two Ways of Connecting to a Polarised DC Breaker with markings on both sides of breaker.

Non-Polarised Breakers – no polarity markings on terminals of circuit breaker.

Non polarised circuit breakers operate safely as load breaking isolators and for fault current protection regardless of the direction of current flow through them.

Figure 9 shows a non-polarised DC breaker—it has no + or – signs at the terminal connections.



Figure 9: Non-Polarised Breaker

Figure 10 shows how the array can be connected such that the current flows in one direction in one connection format and in the opposite direction for the other connection format.

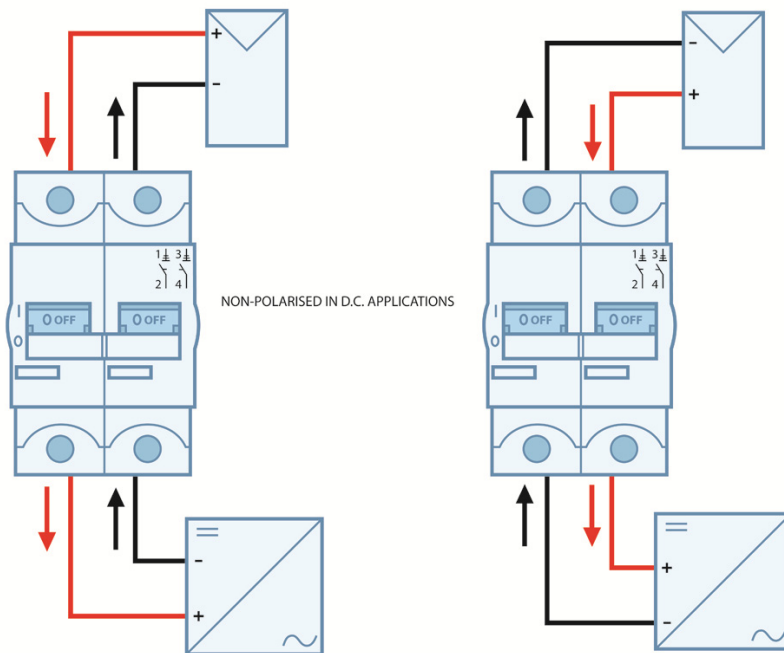


Figure 10: Two Ways of Connecting to non- Polarised DC Breaker