DC Isolator Sizing Requirements

Recently there has been a substantial amount of information released by the Clean Energy Council and other bodies about the requirements for DC circuit Isolators when used as the main isolator on a PV array cable.

To understand why the required ratings are different depending on the type of inverter installed, and whether or not the array cables are earthed it is first necessary to understand what happens when a PV array is electrically connected to earth on the DC side. Initially we would point out the following regarding the different types of inverters on the market. AS/NZS 5033:0 . /2 defines that inverters are either separated or non-separated.

Separated inverters have a transformer (either high or low frequency) that provides galvanic isolation between the AC and DC side of the inverter. Just like in a voltage step transformer there is no electrical connection at all between the two sides and there is no way for a current to flow across the gap. Inverters with transformers were traditionally the major product available on the market.

Non-separated inverters do not have any galvanic isolation, so it is possible that current can flow between the DC and AC sides. In some cases non-separated inverters connect the neutral cable directly to the negative or positive conductor of the array.

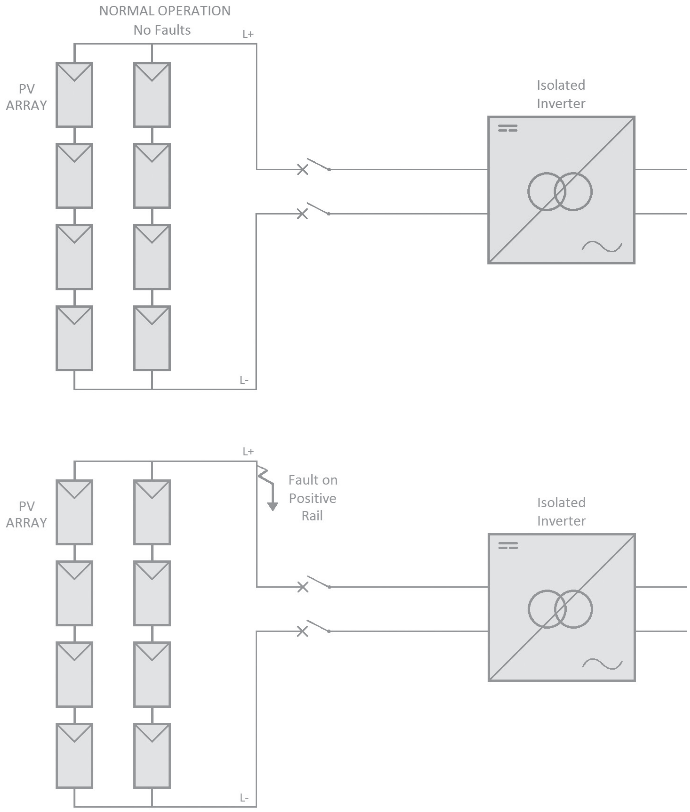
Transformer-less inverters are generally non-separated, but some 'transformer-less' inverters do have a high-frequency isolating transformer so installers should ensure they are familiar with and understand which inverter products they are using.

Connections to Earth

The basis for sizing the DC isolators in a PV system is to address "first-fault" conditions. This means that when the first unintentional connection to earth occurs, the DC isolator will be able to safely disconnect the photovoltaic array from the inverter under load conditions. Of course before the first fault occurs, the device chosen should be able to safely operate as well.

Floating arrays have a separated inverter and no intentional earth connection on the DC side of the inverter, so under normal operating connections there is no path for a current to flow other than around the inverter as designed. If a single earth fault occurs in such a system it will be the first connection to earth, but because there is only one point of connection there is still no way for a fault current to flow through the earth.

Consequently even under first fault conditions both poles still share the full voltage.



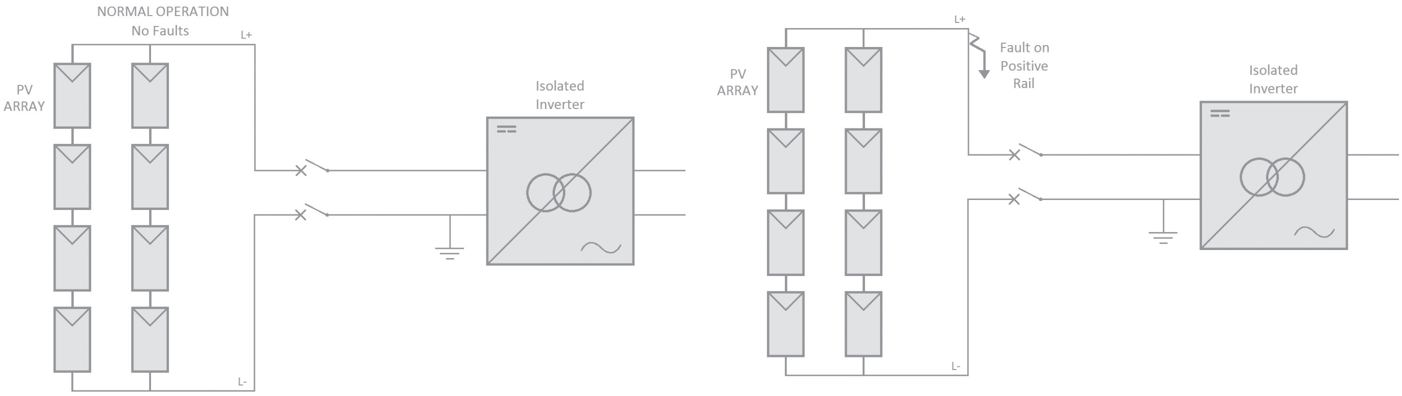
An unearthed isolated array before (left) and after (right) the first earth fault occurs.

When an array is connected to a separated inverter and is electrically earthed, that is the array has an intentional first connection to earth, the normal operating condition is exactly the same as the "first fault" condition from the previous case. These means that one of the array cables is referenced to earth, but no current can flow through earth because the circuit is not complete.

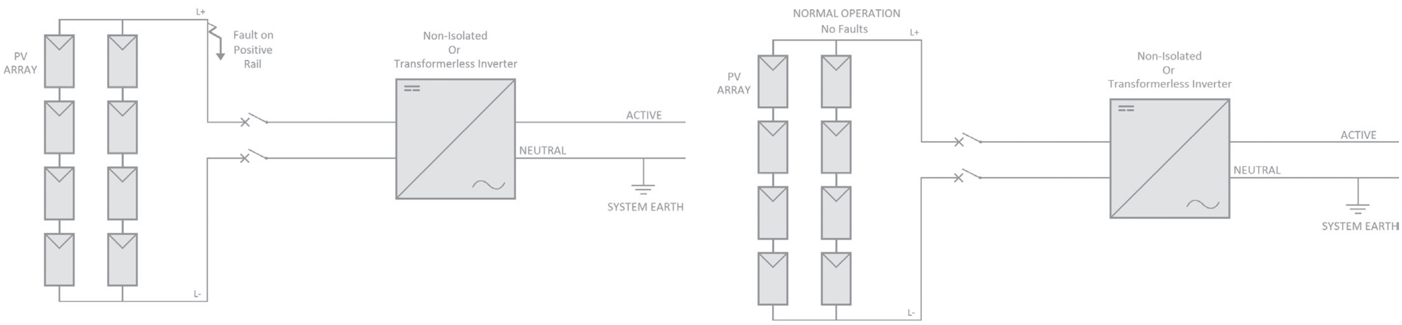
However, when the "first fault" occurs in a system that has an electrical earth it introduces a second connection to earth on the DC side of the inverter. It is then possible for current to flow through the array and the earth fault back to the intentional earth connection so that a complete circuit is formed. The result of this could be to bypass one of the poles of the DC isolator so that the entire voltage of the array needs to be broken by a single pole.

The third option is having a non-separated inverter with no intentional earth connection. In this system there is no connection to earth on the DC array cable, but there is a connection to earth through the inverter. This means that just like the second scenario, when the first fault occurs, it introduces the second connection to earth into the array.

This could again result in one pole of the DC isolator being bypassed by the earth fault current, or even a DC current being introduced onto the AC side of the inverter.



An earthed array with isolated transformer before (left) and after (right) the first fault occurs. Notice how there are now two connections to earth that could allow a current to flow.



A non-isolated inverter with an unearthed array before (left) and after (right) the first fault occurs. With an earth on the AC side of the inverter a current can flow through the inverter.

This scenario requires either pole to deal with the full array voltage and current. Remember that having an earthed array with a nonseparated inverter is not allowed according to AS/NZS 5033:2012.

Rating DC Isolators

The different scenarios above demonstrate that the array earthing and inverter of a PV system will determine the required ratings for any isolator used, whether it is a DC isolator or a double pole DC isolator.

The following table is a summary of what the required rating for an isolator is related back to the consequences of a first fault forming. For more information on this topic contact GSES about their DC Isolator Info Sessions.

Earthing vs Bonding

The term earthed array is being used quite loosely in the industry. Here we are talking about earthing one of the conductors in the DC circuit, NOT bonding the PV array frame.

Array Configuration	Inverter Type	Consequence of first fault	Min Rating for EACH pole
Unearthed Array	Isolated Inverter	No current flowing through earth fault - no poles bypassed	0.5 × PV Array Maximum Voltage(
Earthed Array	Isolated Inverter	Current will flow through earth fault - one pole bypassed	PV Array Maximum Voltage
Unearthed Array	Non-Isolated Inverter	Current will flow through earth fault - one pole bypassed	PV Array Maximum Voltage
Earthed Array	Non-Isolated Inverter		Not Permitted by AS-LXQ 5033:2012

*As isolator ratings are not always linear, ensure that the overall voltage rating of the isolator is higher than PV array maximum voltage