

# Application Note: RCD Requirements to Prevent Nuisance Tripping

Application Note: RCD Requirements to Prevent Nuisance Tripping – Australia

## PV System Residual Current Factors

In every PV installation, several elements contribute to the current leakage to protective earth (PE). These elements can be divided into two main types:

- **Capacitive discharge current** - Discharge current is generated mainly by the parasitic capacitance of the PV modules to PE. The module type, the environmental conditions (rain, humidity) and even the distance of the modules from the roof can affect the discharge current. Other factors that may contribute to the parasitic capacitance are the inverter's internal capacitance to PE and external protection elements such as lightning protection.  
During operation, the DC bus is connected to the alternating current grid via the inverter. Thus, a portion of the alternating voltage amplitude arrives at the DC bus. The fluctuating voltage constantly changes the charge state of the parasitic PV capacitor (i.e., capacitance to PE). This is associated with a displacement current, which is proportional to the capacitance and the applied voltage amplitude.
- **Residual current** - if there is a fault, such as defective insulation, where an energized cable comes into contact with a grounded person, an additional current flow, known as a residual current.

## Residual Current Device (RCD)

All SolarEdge inverters incorporate a certified internal RCD (Residual Current Device) to protect against possible electrocution in case of a malfunction of the PV array, cables, or inverter (DC). The RCD in the SolarEdge inverter can detect leakage on the DC side. There are 2 trip thresholds for the RCD as required by the DIN VDE 0126-1-1 standard. A low threshold is used to protect against rapid changes in leakage typical of direct contact by people. A higher threshold is used for slowly rising leakage currents, to limit the current in grounding conductors for fire safety. The default value for higher speed personnel protection is 30mA, and 300mA per unit for lower speed fire safety.

## Installation and Selection of an External RCD device

Section 7.3.4.1 of AS/NZS 3000:2018 details the general requirements for the AC isolation switch in accordance with clause 2.3.2.2. Requirements of AS/NZS 4777 series are deemed to satisfy these requirements, however. Section 2.6.2.2 defines the specific types of RCD's and their application. There are 6 different types of RCD's available and complaint for installation depending upon the characteristic of supply, these being:

- Type AC RCD - Residential sinusoidal waveforms.
- Type A RCD - As per Type AC and for residential pulsating direct currents
- Type I RCD - Residual alternating currents not exceeding 10mA, interrupt time not exceeding 40ms.
- Type F RCD - Composite residual, pulsating direct or high frequency leakage currents.
- Type B RCD - Residual sinusoidal up to 1000Hz, alternating or pulsating, residual direct currents.
- Type S RCD - Specifically designed where tripping is delayed after a pre-determined time.

## Mitigation of Nuisance Tripping

Selecting the appropriate RCD can be important for correct operation in an installation. An RCD with a rating of 30mA may actually trip at a leakage as low as 15mA (according to IEC 61008). High quality RCDs will typically trip at a value closer to their rating.

Section 2.6.3.2.3.3 of AS/NZS 3000:2018 details the requirements whereby a 30mA RCD shall be provided for final sub circuits with a rating not exceeding 32A. However, these requirements are defined for protection to the final sub circuits only and not for the supply from a Solar PV inverter.

Furthermore, exceptions to these requirements apply as per clause 2.6.3.2.3.3 Exceptions 3 (II) which states that:

*‘These requirements need not apply to the following’...‘may cause spurious nuisance tripping through high leakage currents being generated in the normal operation of the equipment’.*

In addition, AS/NZS 4777.2:2016 clause 3.4.5 states that:

*‘An RCD dedicated for an IES may be used to meet the mechanical cable protection requirements and isolation requirements of AS/NZS 3000 for the cable from the switchboard to IES’.*

- **In conclusion** the requirement for an RCD is not a ‘Shall’ (mandatory) requirement in either AS/NZS 4777.1:2016 or AS/NZS 3000:2018, it is defined as a ‘May’ which is optional.

The purpose of an RCD as part of an IES / Solar PV inverter system is there to meet the mechanical protection requirements of the cable connecting the inverter to the switchboard only. As long as mechanical protection meeting the requirements of the standards are provided then the RCD requirements can be mitigated.

- **Multiple Mode inverters** - with regards to multimode IES clause 5.4.3 of AS.NZS 4777.1:2016 states that:

*‘The provision of AS/NZS 3000 for the use of RCDs as a method for mechanical protection of the IES grid-interactive port submain is not permitted for the multiple mode IES grid-interactive port’.*

## Recommended use of a Residual Current Device (RCD)

If required, SolarEdge suggests an RCD value between 100mA and 300mA. For the three phase inverters stated in the table below, use the following RCD values:

Three Phase Inverter	Minimum RCD Value
SE12.5K, SE15K, SE16K, SE17K	100mA
SE30K, SE40K	100mA
SE25K, SE27.6K, SE33.3K	100mA
SE50K, SE5K, SE66.6K	600mA
SE82.8K, SE100K	900mA

## AS/NZS 3000:2018 and inverter AC cable mechanical protection

SolarEdge do not recommend the use of 30mA RCD's as a means of achieving AC cable mechanical protection for the cable from the switchboard to the IES where there is a likelihood of nuisance or unwanted tripping during the course of normal operation.

### **SolarEdge single phase HD Wave inverters** (excluding StorEdge multi-mode inverters):

Single phase HD Wave inverters operate reliably with Type-A or Type-B 30mA RCD, and are unlikely to cause nuisance tripping under normal operation.

### **StorEdge multi-mode inverters** (StorEdge multi-mode inverters must not use an RCD for the grid-interactive port):

operating in Backup Mode. SolarEdge models that provide Multi-Mode operation: SE3000-AUS, SE5000-AUS, SE6000-AUS

### **SolarEdge three phase Residential inverters** (includes 3 phase Hybrid inverter models):

Three phase residential (non-commercial) inverters operate reliably with Type-A or Type-B 30mA RCD, and are unlikely to cause nuisance tripping under normal operation.

### **SolarEdge three phase Commercial inverters:**

Three phase commercial (non-residential) inverters may not operate reliably with a 30mA RCD, and risk nuisance tripping under normal operation.

Installers should consider carefully whether the possibility of nuisance tripping under normal operation is acceptable for the installation before choosing to install 30mA RCD's for AC cable mechanical protection.

Where the inverter's recommended RCD protection is greater than 30mA, alternative means of mechanical protection are required such as the use of surface ducts or conduits, by location or installation method within walls, or the use of additional local or general mechanical protection as outlined in the standards.

## AS/NZS 3000:2018

### 1.5.4.2 Methods of protection

Basic protection shall be provided by one or any combination of the following methods:

- (a) Insulation, in accordance with Clause 1.5.4.3.
- (b) Barriers or enclosures, in accordance with Clause 1.5.4.4.
- (c) Obstacles, in accordance with Clause 1.5.4.5.
- (d) Placing out of reach, in accordance with Clause 1.5.4.6.

RCDs are not recognized as a sole means of basic protection against contact with live parts but may be used to augment one of the above methods

### 1.5.6.3 Where required

RCDs for the limitation of earth leakage current shall be capable of interrupting the part of the circuit protected by the RCD when an earth leakage current reaches a predetermined value.

RCDs shall be installed for additional protection of the following:

- (b) Wiring systems as specified in Part 2, Clause 3.9.4.4

### 1.7.1 General (Selection and installation of electrical equipment)

Electrical equipment, forming part of an electrical installation, shall be selected and installed to—

- (a) operate in a safe and reliable manner in the course of normal operating conditions; and
- (c) be installed in accordance with the manufacturer’s instructions.

### 1.5.14 Protection against external influences

All parts of an electrical installation shall be designed to be adequately protected against damage that might reasonably be expected from environmental and other external influences to which the electrical installation may be exposed under the conditions of its use. These conditions would be those that would be expected during normal operation.

Damage from such influences may include mechanical damage, and damage because of exposure to weather, water, flora, fauna, seismic activity, excessive dampness, corrosive fumes, galvanic action, accumulation of dust, steam, oil, temperature, explosive atmospheres, vibration or any other influence to which the electrical installation may be exposed under the conditions of its use.

### 2.6.2.1 General

Any device for the provision of additional protection shall be capable of interrupting the part of the circuit protected by the device when an earth leakage current is above a predetermined value.

#### NOTES:

- 1 To avoid unwanted tripping because of leakage currents and transient disturbances, care should be taken to ensure that the sum of the leakage currents of electrical equipment on the load side of an RCD is significantly less than its rated residual current. RCDs may operate at any value of residual current in excess of 50% of the rated residual current.

The loading of the circuit should be such that the leakage current does not exceed one-third of the rated residual current.

### 2.6.3.2.3.2 Location of RCD protection

Where protection of final subcircuits is required, RCDs shall be installed at the switchboard at which the final subcircuit originates.

#### Exception:

Where the wiring system is installed with additional mechanical protection as required by Clause 3.9.4, the RCD protection specifically intended for the protection of that socket-outlet can be installed at, or adjacent to, the socket-outlet (e.g. factory).

#### 2.6.3.2.3.3 Requirements for additional protection

Additional protection by RCDs with a maximum rated residual current of 30 mA shall be provided for final subcircuits with a rating not exceeding 32 A supplying—

(d) direct connected electrical equipment that represents an increased risk of electric shock.

Factors that may represent an increased risk of electric shock include but are not limited to—

- (i) external influences (refer Clause 1.5.14); and
- (ii) type of electrical installation and processes being conducted (e.g. workshops and particular industrial activities).

#### NOTE:

For all other final subcircuits with a rating not exceeding 32 A for direct connected equipment, additional protection by RCDs with a maximum rated residual current of 30 mA should be considered.

**Exceptions:** These requirements need not apply to the following:

Final subcircuits installed for the connection of specific items of equipment, provided that the connected equipment is designed, constructed and installed in such a manner that is not likely to present a significant risk of electric shock and—

- (i) is required by the owner or operator to perform a function that is essential to the performance of the installation and that function would be adversely affected by a loss of supply caused by the RCD operation; or
- (ii) may cause spurious nuisance tripping through high leakage current being generated in the normal operation of the equipment (e.g. VSDs).

#### 3.3.2.6 Impact

Wiring systems shall be selected and installed so as to minimize the risk of mechanical damage.

Protection against mechanical damage shall be provided by one or any combination of the following:

- (a) Mechanical characteristics of the wiring system.
- (b) Location selected.
- (c) Provision of additional local or general mechanical protection.

#### 3.9.4.1 General

Wiring systems installed in positions where they may reasonably be expected to be subject to mechanical damage shall be adequately protected in accordance with Clause 3.3.2.6 and the applicable requirements of Clauses 3.9.4.2 to 3.9.4.4.

### 3.9.4.2 Wiring systems near building surfaces.

Wiring systems that are fixed in position by either fasteners or by passing through an opening in a structural member shall be protected by one of the methods outlined in Clause 3.9.4.4 if they are—

- (a) concealed within 50 mm from the surface of a wall, floor, ceiling or roof; and
- (b) located more than 150 mm from internal wall-to-wall or wall-to-ceiling corners

**Exception:** These requirements need not apply to wiring systems that can move freely to a point not less than 50 mm from the surface in the event of a nail or screw penetrating the cavity at the location of the wiring system.

Figures 3.3 to 3.5 provide examples of protection of wiring systems near building surfaces.

### 3.9.4.3 .2 Protection required

Wiring systems shall be protected by one of the methods outlined in Clause 3.9.4.4 if they pass through a structural member, or are fixed in position, within 50 mm from the face of the supporting member to which the lining or roofing material is attached (see Figure 3.7).

### 3.9.4.4 Protection methods

Where protection of a wiring system is required, in accordance with Clauses 3.9.4.2 and 3.9.4.3.2, the wiring system shall be—

- (a) provided with adequate mechanical protection to prevent damage; or
- (b) provided with an earthed metallic armouring, screen, covering or enclosure; or
- (c) protected by an RCD with a maximum rated operating residual current of 30 mA.

## AS/NZS 4777.1:2016

### 3.4.5 Residual current devices (RCDs)

An RCD dedicated for an IES may be used to meet the mechanical cable protection requirements and isolation requirements of AS/NZS 3000 for the cable from the switchboard to the IES.

#### NOTES:

Where manufacturers specify RCDs for earth fault protection and the protection required is greater than 30 mA, alternatives for mechanical protection are required.

## AS/NZS 4777.1:2016 Multiple Mode Inverter systems & RCD circuit protection

### Stand-Alone port

RCD's shall be used on the final sub-circuits supplied from the stand-alone port of a multi-mode inverter as outlined in AS/NZS 3000:2007 and AS/NZS 4777.1:2016. Type-A or Type-B RCD's are suitable for use.

## Grid-Interactive port

RCD's must not be used on the grid-interactive port of a multi-mode IES.

RCD's detect wiring and appliance faults by measuring the leakage current to Earth, and disconnect both Active and Neutral conductors. An RCD that trips or is opened on the grid-interactive port of a multi-mode inverter compromises the operation of RCD's on the stand-alone port, as the circuits supplied by the stand-alone port will no longer have an Earth fault current return path via the MEN link in the site main switchboard.

Refer to the following excerpts of clauses in AS/NZS 4777.1:2016 regarding multi-mode inverters

### 3.4.5 Residual current devices (RCDs)

An RCD dedicated for an IES may be used to meet the mechanical cable protection requirements and isolation requirements of AS/NZS 3000 for the cable from the switchboard to the IES.

If an RCD is used, the RCD shall—

- (a) disconnect all live conductors (including the actives and neutral); and
- (b) be of the type specified in the inverter manufacturer's instructions or as labelled on the inverter

#### NOTE:

If the IES is a multiple mode IES with stand-alone functionality, then the requirements of Clause 5.4 apply.

Where manufacturers specify RCDs for earth fault protection and the protection required is greater than 30 mA, alternatives for mechanical protection are required. Manufacturers' instructions cannot be used to override the 30 mA requirement for RCDs in AS/NZS 3000.

## 5.4.1 General

#### NOTE:

Alternative supply arrangements in AS/NZS 3000 include important functions to be maintained, including the maintenance of an MEN connection, the operation of RCDs and the continuity of neutral conductors.

## 5.4.3 Circuit arrangement

The provision of AS/NZS 3000 for the use of RCDs as a method for mechanical protection of the IES grid-interactive port submain is not permitted for the multiple mode IES grid-interactive port.

## 5.4.4 RCDs on multiple mode inverter system final subcircuits

RCD protection shall be installed on final subcircuits in accordance with AS/NZS 3000.

When RCDs are installed to protect electrical installation connected loads on a stand-alone port of a multiple mode inverter, they shall be of a type that correctly operates on the standalone port output waveform and be in accordance with the requirements specified by the manufacturer for use with the inverter.