Overvoltage Surge Protection - Technical Note, North America

Revision History
Version 2.2 (November 2017)
- Use of SolarEdge Surge Protection Device in three phase inverters
- Updated sample surge protection design drawing for commercial PV system
Version 2.1 (December 2016)
- Recommended External Surge Protection Devices for SolarEdge inverters
Version 1.0 (December 2014)
- Initial version

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Overview
The purpose of this Technical Note is to describe proper protection of SolarEdge products in the field from overvoltage surges caused by lightning strikes, grid overvoltage events and ground faults. Properly installed surge protection can reduce the likelihood of permanent damage to inverter components, Control and Communication Gateways (CCGs), communication devices and interconnected meters.

Rapidly changing currents create electromagnetic pulses (EMPs) that radiate and create current and voltage “surge” when passing over conductive elements like electrical wires, communication lines, or metallic pipes. These surges may result in the destruction of delicate electronics and semiconductors. Devices known as surge protectors (SPD) or transient voltage surge suppressors (TVSS) connected to these conductors can route these transient currents to the ground, protecting the equipment from damage.

SolarEdge recommends that all three phase inverters be installed with external surge protection devices (SPDs) on the AC, RS485, and Ethernet lines to mitigate the effect of environmental factors which are beyond SolarEdge’s control and which fall outside of SolarEdge’s limited product warranty (http://solaredge.com/us/service/warranty).

Lightning Strikes and Electromagnetic Pulses
One of the common sources of voltage surge is lightning strikes. It is not necessary for lightning to strike the PV site to damage it; therefore, it is worthwhile to consider all the ways in which lightning can induce surge, including electrostatic and magnetic induction.
Direct Lightning Strike
Direct lightning strike energy is enormous, and a surge protector alone cannot protect the stricken instruments. External protection is required to attract the lightning and redirect it to the ground, during which SPDs only absorb residual energy. External protection equipment includes lightning rods, grounding wires, catching devices and conductors, as well as the accompanying ground system.

One effect of a direct lightning strike is increased ground potential – when the lightning strikes a building or a lightning rod, high current flows to the ground and the ground potential rises. This creates a potential difference between ground and external conductors, leading to surge behavior.

Electrostatic Induction
Thunderclouds contain negative charges in their lower sections. These high negative charges can induce high positive charges within nearby cables, especially power lines and communication cables.
During discharge of the thundercloud (lightning), the positive charge accumulated in the cable is released, resulting in a surge in the cable in both directions.

**Electromagnetic Induction (Indirect Lightning)**

A discharge between clouds and the ground generates a surging magnetic wave. When the magnetic wave reaches AC lines or communication cables, it induces a voltage surge.

**What is a Surge Protection Device?**

In order to avoid high voltage damage to a PV system, voltage surges should have a path to ground to avoid high energy from passing through electronics. In order to provide this path, all of the wiring exiting and entering the system should be coupled to ground through a Surge Protection Device (SPD), and all conductive surfaces should be directly grounded.

Examples of lines exiting and entering the system include the AC mains and communication lines, such as Ethernet cables, RS485 cabling and telephone lines. Note that SPDs on power lines provide protection that is different from circuit breakers; breakers protect equipment from overcurrent while SPDs protect equipment from overvoltage.

SPDs are usually a combination of Metal Oxide Varistors (MOV), Gas Discharge Tubes (GDT) and/or Zener diodes, and current limiting devices that act to shunt charge to ground and to divert it from entering the protected system in the event of high voltage or current surges. Both MOVs and GDTs have a limited lifetime, and can handle a finite number of surge events.
**Protection of SolarEdge Systems**

**Internal AC and DC Overvoltage Protection**

SolarEdge inverters and power optimizers conform to the UL1741/IEEE1547 safety standards, which include internal overvoltage protection. Varistors and GDTs in the inverters connect between phase and neutral cables, between neutral and ground conductors, and between PV terminals.

**NOTE**

Overvoltage surge protection requirements depend on the system configuration, physical parameters and geographic location, and should be implemented according to installation requirements. The SolarEdge inverter’s internal SPD cannot match the surge protection capabilities provided by external protection devices.

The SolarEdge power optimizers have the same protection level as regular protection diodes that exist in every PV module. This means that the power optimizers can withstand the same surge events and voltages as the PV module.

**Internal RS485 Overvoltage Protection**

SolarEdge commercial three phase inverters (SE43.2K or higher) are supplied with a built-in RS485 SPD that protects the RS485-1 bus.

**Adding External SPDs to Your PV System**

**DC Side**

When using string protectors such as fuses, DC breakers or string diodes together with SPDs, the SPD must be installed between the fuses and the inverter, otherwise the PV strings would be unprotected if the fuse is triggered.

For inverters with an integrated fuse box, internal fuses should be bypassed in order to connect an SPD, and external string fuses should be connected.
SolarEdge recommends the Citel DS50VGPVS-1000 (or equivalent) for 277/480V inverters and the Citel DS50VGPVS-500 for 208V inverters: [Citel DS50VGPV Series](http://www.evita.lt/en/vpvc9_53-polivinilchlorido-pvc-izoliacinis-vamzdelis-9_53mm-1m-600v-105c).

**Installation specifications:**
- Devices must be mounted outside of the inverter and in a NEMA Type 3R or higher enclosure for outdoor applications
- Each string can have an individual SPD, or multiple strings may be combined in a combiner box prior to wiring into the SPD

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**AC Side**

SolarEdge recommends the Citel DS74US-277Y/G (or equivalent) for 277/480V inverters and the Citel DS74US-120Y/G (or equivalent) for 208V inverters: [Citel DS70U Range](http://www.evita.lt/en/vpvc9_53-polivinilchlorido-pvc-izoliacinis-vamzdelis-9_53mm-1m-600v-105c).

**Installation specifications:**
- Maximum wire length (not physical distance) between the SPD and the protected inverters: 9 m / 30 feet
- Many SPDs are DIN rail mountable, and should be mounted in a NEMA Type 3R or higher enclosure for outdoor applications, usually in the distribution panel closest to the inverters
- Multiple inverters can be connected to the same SPD if they share the same grid connection

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**Communications Lines**

Power lines are not the only conductive cables that provide a path for voltage surges into inverter electronics. The communication lines (RS485 and Ethernet) should also be protected using external surge protection.

- Three phase inverters manufactured from week WW41 2017 are supplied with the SolarEdge [RS485 Surge Protection Device](http://www.evita.lt/en/vpvc9_53-polivinilchlorido-pvc-izoliacinis-vamzdelis-9_53mm-1m-600v-105c). Refer to the datasheet for technical specifications. Installation instructions are supplied with the SPD.

**NOTE**

| To check an inverter manufacturing week, check its serial number: the 3rd and 4th characters indicate the production week; 5th-6th characters indicate the year. For example, an inverter with serial number SJ114A-07F004FE5-B3 was manufactured in week 51 2014. |

- Commercial three phase inverters (SE43.2K or higher) are supplied with built-in RS485 SPD that protects the RS485-1 bus.
- For other types of communications lines (for example, Ethernet, or RS485 in single phase inverters), SolarEdge recommends using external surge protection devices on each communication line when the following conditions apply:
  - The distance between devices is more than 10 m / 33 feet
  - There is a risk of induced surges

When possible, it is recommended to mount the communications SPD inside the SolarEdge inverter DC Safety Switch. Otherwise, when routing communication wires near AC and DC power lines, ensure that the conductor insulation used in the communications wires is rated as follows:
- When routing near DC power lines: 600V
- When routing near AC power lines: 300V

When routing communication wires from the DC Safety Switch into the inverter through the DC or AC power conduits, you may also put an insulating sleeve over the conductors – an example can be found here:

http://www.evita.lt/en/vpvc9_53-polivinilchlorido-pvc-izoliacinis-vamzdelis-9_53mm-1m-600v-105c
NOTE
It is not advisable to route communication lines in the same conduit as DC or AC power lines external to the inverter. Instead, a separate conduit should be provided, using one of the DC Safety Switch knockouts as a point of entry.

RS485 Surge Protection
RS485 surge protection wiring requirements:
- Cable type: minimum 3-wire shielded twisted cable (a 4-wire cable may be used)
- Wire cross-section: 0.2-1.0 mm²/24-18 AWG (a CAT5 cable may be used)
- Maximum nodes: 32
- Maximum wire length between first and last devices: 1 km / 3300 feet

For three phase inverter applications, SolarEdge recommends the SE-RS485-SPD2-K1 RS485 Surge Protection Device (SPD).
- Nominal Discharge Current: In(8/20)µs 5 kA
- Maximum Discharge Current: Imax(8/20)µs 15 kA

NOTE
New commercial, three phase inverters are supplied with the Surge Protection Device. Older models can be retro-fit with the device.

For other types of applications, an alternative to the above RS485 SPD is the ZIBENY BUD-40/3 SPD.
- Nominal Discharge Current: In(8/20)µs 20 kA
- Maximum Discharge Current: Imax(8/20)µs 40 kA

An additional alternative to the RS485 SPD is the Citel DLA-12D3 (Citel DLA Series) or equivalent:

Ethernet Surge Protection
Ethernet surge protection wiring requirements:
- Cable type: CAT5/CAT6
- Maximum wire length between the inverter and the router: 100 m / 330 feet

Devices should provide surge discharge ratings of:
- In: 10 kA 8/20 µs
- Imax: 20 kA 8/20µs

SolarEdge recommends the Citel MJ8 series Ethernet SPD or equivalent.
Appendix - Sample Commercial System with Surge Protection

A sample SPD line diagram for a small commercial system appears in the figure below.