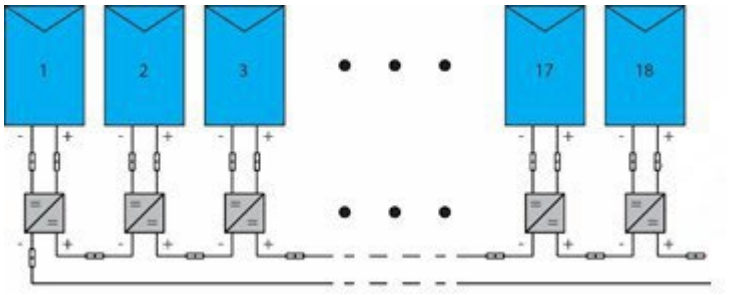
SolarEdge systems - String fuse requirements - Technical note – EU and APAC

Revision history

- Version 1.7, June 2025 – change S1400 to S1500
- Version 1.6, October 2024 - General update
- Version 1.5, January 2024 - Content update
- Version 1.4, June 2022 – Content update

Overview

String design and installation is significantly different in a SolarEdge system when compared to a traditional string inverter. PV modules do not get connected in series directly. Every PV module in the array is connected to the input of a SolarEdge power optimizer, and the power optimizer output wires are connected to each other in series.



Consequently, the behavior of a SolarEdge system under fault conditions differs from that of a traditional string inverter system.

This document compares the overcurrent protection mechanisms of the SolarEdge system and the string inverter system and analyzes their response to various fault scenarios. From this analysis it follows that for most common installations[1], string fuses should be used only in cases where four or more strings are installed.

All equipment within the inverter-optimizer segment (connectors[2], wires, disconnectors, etc) must be rated at 2x the maximum output current of the Power Optimizer[3] and must comply with the requirements of local regulations.

ie, 36A for P-Series Power Optimizers and 40A (or 48A) for S-Series commercial Power Optimizers.

When the strings are directly connected to the inverter, fuses in one polarity are sufficient to protect both polarities, as required by HD 60364-7-712 cl. 712.432.101.

[1] Excluding the use of the M1600 Power Optimizer.

[2] Refer to the original Staubli MC4 datasheet on the Staubli website.

[3] Refer to the "Maximum Output Current" in the relevant Power Optimizer datasheet for the maximum rating.

String fuse requirements

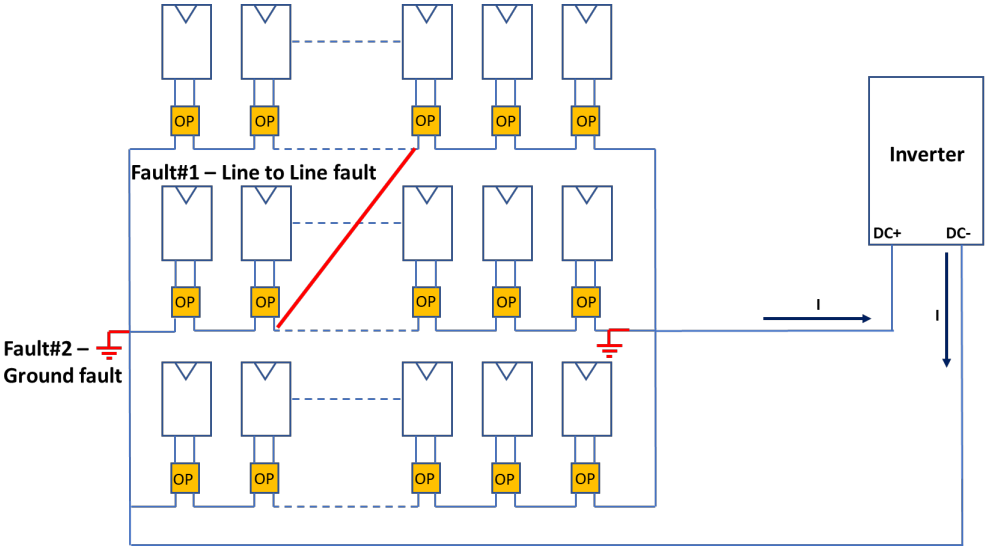
According to IEC 62548 and US NEC -2017 Article 690.9, there is a need for string overcurrent protection (string fuses) if the possible reverse current is higher than the maximum rating of the PV module. According to EN 60269-6, a string fuse must disconnect a current that is 1.35x (IEC)/1.56x (US NEC) its rating within one hour. That is, wires and modules must withstand currents up to 35% (IEC)/56% (US NEC) higher for one hour. For shorter time frames, higher currents may occur so wires and modules must withstand higher currents for up to one hour.

In a SolarEdge system, the PV modules are not connected directly to the inverter. Hence, when evaluating whether string fuses are required, the installer must consider if reverse or fault currents can affect all the system's components such as: PV modules, Power Optimizers, combiner boxes, connectors, etc.

Fault scenarios

To create reverse current in a PV system, a string or a part of a string must be short-circuited. This can be caused either by two consecutive ground faults or by a line-line fault.

A schematic of the two insulation faults is depicted in the following figure:



Short-circuits due to Line-Earth (Ground) faults

String inverter systems

In string inverter systems, an earth fault will create an insulation fault indication at the inverter and a transformer-less inverter will also disconnect from the grid, however the fault remains. In the case of a second insulation fault in another part of the DC system (either in the same string or in a different string), the string or part of it is short-circuited. Then, a critical reverse current, being higher than the fuse rating of the PV module, can flow through the PV modules. A string overcurrent protection device is required, with a lower current rating than the max rating of the PV module, to interrupt this current. In case of a reverse current lower than the module rating, this current will not be interrupted, and there may be risk of a fire at the earth fault location. From the standard's point of view, this risk is considered low and therefore protection is not required.

SolarEdge Systems

In SolarEdge systems, an earth fault will create an insulation fault reaction leading to system shutdown. Not only is the inverter disconnected, but the optimizers shut down and enter safety mode, reducing the string current to a safe level around 0A . In case of a second fault, there might be scenarios where current will flow momentarily. When there are three parallel strings or fewer installed, the SolarEdge system sustains the resulted current, and the optimizers minimize the chance of reverse current flowing to the modules. Thus, no additional string protection is required.

Short-circuits due to Line-Line faults

Due to the use of double-insulated single-core wires, the risk of line-line faults is low. Therefore, to protect PV modules from the effects of short-circuits, no additional overcurrent protection devices (such as string fuses) are required by the standard. Nevertheless, such faults must be considered.

String inverter systems

In string inverter systems, a line-line fault can create a critical reverse current. To protect the PV modules, string overcurrent protection is necessary if the PV module rating is insufficient. However, even with string fuses, when the current is lower than the module rating there is a current at the fault location, and it may cause a fire.

SolarEdge systems

SolarEdge Power Optimizers provide internal current limitation. Due to the topology and the control of the switches, no reverse current can flow to a PV module. The Power Optimizers limit current at the PV module input to 20A, depending on the model[4]. They also limit current at the Power Optimizer DC output circuit up to a constant value of the “Maximum Output Current”. For the S1200 this value is 20A, and for the S1400/S1500 the value is 24A. The SolarEdge Power Optimizers are certified to provide zero back feed current to the PV module, and zero back feed current to the rest of the string, meaning that the string current can flow in only one direction. Therefore, there is no risk of reverse currents in the modules.

In most cases, a line-line fault affects the fixed-voltage control and immediately leads to system shutdown, including shutdown of the optimizers, reducing the string current to a safe level around 0A. However, if the wires are not sized to have current carrying capabilities appropriate for the maximum current, there may be a need to have overcurrent protection devices to protect the wires until the shutdown occurs.

When installing three (or fewer) parallel strings, no string overcurrent protection is needed if the wires are able to withstand the potential reverse current for 15 seconds. In comparison to the traditional string inverter systems, there is no current after this time, and no risk of a fire at the location of the fault itself.

[4] As specified in the "Maximum Short Circuit Current" parameter in the relevant Power Optimizer datasheet.

Overload protection

String inverter systems

In string inverter systems, string currents can be higher than the STC values in the module datasheet. Therefore, a safety margin is used (for example 10%) to account for higher irradiances and other ambient conditions, which may increase the current.

SolarEdge systems

In a SolarEdge system, the string current is limited to the Power Optimizer's maximum output current, even if module current increases due to ambient conditions. In addition, the Power Optimizers limit the current at the PV module input. Therefore, no safety margin is needed when calculating maximum string current.