SolarEdge Always Puts Safety First

With millions of installations worldwide, solar energy is designed to be safe and reliable. However, as the industry grows and matures and installations increase, stricter safety standards and regulations are becoming more commonplace, much the same as they are across many other industries. These outline that should a fire break out, installers, maintenance personnel and fire fighters must be able to reduce DC to a safe voltage whenever AC power is off.

Without adequate precautions, a high DC voltage can lead to electrocution and burn hazards for these individuals. Due to increasing awareness, fire brigades and insurance companies are requesting stricter safety standards.

SolarEdge offers enhanced safety with two embedded features, SafeDC™ and arc fault detection and interruption to reduce the risk of electrocution and fires.

Arcing can happen when connecters and/or cables in a PV system are damaged or improperly connected, when PV systems age and connectors and cables degrade, or, when animals chew the cables.

When connecters or cables are damaged, it may result in an electric arc. Arcing generates heat, which could lead to fires. Additionally, arcs can electrify the installation, causing the mounting system to become charged, which can potentially result in electric shocks for anyone touching the system.

In compliance with the UL1699B arc detection standard, SolarEdge inverters have built-in protection designed to mitigate the effects of some arcing faults that may pose a risk of fire. SolarEdge is compliant with this requirement that defines automatic shutdown of inverters until necessary checks can be undertaken and manual restart where the inverter remains in standby/night mode pending a status change. This helps to increase personal safety, protect equipment and prevent structural damage.

solaredge

SafeDC™ reduces the risk of working around damaged cables

To decrease DC voltage to a safe level, SolarEdge inverters are designed to automatically switch into safety mode when AC is shutdown. This built-in SafeDC™ feature ensures that the output voltage of each module is reduced to a touch-safe 1V whenever AC power is off.*

Why SolarEdge PV systems compare more favorably against traditional inverters

SolarEdge System	Traditional Inverters
SafeDC™ is always on and embedded in the technology.	Even when the inverter is shutdown, there is still high voltage in the wiring, making it unsafe to the touch.
When there is no communication between the inverter and power optimizer, the default output voltage of each power optimizer is 1V per module.	Rooftop array disconnect switches only terminate the flow of current from the roof to the inverter. The modules on the roof, their cabling, and the cabling all the way to the inverter remain energized and dangerous while there is daylight.
SolarEdge inverters are designed to identify arc detections and subsequently shut down, in compliance with UL1699B arc detection standard.	Third-party arc fault detectors are usually required, adding further costs and installation effort.

Don't just take our word for it

Riccardo Betti, CEO of All Energy & Architecture, had this to say about SolarEdge's SafeDC™ feature:
"Because of the high fire risk at the fuel deposit, we chose a technology that would allow the customer to go about their business with total peace of mind. We proposed SolarEdge DC optimized inverters due to its positive safety record, embedded SafeDC™, and arc fault detection technology. This PV solution allows the customer to work safely during normal operations and even during potential emergencies."

For more information on SolarEdge's enhanced safety features, see this white paper.

*Certified in Europe as a DC disconnect According to IEC/EN 60947-1 and IEC/EN 60947-3, VDE AR 2100-712, and OVE R-11-1.

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About SolarEdge

SolarEdge is a global leader in smart energy technology. By deploying world-class engineering capabilities and a relentless focus on innovation, we create smart energy products and solutions that power our lives and drive future progress.

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Safety Risks & Solutions in PV Systems for North America

White Paper

Introduction

In traditional photovoltaic (PV) systems, high DC voltages are present and pose risks to installers, maintenance personnel and firefighters. In addition, the possibility of electrical arcs, which can result in a fire, creates a threat to people working or living in the vicinity of a PV system. Safety mechanisms required by the National Electric Code (NEC) and Electrical Safety Authority (ESA) are not sufficient to remove all risks and ensure a safe working environment. The SolarEdge system provides a level of safety beyond that required by code.

This document details the safety risks inherent to traditional PV systems and the SolarEdge safety mechanisms which overcome these risks.

Traditional systems

Installation Safety

PV modules typically have an output voltage of 30-60V. Connecting several of these modules serially in a string creates a high voltage which can be dangerous to installers during system installation. Traditional string inverters cannot reduce this DC voltage even if they are turned off.

Maintenance and Firefighting Safety

Once modules are connected in a string, the voltage can reach up to 600Vdc (residential and commercial systems) or up to 1000Vdc (commercial systems). After connecting the strings to an inverter the PV system will operate at these high voltages. Installers, maintenance personnel or firefighters who need to work on or near the system are exposed to these high voltages. Shutting down the main circuit breaker will shut down traditional string inverters but will not shut down the DC voltage, which will remain high as long as the sun is out.

Several safety measures can be employed in these cases, but none of them remove the high voltages:

1. Shutdown functions in traditional inverters merely interrupt current flow while voltages remain dangerously high.

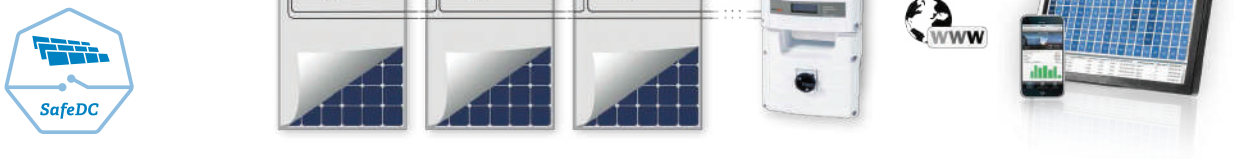
2. Automatic DC breakers located on the inverter cannot disconnect the voltage at the modules (only at the inverter), adding cost without decreasing the risk.

3. PV module covering (during firefighting):

   a. Spray Foam – this approach has proven to be ineffective because the foam evaporates or slides off the modules before the fire is extinguished.

   b. Covering the module with an opaque material – this approach requires the firefighters to climb onto the burning roof, risking electrocution.

SafeDC™ = Shutdown, arc detection & termination at the module-level



Arc Prevention

When connecters and/or cables in a PV system are improperly connected or are damaged, the electric current may pass through the air, causing an electric arc. Arcs generate heat which can cause fires and they also pose a risk of electrocution to those working near them. As PV systems age and connectors and cables degrade, the risk for electric arcs, while still low, increases. UL/CSA safety requirements pertaining to arcs are being put into place, but they require only the ability to terminate an arc through inverter shut down, not the ability to prevent its occurrence. This means that the associated risks of electrocution and fire are not eliminated.

The SolarEdge solution

The SolarEdge system consists of power optimizers connected to each module, a PV inverter and module-level monitoring. In addition, SolarEdge systems have a built-in safety feature, Safe DCTM, which eliminates safety risks during installation, maintenance and firefighting.

The SolarEdge SafeDC™ does the following:

1. Automatic shut-down of PV arrays during emergency shut-down.
2. Lowers and maintains the voltage in all DC conductors below 50V.

Installation Safety

When the SolarEdge power optimizers are not connected to an operating SolarEdge inverter, they each limit their output to a safe voltage of 1V. This means that during installation, long strings of power optimizers can be connected without creating a high DC voltage. For example if 19 power optimizers are connected in series, the string voltage will be 19V.

Maintenance and Firefighting Safety

Once the strings are connected to the SolarEdge inverter and the PV system is operating, the system operates at a fixed DC voltage of 350V (single phase non-HD-Wave inverters), 380V/400V (single phase HD-Wave inverters) or up to 425V to ground (three phase inverters).

For maintenance or firefighting purposes, shutting down the AC power will automatically reduce the DC voltage to 1V per power optimizer. This can be done in one of several methods:

1. Shutting down the main AC breaker
2. Turning the inverter ON/OFF switch to OFF
3. Turning the AC/DC Safety Switch to OFF
4. Pressing the Firefighter Gateway switch (available if gateway is installed; SolarEdge systems have full safety capabilities also if Firefighter Gateway is not installed)

Arc Prevention

In addition to the built in safety features of the SolarEdge system, SolarEdge inverters are UL1699B certified, providing NEC 2011 690.11 compliance[1].

Conclusion

High DC voltages created by PV arrays can be dangerous if not adequately controlled. Traditional string and central inverters have a limited ability to control DC string voltage and therefore pose a risk to those living or working near an array. The SolarEdge system, with its built-in SafeDCTM mechanism and arc prevention capabilities, is the best solution to ensure complete safety for PV installers, maintenance personnel and firefighters.

[1)] Refer to the SolarEdge inverter datasheets for details on specific model compliance.

Application Note - Inverter Arc Detection in SolarEdge Systems

Revision History

- Version 1.4, March 2020: Merged North America and Europe/APAC versions
- Version 1.3 (Europe/APAC) January 2020: Automatic reconnection process is described
- Version 1.2, May 2018: Addition of SetApp usage
- Version 1.1 (North America), January 2018: Canadian Electric Code update
- Version 1.1, Nov. 2017:
  - Error codes update according to new format released in inverter CPU v3.19xx
  - Auto reconnection time is the grid reconnection time according to the country setting (Europe/APAC)
- Version 1.0, June 2016 - Initial release

Electric Arcs and Related Standards

An electric arc is an ongoing high-energy discharge, resulting from a current through a normally non-conductive material such as air.

When connecters or cables in a PV system are improperly connected or are damaged, the electric current may pass through the air, causing an electric arc. Arcs generate heat which can cause fires and they also pose an electrocution risk to those working near them. As PV systems age and connectors and cables degrade, the risk of electric arcs, while still low, increases.

In **North America**, UL/CSA safety requirements pertaining to arcs (UL1699B), requiring the ability to detect and terminate an arc through inverter shut down. The system has to remain shut down until an installer has checked the site and replaced any components if needed. Only then can the system be manually restarted.

In **Europe and APAC**, there are currently no standards for arc fault detection. In addition, there is no IEC or EN product standard available for arc fault detection (however there are recommendations in installation standards, e.g. IEC 62548). Since the risk of arcs in PV systems exists everywhere, arc fault detection is recommended and may be required in the future.

Arc Fault Detection in SolarEdge Systems

North America

SolarEdge inverters with model numbers 3000H/9K and higher are compliant with the North American UL1699B safety requirement, and are designed to detect arcs as specified in this standard. After detection, the power optimizers and inverter interrupt production, and, as required by this standard, a qualified person must re-enable the inverter after properly checking the installation.

The above-mentioned SolarEdge inverter models (*excluding* the Single Phase Inverter with compact technology) with CPU version 3.19xx / 4.xx and higher support Arc Fault Circuit Interruption (AFCI) functionality as follows:

- In inverters with DSP1 version 1.210.787 (single phase inverters) / 1.13.702 (three phase inverters) and above, the AFCI function is enabled by default.
- In inverters with lower versions that support AFCI, the AFCI function is disabled by default. The AFCI function can be enabled from the inverter menu, as described in the section, Enabling and Testing Arc Fault Detection.

When AFCI is enabled, the inverter performs an automatic self-test for the arc fault detector each time the inverter “wakes-up” or is switched ON.

Canadian Electric Code

The optimizer is a DC/DC converter located at the PV modules. Once an arc is detected, the optimizer stops production instantly. This is SolarEdge's SafeDC™ technology and is commonly referred to as "module level shutdown". Optimizer outputs are connected in series to build a DC output circuit that connects to the inverter which also stops production when an arc is detected.

Canadian Electric Code 2015 has specific requirements for protection against damage from rodents. Rule 64-210(5) states, "*Where the dc arc-fault protection referred to in Rule 64-216 is not located at the module, photovoltaic source circuit conductors and cables installed on or above a building and installed in accordance with Subrules (1), (2) and (3) shall be provided with mechanical protection, in the form of an enclosed raceway or other acceptable material to protect against damage from rodents.*" The SolarEdge DC arc-fault prevention and protection is located at both the module level and the inverter level. Therefore PV arrays with SolarEdge optimizers and inverters do not require additional mechanical protection of the conductors to comply with 64-210(5).

For additional information refer to *Safety Risks & Solutions in PV Systems for North America*
https://www.solaredge.com/sites/default/files/fire_safety_white_paper-na.pdf

In the event of rodent damage that results in a fault on the DC input conductors to the optimizer, the available fault current and voltage are limited to the input of the optimizer. In the event of rodent damage at the DC output conductors that results in a fault, the available fault current is zero and voltage is less than 30 volts DC[(1)].

Europe and APAC

SolarEdge inverters with model numbers 2200H/3K and higher are compliant with the North American UL1699B safety requirement. The same inverters with CPU version 3.19xx / 4.xx and higher support Arc Fault Circuit Interruption (AFCI) functionality. When AFCI is enabled, the inverter performs continuous arc testing.

There are two modes of inverter reconnection after an arc detection event:

- **Manual Reconnect** - The system must be manually restarted on site following inverter shut down.
- **Auto Reconnect** - Reconnects the system automatically after grid reconnection time according to the country-specific setting. If no country-specific reconnection time is specified, the default reconnection time is 30 seconds following inverter shutdown. If the arc detection persists, the inverter again disconnects and reconnects after the grid connection time, which is doubled following each detection, until the event is resolved.

(1) Each optimizer has a 1V output when the system is shut down. To comply with rapid shutdown, string length is limited to 30 optimizers in series, resulting in no more than 30V present on the DC circuit conductors after a fault is detected.

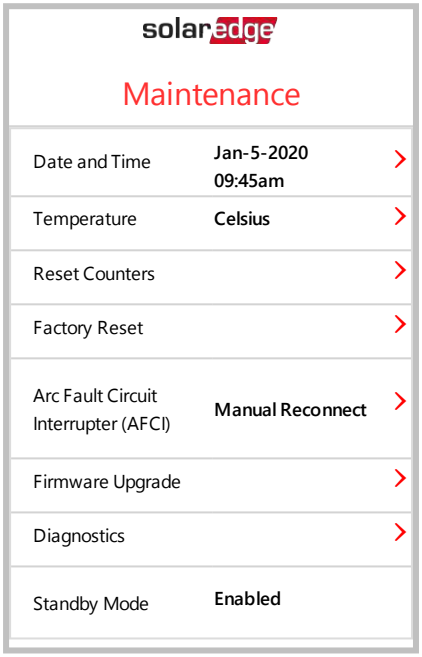
Enabling and Testing Arc Fault Detection

The following sections describe how to enable and test the arc fault detection using :

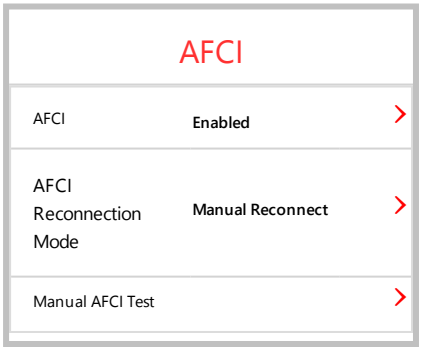
- SetApp
- The inverter display (LCD)

Using SetApp

1. Access SetApp from your mobile device and select **Commissioning ➔ Maintenance** . The Maintenance screen is displayed.



2. Tap **Arc Fault Circuit Interrupter (AFCI)**. The AFCI screen is displayed.



3. Select **AFCI ➔ Enable** or **Disable**.

→ To enable manual reconnect / auto connect (Europe and APAC only):

1. From the **AFCI** screen tap **AFCI Reconnection Mode** and choose the required mode: **Manual Reconnect** or **Automatic Reconnect**.

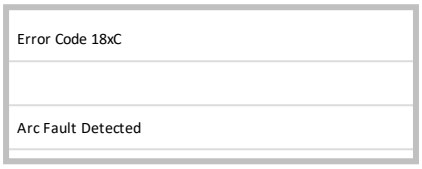
→ To manually test the arc detection functionality:

1. Make sure the inverter ON/OFF switch is turned ON.
2. From the **AFCI** screen tap **Manual AFCI Test**.

If the test is successful, the following message is displayed:

The inverter production is then interrupted (as if a real arc detection has occurred), and one of the following error codes is displayed, as shown in the example below:

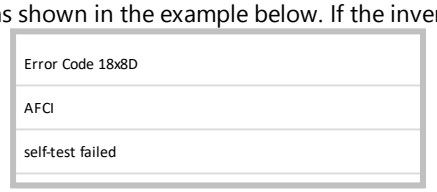
- Single phase inverter error codes: 18xC, 18xD
- Three phase inverter error codes: 8xC, 8xD, 8xBA



3. Perform manual restart to resume system operation: Turn the inverter ON/OFF switch to OFF and then to ON. The inverter performs an arc detection self-test and starts normal operation. If the test fails, contact SolarEdge support.

→ To troubleshoot self-test failures:

If the self-test fails, the SetApp displays an error message indicating that the arc detector hardware failed during the wake-up tests, as shown in the example below. If the inverter is connected to the monitoring platform, the error is displayed there as well.



The inverter continuously repeats the arc detection self-test until it is successful.

If the problem persists, contact SolarEdge support.

Using the Inverter Display (LCD)

→ To enable/ disable arc detection:

1. Enter Setup mode and scroll to the **Maintenance** menu.
2. Select **AFCI ➔Enable** or **Disable**.

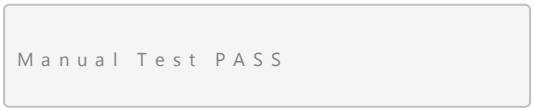
→ To enable manual reconnect / auto connect (Europe and APAC only):

1. Enter Setup mode and scroll to the **Maintenance** menu.
2. Select **AFCI ➔AFCI Mode** and choose the required mode: **Manual Reconnect** or **Auto Reconnect**.

→ To manually test the arc detection functionality:

1. Make sure the inverter ON/OFF switch is turned ON.
2. Select **Maintenance ➔Manual AFCI Test**.

   If the test is successful, the following message is displayed:



   The inverter production is then interrupted (as if a real arc detection has occurred), and one of the following error codes is displayed, as shown in the example below:

- Single phase inverter error codes: 18xC, 3x11
- Three phase inverter error codes: 8xC, 8xBA

3. Perform manual restart to resume system operation: Turn the inverter ON/OFF switch to OFF and then to ON. The inverter performs an arc detection self-test and starts normal operation. If the test fails, contact SolarEdge support.

→ To troubleshoot self-test failures:

If the self-test fails, the SetApp displays an error message indicating that the arc detector hardware failed during wake-up tests, as shown in the example below. If the inverter is connected to the monitoring platform, the error is displayed there as well.

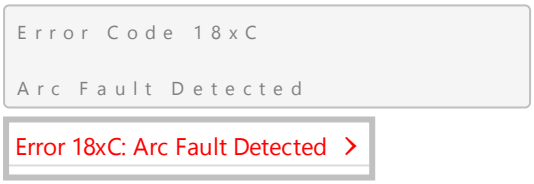
The inverter continuously repeats the arc detection self-test until it is successful.

If the problem persists, contact SolarEdge support.

Troubleshooting Arc Fault Events

The inverter continuously performs arc detection while producing power. If an electric arc is detected, the inverter stops producing power, and an error code is displayed on the LCD or SetApp, as shown in the example below; if the inverter is connected to the monitoring platform, the error is displayed there as well):

- Single phase inverter error codes: 18xC, 3x11
- Three phase inverter error codes: 8xC, 8xBA



If this message is displayed:

1. Turn the inverter ON/OFF switch to OFF.
2. Check all PV strings for the correct open-circuit voltage:
   - Inspect all connections and cables between the power optimizers in the strings: Verify they are connected properly by firmly pushing and pulling the plugs and verifying the connectors are locked.
   - Inspect all connections and cables between the PV modules and the power optimizers: Verify they are connected properly by firmly pushing and pulling the plugs and verifying the connectors are locked.
   - Verify that the strings are firmly attached to the DC Safety Unit (if applicable) terminal blocks.
   - Verify all site-made connectors are firmly connected to their conductors by pulling from the conductor side of the connection.
3. If the system is set to manual reconnect, do the following:
   - Turn the inverter ON/OFF switch to OFF.
   - Turn the inverter ON/OFF switch to ON. The inverter performs an arc detection self-test and starts normal operation.

Application Note - Rapid Shutdown in SolarEdge Systems, Europe & APAC

Revision History

- Version 1.0, Feb. 2019 – Initial release

Introduction

The SolarEdge system incorporates many safety mechanisms, ensuring safety for installers, maintenance works and firefighters. Rapid shutdown (RSD) is a safety mechanism which refers to the fast discharge of conductors to a safe voltage level.

In North America, the National Electrical Code (NEC), section 690.12, defines RSD requirements for PV systems on buildings. The requirements were first introduced in NEC 2014, and updated in NEC 2017. SolarEdge inverters installed in North America have complied with these requirements since they have come into effect. Specifically, NEC 2017 690.12 requires that in rooftop PV systems, controlled conductors beyond 1ft (30.5cm) of the array will be reduced to 30 volts or less within 30 seconds.

The SolarEdge SafeDC™ feature ensures the DC voltage of a system is reduced to a safe level when the system is shut down, within up to 5 minutes. While in Europe and APAC there is currently no RSD standard, reducing the DC voltage within 30 seconds allows installers, maintenance works and firefighters to handle the system very soon after shutdown, which is of particular importance in case of an emergency. Therefore, adopting RSD is recommended, and may be required in the future by local regulation. To this end, SolarEdge inverters installed in Europe and APAC comply with the NEC 2017 rapid shutdown requirements as detailed below.

SolarEdge Rapid Shutdown Advantage

SolarEdge is among very few solar equipment manufacturers who provide **integrated** rapid shutdown functionality in compliance with NEC regulations. Other manufacturers offer this capability via external components (contactors, shunt trip breakers, or other remotely controlled switches), which may add complexity and increase the cost. The SolarEdge RSD solution advantages are:

- No additional components: 3rd party solutions typically need extra fuses or circuit breakers, adding cost, field work and potential quality issues that can increase time on site for troubleshooting
- No additional wiring: 3rd party solutions require additional wires for RSD, and they must have suitable voltage ratings in order to be placed in a conduit together with PV system conductors, otherwise they must be placed in a different conduit, increasing cost and labor

Rapid Shutdown in SolarEdge Systems

Supporting Inverters

The following SolarEdge inverters support rapid shutdown (no additional hardware installation required):

- Single Phase Inverters with HD-Wave Technology, SE2200H-SE6000H, with the following part number: SExx00H-RW**R**00**B**NN2
- Three Phase Inverters, SE27.6K-SE100K, with the following part numbers: SExxK-RWRxxxxxx, SExxK-INRxxxxxx

String Length

To comply with NEC rapid shutdown, each string must have no more than 30 optimizers per string. If longer strings are connected, their voltage will be reduced within 30 seconds upon rapid shutdown initiation, but the voltage will be >30V (it will be reduced to 1V * number of optimizers in the string).

Initiating Rapid Shutdown

Rapid Shutdown can be initiated by one of the following methods:

- The inverter AC breaker is turned OFF, or AC to the inverter is disconnected by another method (intentionally or as the result of a fault)
- The inverter ON/OFF switch is turned OFF
- The DC switch is turned OFF (applicable only to inverters with a DC safety Unit)