Application Note

Arc Fault Detection in SolarEdge Commercial Three Phase Inverters – North America

Version 1.0

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Electric arcs and related standards

An electric arc is an ongoing high-energy discharge, resulting from a current passing through a normally non-conductive material such as air. As PV systems age and connectors and cables degrade, the risk of electric arcs, while still low, increases. Arcs generate heat which can cause fires as well as pose an electrocution risk to those working near them. Another common factor which can cause risk of electric arcs are rodents damaging the cables.

In North America, UL/CSA safety requirements pertaining to arcs (UL1699B) require 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. Only then can the system be manually restarted. In compliance with this safety standard, SolarEdge inverters have a built-in protection mechanism that keeps the inverter standby/night mode pending a status change, and then is manually restarted. This mechanism is designed to protect against the effects of arcing faults - enhancing personnel safety, and protecting stakeholder assets. Please refer to the SolarEdge AFCI Standard compliance compatibility table below to check the type of inverters that are compliant with this standard.

In Europe and APAC, there is the new IEC63027 standard for arc fault detection, which is not mandatory yet. In compliance with this standard, SolarEdge inverters have built-in protection designed to protect against the effects of arcing faults through automatic shutdown, thorough checks, and manual restart where the inverter remains in standby/night mode pending a status change.

A comparison between the two above-mentioned standards appears in the following table:

Topic	UL 1699B (2018)	IEC 63027
Type of arc fault	Series	Series
Location of arc fault	Input and string wires	Input and string wires
Full string impedance	50 µH + 0.7 µH/meter beyond 80 meters	50 µH
Arc duration and energy thresholds	Disrupt arcing event in less than 2.5 seconds, and limit energy to a maximum of 750 J.	Disrupt arcing event in less than 2.5 seconds, and limit energy to a maximum of 750 J.
Resuming operation	After each arc is extinguished, the system shall delay no less than five minutes before resuming operation. The five-minute delay is not required after a manual reset. If five arc events occur during a 24-hour period, the system shall open the circuit and shall require a manual reset before returning to operation.	No manual procedure is required if a minimum interruption time of five minutes is ensured before resuming operation of the array. If five arc events occur during a 24-hour period, the reset must be performed manually.

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 inverters interrupt production, and, as required by this standard, a qualified person must re-enable the inverters after properly checking the installation.

The above-mentioned 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 Power Optimizer is a DC/DC converter located at the PV modules. Once an arc is detected, the Power 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 Power Optimizers and inverters do not require additional mechanical protection of the conductors to comply with 64-210(5).

For additional information refer to the document: Safety Risks and Solutions in PV Systems for North America

In the event of rodent damage that results in a fault on the Power Optimizer DC input conductors, the available fault current and voltage are limited to the input of the Power Optimizer. In the event of rodent damage at the DC output conductors that results in a fault, the available fault current is zero and the voltage is less than 30 VDC.

NOTE

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

Introduction to IEC 63027 Classification Scheme

The IEC 63027 classification scheme provides a standardized method for describing the type, coverage area, and other critical aspects of devices used in testing and installation. Manufacturers must provide this information as a code, with individual features separated by dashes. The table below outlines the structure of this classification:

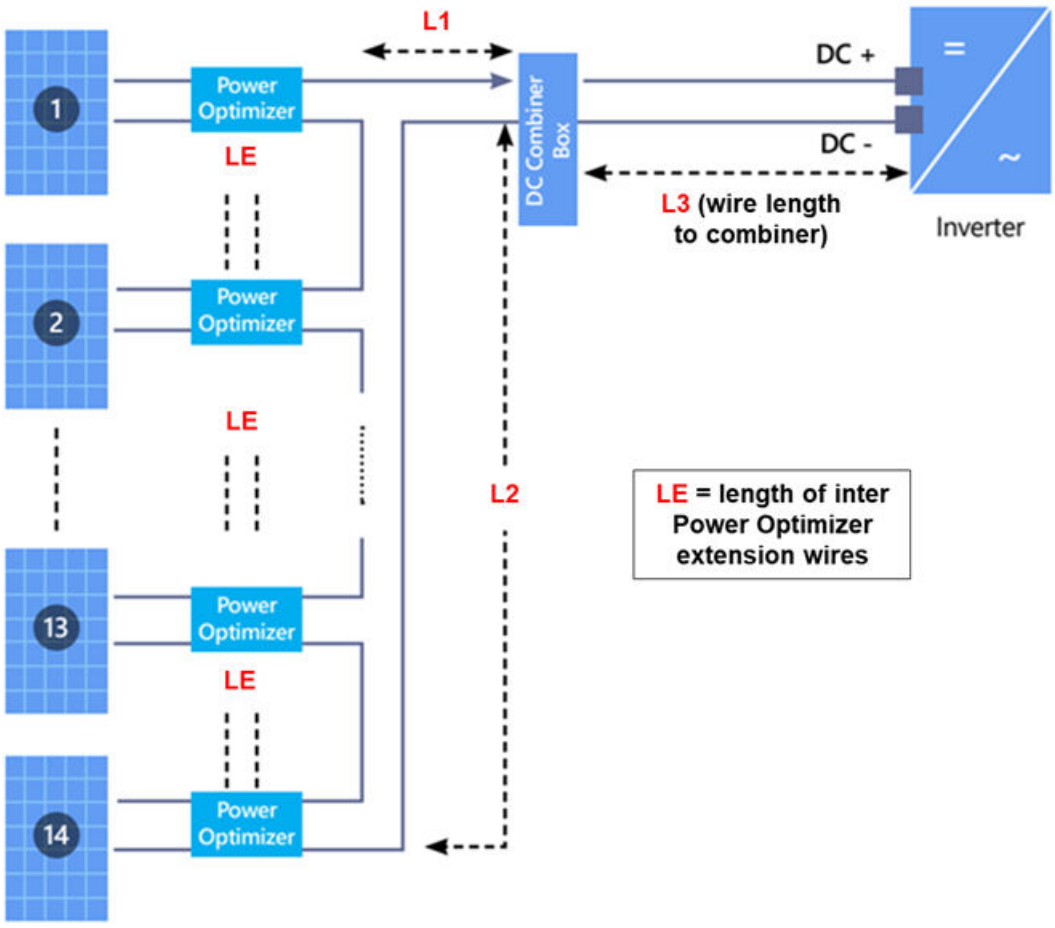
Position	Description	Code	Explanation
1st	Scope of protection	F	The arc-fault monitoring system covers all PV modules up to the DC inputs of the inverter.
		P	All PV modules are covered up to a Combiner Box, but not the main line up to the input terminals of the inverter.
2nd	Implementation method	I	Integrated solution (e.g., in the inverter)
		S	Stand-alone device
3rd	Scope of functionality	D	The functionality is achieved by a combination of several devices.
		AFPE	Complete solution: both detection and disconnection/interruption of the electric arc are integrated.
		AFD	The product can only detect the electric arc but cannot directly disconnect and interrupt it.
4th	Maximum number of strings per DC input	-	Number of strings that may be connected per DC input in the respective constellation.
5th	Number of DC inputs per arc fault sensor (AFS)	-	Number of DC inputs assigned to an arc fault sensor (AFS).
6th	Number of integrated arc fault sensors (AFS)	-	Total number of arc fault sensors (AFS) per device.

SolarEdge Arc Fault Circuit Interrupter

The SolarEdge safety solution employs a variety of active safety mechanisms that are designed to ensure continuous protection of the SolarEdge PV system. This includes rapid reduction of DC voltage to touch-safe levels upon system shutdown, early fault detection and possible prevention, and real-time, actionable module-level alerts.

In doing so, the SolarEdge safety solution is compliant with US UL 1699B 2018 and European IEC 63027 safety standards as detailed in the following table and figure.

Arc Types (refer to the below image)	As defined in UL 1699B 2018
Maximum length (L1 + L2 + LE + L3), for a single string (round trip)	Up to 400 meters
Total string length (L1 + L2 + LE + L3), total for all strings connected to an inverter (round trip)	Up to 700 meters
Arc detection accuracy	99%
Additional technical requirements	None

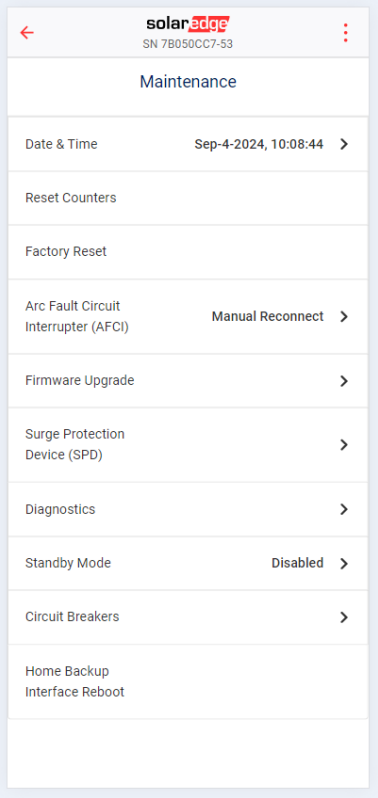


Enable and test arc fault detection

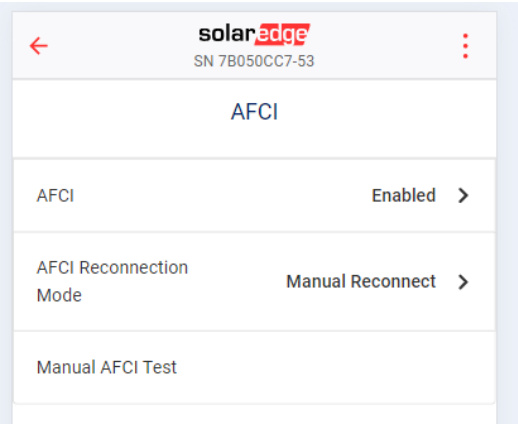
The following sections describe the process for enabling and testing arc fault detection using SetApp or the inverter LCD display.

Fault detection using SetApp

1. Access SetApp from your mobile device and select Commissioning > Maintenance. The Maintenance screen displays.

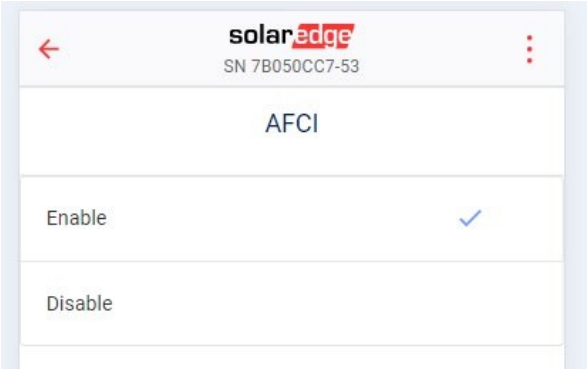


1. Select Arc Fault Circuit Interrupter (AFCI). The AFCI screen displays.



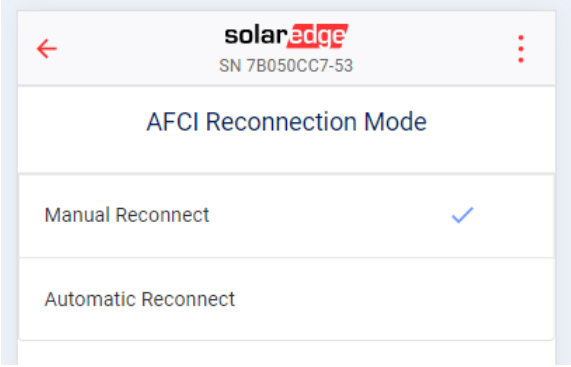
2. Select AFCI.

3. Ensure AFCI is in enable mode.



To enable Manual Reconnect or Automatic Reconnect (Europe and APAC only):

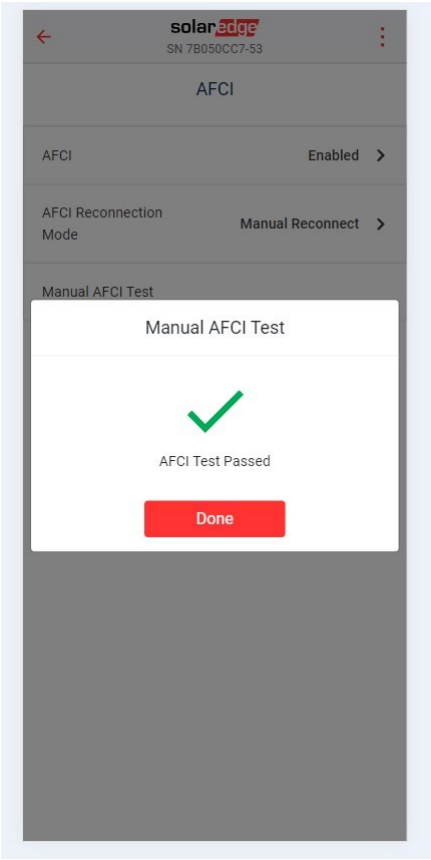
1. In the AFCI screen tap AFCI Reconnection Mode.
2. Select Manual Reconnect or Automatic Reconnect.



To manually test the arc detection functionality:

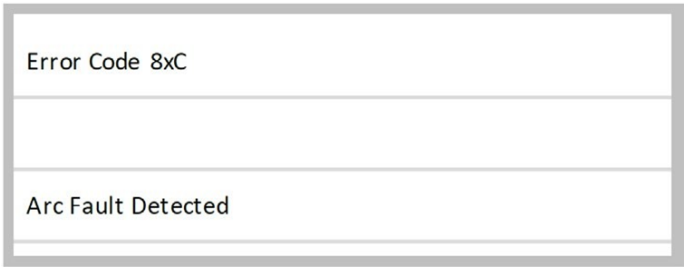
1. Power ON the inverter.
2. In the AFCI screen select Manual AFCI Test.

If the test is successful, the following message displays:



Inverter production is interrupted simulating a detected arc, and one of the following error codes displays:

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



To resume system operation, perform a manual restart as follows:

Power OFF the inverter and then ON again. The inverter performs an arc detection self-test and starts normal operation.

To troubleshoot self-test failures:

If the self-test fails, SetApp displays an error message indicating that the arc detector hardware failed during the wake-up tests.

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.

Fault detection using the inverter LCD display

To enable or disable arc detection:

1. Enter Setup mode and scroll to the Maintenance menu.
2. Select AFCI < En/Dis >.

3. Select Enable or Disable.

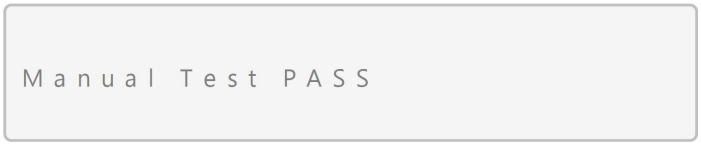
To enable Manual Reconnect or Auto Reconnect (Europe and APAC only):

1. Enter Setup mode and scroll to the Maintenance menu.
2. Select AFCI Mode < MAN / AUTO > and choose Manual Reconnect or Auto Reconnect.

To manually test the arc detection functionality:

1. Power ON the inverter.
2. Select Maintenance > Manual AFCI Test.

If the test is successful, the following message displays:



Inverter production is interrupted simulating a detected arc, and one of the following error codes displays:

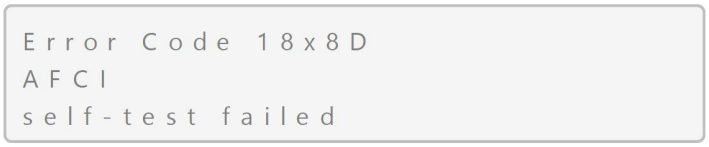
- Three phase inverter error codes: 8xC, 8xBA

To resume system operation, perform a manual restart as follows:

Power OFF the inverter and then ON again. The inverter performs an arc detection self-test and starts normal operation.

To troubleshoot self-test failures:

If the self-test fails, an error message displays indicating that the arc detector hardware failed during the wake-up tests.

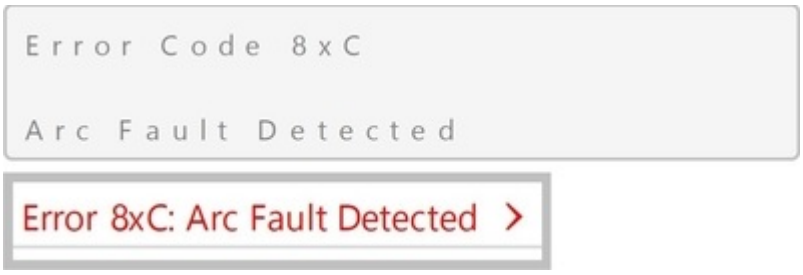


If the inverter is connected to the monitoring platform, the error is displayed there as well.

The inverter continuously repeats the arc detection self-test until it is successful. If the problem persists, contact support.

Troubleshoot 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 in SetApp, as shown below.



- Three phase inverter error codes: 8xC, 8xBA

If the inverter is connected to the monitoring platform, the error is displayed there as well. If one of these messages displays, perform the following:

1. Power OFF the inverter.
2. Check all PV strings for the correct open-circuit voltage:

- Inspect all connections and cables between the Power Optimizers in the strings. Verify that they are connected properly by firmly pushing and pulling the plugs and verifying that the connectors are locked.
- Inspect all connections and cables between the PV modules and the Power Optimizers. Verify that they are connected properly by firmly pushing and pulling the plugs and verifying that the connectors are locked.
- Verify that the strings are firmly attached to the terminal blocks (if applicable).
- Verify that all site-made connectors are firmly connected to their conductors by pulling from the conductor side of the connection.

If the system is set to Manual Reconnect, perform the following:

1. Power OFF the inverter.
2. Power ON the inverter.

The inverter performs an arc detection self-test and starts normal operation.

Upgrade inverter firmware via Monitoring Platform

To see the inverter version and instructions to upgrade it, refer to Remote Inverter Firmware Update in the Monitoring Platform - Application Note.

Upgrade inverter firmware via SetApp

To connect to the inverter via SetApp to upgrade it, follow the onscreen instructions. When the upgrade is successful, the screen will appear as below: