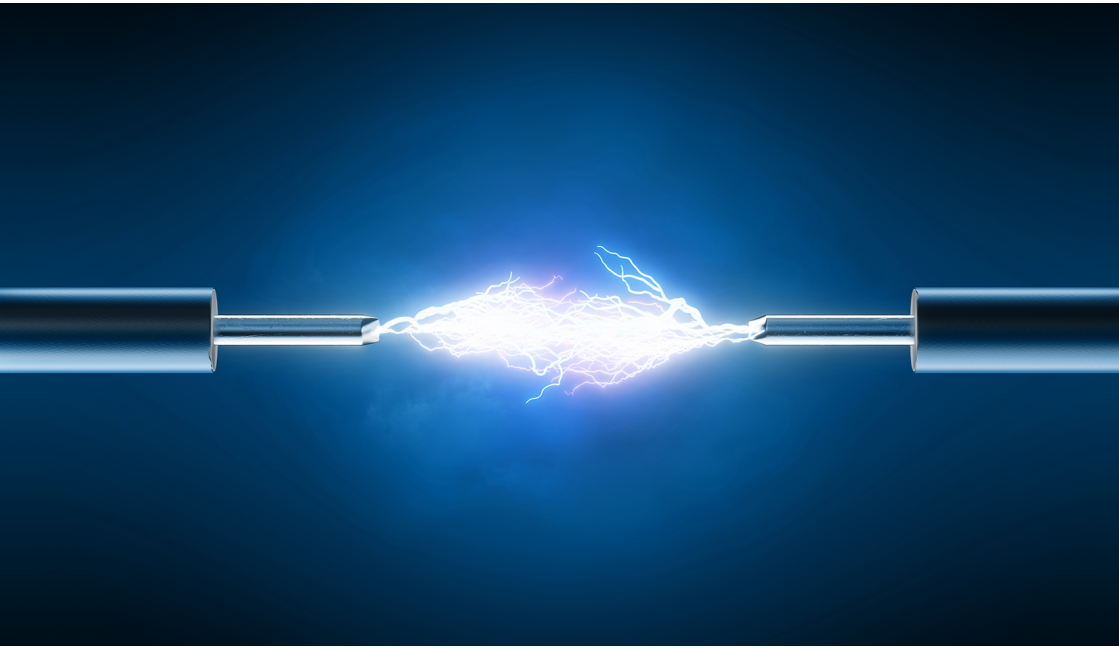
Technical Information



Arc-fault circuit interrupter

SUNNY BOY / SUNNY BOY SMART ENERGY / SUNNY TRIPOWER

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1 Introduction

PV systems that are built according to today's installation standards and with high-quality components are generally very safe. Nevertheless, in rare cases, faulty contact points in the cabling of the PV module or the installation on the DC circuit can cause electric arcs, which can damage both the system and the building.

When a PV inverter with an integrated arc-fault circuit interrupter (AFCI) is used, a serial electric arc in the PV array is detected soon enough and extinguished by an interruption of the current.

To give customers the highest level of safety, SMA Solar Technology AG has equipped the inverters listed in this document with SMA ArcFix, the effective arc-fault circuit interrupter (AFCI). This is an important component of the SMA SafeSolar holistic safety approach.

2 Target Group

This Technical Information is for installers and system designers and describes the basic information as well as all the necessary steps and prerequisites for using the arc-fault circuit interrupter.

3 Validity

This document is valid for:

Product	Device type
Sunny Boy 3.0 / 3.6 / 4.0 / 5.0 / 6.0	SB3.0-AV-41 SB3.6-AV-41 SB4.0-AV-41 SB5.0-AV-41 SB6.0-AV-41
Sunny Boy Smart Energy	SBSE3.6-50 SBSE4.0-50 SBSE5.0-50 SBSE6.0-50 SBSE8.0-50 SBSE9.9-50
Sunny Tripower X 12 / 15 / 20 / 25	STP 12-50 STP 15-50 STP 20-50 STP 25-50
Sunny Tripower CORE1	STP 50-41
Sunny Tripower CORE2 with AFCI	STP 110-60
Sunny Tripower 125	STP125-70

4 Basic Information

If an electric arc occurs in the DC installation of a PV system during feed-in operation, this causes a change in the current and a typical interference spectrum. In this case, high-frequency portions are superimposed upon the normal operating current. These two specified criteria are the basis for detecting an electric arc reliably.

5 Function

When the arc-fault circuit interrupter (AFCI) is enabled in the inverter, the PV array is monitored for electric arcs since they pose a risk of fire with larger currents. If a current phenomenon that is typical for electric arcs occurs (e.g. change in current, high-frequency portions), an electric arc is detected and the inverter immediately terminates the feed-in operation and reports this event. This event is reported via the user interface of the inverter or a higher-level communication device and Sunny Portal. Stopping the feed-in operation interrupts the current flow on the DC circuit and extinguishes the electric arc.

6 Settings options of the arc-fault circuit interrupter per inverter

The following settings can be made for the respective inverters:

Product	Activation type		
	Automatic restart	Manual Restart	Manual restart after 5 AFCI detections
Sunny Boy 3.0 / 3.6 / 4.0 / 5.0 / 6.0	✓	-[1]	-[1]
Sunny Boy Smart Energy	✓	✓	✓
Sunny Tripower X	✓	✓	✓[2]
Sunny Tripower CORE1	✓	✓	✓[3]
Sunny Tripower CORE2	-	-	✓
Sunny Tripower 125	✓	✓	✓

[1] The process used in the Sunny Boy ensures that electric arcs with an energy below 200 J are extinguished within 2.5 s. According to IEC 63027, a manual restart is not required.

[2] * Available from firmware version 03.02.07.R

[3] Available from firmware version 04.06.08.R

Arc-fault circuit interrupter without permanent operation interruption

If the arc-fault circuit interrupter (AFCI) is configured with automatic restart, the system should be monitored closely and recurring faults in the AFCI should be investigated immediately by qualified persons. If it is not possible to identify the cause of the error, the inverter should be taken out of operation until the investigation and corrective action can be completed. Recurring errors may cause damage to neighboring conductors and system components, which could result in more extensive system failures and damage and even to uncontrolled electric arcs and fires.

7 Operating modes of the arc-fault circuit interrupter

7.1 Automatic restart

The feed-in operation of the inverter is interrupted when an electric arc is detected, however the inverter resumes feed-in operation automatically. Yield losses can thus be avoided. Nevertheless, it is recommended to have the PV array checked by a qualified person after a fault has been reported.

7.2 Manual Restart

The feed-in operation of the inverter is interrupted when an electric arc is detected and the inverter goes into operation inhibition. The operation inhibition must actively be reset by the system operator so that the inverter resumes operation.

7.3 Manual restart after 5 AFCI detections

The feed-in operation of the inverter is interrupted when 5 electric arcs are detected within 24 hours and the inverter goes into operation inhibition. The operation inhibition must actively be reset by the system operator so that the inverter resumes operation.

8 Activation of the arc-fault circuit interrupter

The setting for activating the relevant operating mode can be made either on the user interface of the inverter or on a system manager (e.g. data manager or inverter as system manager). If the arc-fault circuit interrupter (AFCI) with manual restart is activated, this state can be reset via the inverter or, if necessary, a system manager. Follow the instructions of the relevant inverter manual.

9 Certifications and normative requirements

9.1 Overview of the standards

The following inverters conform to the following standards and functions:

Standard	UL 1699B Ed 1.1 STANDARD FOR SAFETY - Photovoltaic (PV) DC Arc-Fault Circuit Protection	IEC 63027:2023 - Photovoltaic power systems – DC arc detection and interruption	Assessment according to SMA test procedure
Explanation	The arc-fault circuit interruption (AFCI) has been copied completely and without modifications from the inverters indicated here which are used for the US market. They therefore use the UL 1699B Ed1.1 certified method for arc fault detection.	The compliance with IEC 63027 depends on the connection type of the PV modules. The permissible inverter connection types are listed in the following sections.	Reliability tests according to SMA standard.
Inverter			
Sunny Boy 3.0 / 3.6 / 4.0 / 5.0 / 6.0	-	✓	✓
Sunny Boy Smart Energy	✓	✓	✓
Sunny Tripower X	✓	✓	✓
Sunny Tripower CORE1	✓	✓	✓
Sunny Tripower CORE2	-	✓	✓
Sunny Tripower 125	-	✓	✓

9.2 Classification scheme IEC 63027

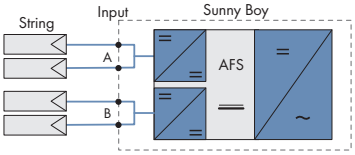
The classification scheme of IEC 63027 describes the device type, the coverage area and other important aspects relevant for testing and installation. This information must be provided by the manufacturer as a code. The individual features are separated by a dash. The following table provides an overview of how the classification is structured:

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

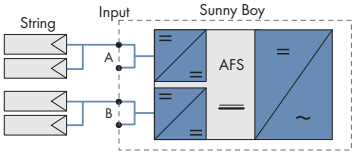
9.3 Permitted connection options for Sunny Boy 3.0 / 3.6 / 4.0 / 5.0 / 6.0

The following figure shows the permitted connection options for the particular application classes with a Sunny Boy.

F-I-AFPE-1-2-2



F-I-AFPE-2-1-2



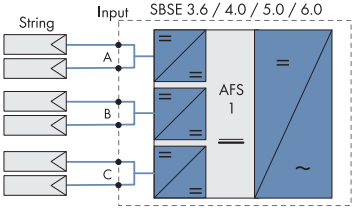
In the case of application class F-I-AFPE-2-1-2, an additional restriction applies. When only one DC input per MPPT tracker is assigned and the arc-fault circuit interruption is used simultaneously, the maximum short-circuit current must never be exceeded. In general, no more than 2 DC strings must be switched in parallel per MPP tracker in the system.

When the open-circuit voltage of the connected strings is less than 90% of the permitted open-circuit voltage of the inverter, yield losses of no more than 0.3% per year are incurred when the arc-fault circuit interrupter is activated. Higher losses in yield are likely to occur at higher open-circuit voltages.

9.4 Permitted connection options for Sunny Boy Smart Energy

The following figure shows the permitted connection options for the particular application classes with a Sunny Boy Smart Energy.

F-I-AFPE-1-3-1



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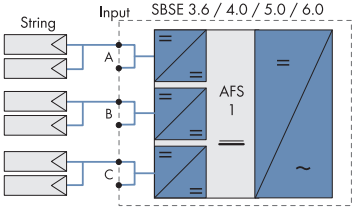

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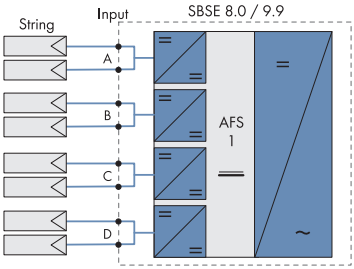

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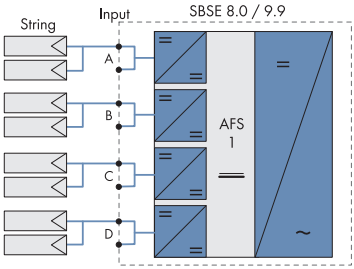
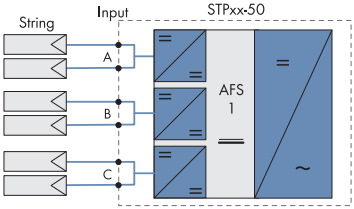


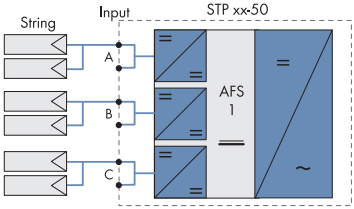
9.5 Permitted connection options for Sunny Tripower X

The following figure shows the permitted connection options for the particular application classes with an Sunny Tripower X.

F-I-AFPE-1-6-1



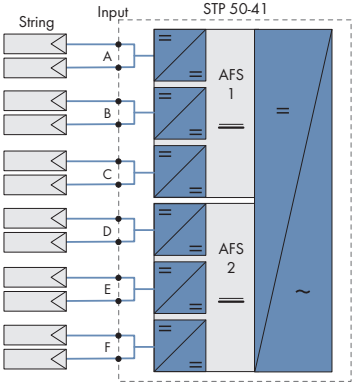
F-I-AFPE-2-3-1



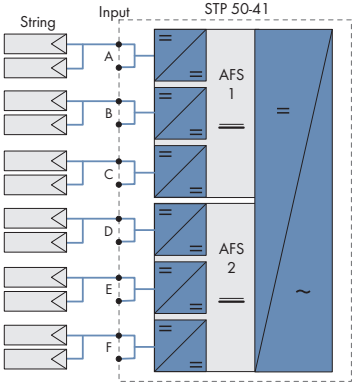
9.6 Permitted connection options for Sunny Tripower CORE1

The following figure shows the permitted connection options for the particular application classes with an Sunny Tripower CORE1.

F-I-AFPE-1-6-2



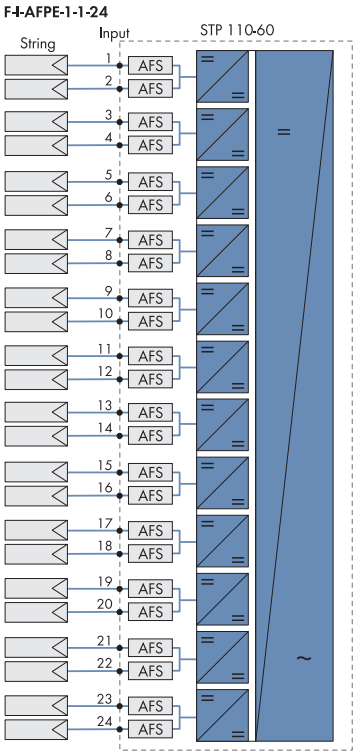
F-I-AFPE-2-3-2



In the case of application class F-I-AFPE-2-3-2, an additional restriction applies. If only one DC input is assigned per MPP tracker and the arc-fault current interrupter (AFCI) is used at the same time, the maximum 16 A input current of the DC input must not be exceeded.

9.7 Permitted connection options for Sunny Tripower CORE2

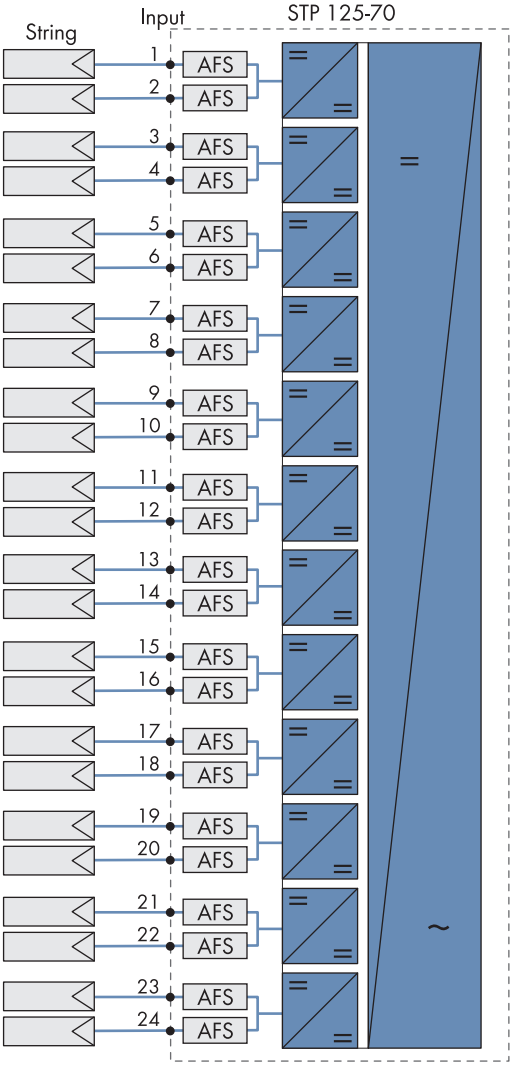
The following figure shows the permitted connection options for the particular application classes with an Sunny Tripower CORE2.



9.8 Permitted connection options for Sunny Tripower 125

The following figure shows the permitted connection options for the particular application classes with a Sunny Tripower 125.

F-I-AFPE-1-1-24



10 Hard- and software requirements

The following table contains an overview of the inverters equipped with an arc-fault circuit interrupter. SMA Solar Technology AG will provide information about implementation in further devices in due time.

Inverter	Device type	Date of manufacture	Firmware version
Sunny Boy 3.0 / 3.6 / 4.0 / 5.0 / 6.0	SB3.0-1AV-41 SB3.6-1AV-41 SB4.0-1AV-41 SB5.0-1AV-41 SB6.0-1AV-41	As of 02/2021	Starting at 4.00.21.R
Sunny Boy Smart Energy	SBSE3.6-50 SBSE4.0-50 SBSE5.0-50 SBSE6.0-50 SBSE8.0-50 SBSE9.9-50	As of production start	As of production start
Sunny Tripower X	STP 12-50 STP 15-50 STP 20-50 STP 25-50	As of production start	As of production start
Sunny Tripower CORE1	STP 50-41	As of production start	As of production start
Sunny Tripower CORE2	STP110-60 with AFCI	As of 02/2023	Starting at 01.01.01.R
Sunny Tripower 125	STP125-70	As of production start	As of production start

11 Restrictions

The following limitations apply when using an arc-fault circuit interrupter (AFCI):

- Only 2 strings may be connected to each input. If more strings are operated in parallel at one input, electric arcs might not be detected reliably.
- Parallel operation of the MPP Trackers of the inverter is not permitted.
- Do not connect any optimizers to the PV modules. The arc-fault circuit interrupter is not designed for operation with optimizers. If optimizers are used, electric arcs cannot be reliably detected and extinguished.

12 Event messages

12.1 Overview of event messages according to inverter

The following event messages may occur for the respective inverters:

Event	088	4301	4302	8204	8205	8208	8209
Inverter							
Sunny Boyx.x-AV-41	-	✓	-	✓	✓	-	-
Sunny Boy Smart Energy	-	✓	-	-	✓	-	-
Sunny Tripower X	-	✓	-	-	-	✓	✓
Sunny Tripower CORE1	-	✓	✓	-	-	✓	✓
Sunny Tripower CORE2	✓	-	-	-	-	-	-
Sunny Tripower 125	-	✓	-	✓	-	-	-

12.2 Event 088

Event message:

- Serial electric arc in string |s0| detected by AFCI module.

Explanation:

The inverter has interrupted the grid feed-in because an electric arc has been detected. After 10 minutes the inverter will attempt to start operation again.

Corrective measures:

- Check the PV modules as well as the cabling in the affected string for damage.
- After 5 detections within 24 hours, the inverter must be started manually.

12.3 Event 4301

Event message:

- **Serial el.arc in String |s0| detected by AFCI mod.**

Explanation:

The inverter has detected an electric arc in the displayed string. If "String N/A" is displayed, the string could not be uniquely assigned.

The inverter stops feeding into the utility grid.

Corrective measures:

- Disconnect the inverter from voltage sources and secure it against being switched on again.
- Check the PV modules and the cabling in the affected string or, if the string was not displayed, in all strings for damage.
- Ensure that the DC connection in the inverter is correct.
- Repair or replace defective PV modules, DC cables or the DC connection in the inverter.
- Start manual restart (if necessary).

12.4 Event 4302

Event message:

- Serial electric arc in string |s0| detected by an AFCI module of the 2nd string group

Explanation:

An electric arc in string D, E or F has been detected.

Corrective measures:

- Check the PV modules as well as the wiring in the affected string for damage.
- If manual restart has been set, the operation inhibition due to the electric arc must be reset in order to continue feed-in operation.

12.5 Event 8204

Event message:

- Arc fault detection self-test failed.

Explanation:

An error has occurred during the self-test of the arc-fault circuit interrupter. It is not guaranteed that it will function correctly. The device does not feed in.

Corrective measures:

- Contact the Service.

12.6 Event 8205

Event message:

- Arc fault detection self-test successful.

Explanation:

The self-test of the arc-fault circuit interrupter has been completed successfully.

12.7 Event 8208

Event message:

- AFCI self-test failed

- Self-test arc detection: Interference level too high

Explanation:

An error has occurred during the self-test of the arc-fault circuit interrupter. The cause must be determined by the Service.

Corrective measures:

- Contact Service.

12.8 Event 8209

Event message:

- AFCI self-test failed
- Self-test arc detection: Signal level too low

Explanation:

An error has occurred during the self-test of the arc-fault circuit interrupter. The cause must be determined by the Service.

Corrective measures:

- Contact Service.

13 Frequently Asked Questions

13.1 Do I need to activate the arc-fault circuit interrupter?

This basically depends on the regulations in the country in which it is used. The design of the system can also be relevant here (e.g. whether it is a roof-mounted system or an open-field system). Furthermore, there may be special requirements for the PV system that prescribe an arc-fault circuit interrupter. Even if an arc-fault circuit interrupter is not required for your system, SMA Solar Technology AG recommends to activate it, as this increases the safety of the system.

13.2 An insurance company requires an electric-arc protection function for a PV system. Can I use the inverters mentioned in this document?

Obtain approval from the insurance company based on the standard (see Section 9.1, page 6) met by the inverter or the SMA manufacturer's declaration (available for some inverter types from SMA Solar Technology AG). The person who installs the system is then responsible for activating the function.