

Technical Information

# PV Inverters

Use of PV Inverters in Off-Grid and Backup Systems in North and South America



## Content

Both in off-grid systems and in the event of grid failures in battery-backup systems, grid fluctuations in the stand-alone grid are possible. This may cause severe deviations in nominal voltage and nominal frequency. Despite such fluctuations, all of the components in these systems must function without problems.

This technical information will inform you about the following topics:

- Which PV inverters you can use in off-grid systems and battery-backup systems.
- Which parameters you need to set in the PV inverter
- What type of communication you need to install in battery-backup systems
- Which values the parameters of PV inverters will take in stand-alone mode
- How the output power of the PV inverter can be limited by the Frequency-Shift Power Control (FSPC) function of the Sunny Island

## 1 PV Inverter

### 1.1 PV Inverters for Planned Systems (as of November 2022)

#### **i** System failures due to excessive power output of AC sources in the stand-alone grid

If the power of the AC sources (e.g. PV inverters) in off-grid systems or battery-backup systems is too high, it may cause system failures.

- Design the total nominal AC power of the PV inverters to be no more than twice as high as the nominal AC power of the Sunny Island.
- If wind power inverters feed into the stand-alone grid, design the total nominal power of the AC sources in the stand-alone grid to be no larger than the nominal AC power of the Sunny Island.
- Allow at least 100 Ah of battery capacity per 1000 W of nominal AC power from the AC sources in the stand-alone grid.

#### Sunny Boy (SB)

PV inverter	Off-grid system	Battery-backup system
SB3.0-1 SP-US-4x	✓	✓ <sup>1</sup>
SB3.8-1 SP-US-4x	✓	✓ <sup>1</sup>
SB5.0-1 SP-US-4x	✓	✓ <sup>1</sup>
SB6.0-1 SP-US-4x	✓	✓ <sup>1</sup>
SB7.0-1 SP-US-4x	✓	✓ <sup>1</sup>
SB7.7-1 SP-US-4x	✓	✓ <sup>1</sup>

✓ Compatible

✓<sup>1</sup> Compatible if country data set CA Rule 21 is set

#### Sunny Tripower (STP)

#### **i** Sunny Tripower in off-grid systems and in battery-backup systems

A three-phase off-grid or battery-backup system with Sunny Island 4548-US / 6048-US provides an AC grid voltage of 127 V / 208 V. However, the Sunny Tripower operates at a nominal AC voltage of 277 V / 480 V.

- When using a Sunny Tripower in off-grid systems or battery-backup systems with Sunny Island 4548-US / 6048-US, always use a transformer.\*

\* The use of a generator has no effect on the Frequency Shift Power Control (FSPC) function.

PV inverter	Off-grid system	Battery-backup system
STP 50-US-40	✓	✗
STP 33-US-41	✓	✗
STP 50-US-41	✓	✗
STP 60-US-41	✓	✗

✓ Compatible

✗ Not compatible

## Sunny Highpower PEAK3 (SHP)

PV inverter	Off-grid system	Battery-backup system
SHP 125-US-21	✓	✗
SHP 150-US-21	✓	✗
SHP 165-US-21	✓	✗
SHP 172-US-21	✓	✗

✓ Compatible      ✗ Not compatible

## 1.2 PV Inverters for Installed Systems (as of November 2022)

### **i** System failures due to excessive power output of AC sources in the stand-alone grid

If the power of the AC sources (e.g. PV inverters) in off-grid systems or battery-backup systems is too high, it may cause system failures.

- Design the total nominal AC power of the PV inverters to be no more than twice as high as the nominal AC power of the Sunny Island.
- If wind power inverters feed into the stand-alone grid, design the total nominal power of the AC sources in the stand-alone grid to be no larger than the nominal AC power of the Sunny Island.
- Allow at least 100 Ah of battery capacity per 1000 W of nominal AC power from the AC sources in the stand-alone grid.

### Sunny Boy (SB)

PV inverter	Off-grid system	Battery-backup system
SB 700U	✓	✗
SB 3000US	✓	✓
SB 3800-US-10	✓	✓
SB 4000US	✓	✓
SB 5000US	✓	✓
SB 6000US	✓	✓
SB 7000US	✓	✓
SB 8000US	✓	✓
SB 2000HFUS-30	✗	✗
SB 2500HFUS-30	✗	✗
SB 3000HFUS-30	✗	✗
SB 3000TL-US-22	✗ <sup>1</sup>	✓
SB 3800TL-US-22	✗ <sup>1</sup>	✓
SB 4000TL-US-22	✗ <sup>1</sup>	✓
SB 5000TL-US-22	✗ <sup>1</sup>	✓

PV inverter	Off-grid system	Battery-backup system
SB 6000TL-US-22	✘ <sup>1)</sup>	✓
SB 7000TL-US-22	✘ <sup>1)</sup>	✓
SB 7700TL-US-22	✘ <sup>1)</sup>	✓
SB 5000TLUS-12	✓	✘
SB 6000TLUS-12	✓	✘
SB 7000TLUS-12	✓	✘
SB 8000TLUS-12	✓	✘
SB 9000TLUS-12	✓	✘
SB 10000TLUS-12	✓	✘
SB 11000TLUS-12	✓	✘

<sup>1)</sup> not supported since 2016

✓ Compatible

✘ Not compatible

## Sunny Tripower (STP)

### **i** Sunny Tripower in off-grid systems and in battery-backup systems

A three-phase off-grid or battery-backup system with Sunny Island 4548-US / 6048-US provides an AC grid voltage of 127 V / 208 V. However, the Sunny Tripower operates at a nominal AC voltage of 277 V / 480 V.

- When using a Sunny Tripower in off-grid systems or battery-backup systems with Sunny Island 4548-US / 6048-US, always use a transformer.\*

\* The use of a generator has no effect on the Frequency Shift Power Control (FSPC) function.

PV inverter	Off-grid system	Battery-backup system
STP 12000TL-US-10	✓	✘
STP 15000TL-US-10	✓	✘
STP 20000TL-US-10	✓	✘
STP 24000TL-US-10	✓	✘
STP 30000TL-US-10	✓	✘

✓ Compatible

✘ Not compatible

## 2 Configuration of PV Inverters in Off-Grid Systems

The country data set must be set to stand-alone mode in off-grid systems.

You can order PV inverters configured for stand-alone mode or you can configure existing PV inverters for stand-alone mode (see Section 4 "Communication Products for Configuring PV Inverters", page 6). During the first 10 operating hours you can adjust the country data set for many PV inverters by means of rotary switches (see the manual of the PV inverter).

### Setting the country data set via RS485

The following table shows how the country data set must be set during configuration of the PV inverter via RS485. The parameter name and the configurable value depend on the PV inverter and the communication product in use.

Parameter name	Value
<b>Default</b>	<b>Off-grid</b>
or	or
<b>CntrySet</b>	depending on power frequency, <b>OFF-Grid50</b> for 50 Hz power frequency or <b>OFF-Grid60</b> for 60 Hz power frequency

### Setting the country data set via Speedwire (e.g. with Sunny Explorer)

The following table shows how the country data set must be set during configuration of the PV inverters via Speedwire. The country data set value depends on the PV inverter being used.

Parameter name	Value
Set country standard	Either "Island mode" or depending on power frequency, <b>Island mode 50</b> for 50 Hz power frequency or <b>Island mode 60</b> for 60 Hz power frequency

### Setting the country data set via the user interface of the inverter

Depending on the grid frequency, the parameter **Set country data set (GridGuard.CntrySet)** must be set to the value **SMA stand-alone mode 50 Hz (OFF-Grid50)** or to the value **SMA stand-alone mode 60 Hz (OFF-Grid60)**.

These settings can also be made via a higher-level information product (e.g. SMA Data Manager).

## 3 Configuration of PV Inverters in Battery-Backup Systems

In a battery-backup system, the Sunny Island is connected to the utility grid and communicates with the PV inverters via RS485. This is why each PV inverter without its own RS485 interface and the Sunny Island must be equipped with an RS485 Piggy-Back or an RS485 data module. In a cluster, only the master of the Sunny Island inverters must be equipped with an RS485 Piggy-Back. In a battery-backup system, all PV inverters must be set to battery-backup operation (see Section 4 "Communication Products for Configuring PV Inverters", page 6).

### Setting backup operation via RS485

The following table shows how backup operation must be set during configuration of the PV inverter via RS485. The parameter name and the configurable value depend on the PV inverter and the communication product in use.

Parameter name	Value
<b>Backup mode</b>	<b>On all</b>
or	or
<b>Op.BckOpMod</b>	<b>OnAllPhs</b>

In battery-backup systems, you operate the PV inverters with the locally typical country data set for grid-tie PV systems in accordance with UL1741. If the parameter is set to **On all** or **OnAllPhs**, the system meets the requirements as per UL1741.

#### **i** SBxx-1SP-US-40 / SBxx-1SP-US-40 with CA Rule 21

For SBxx-1SP-US-40 / SBxx-1SP-US-40 with set country data set CA Rule 21, the Sunny Island is able to curtail the power of these PV inverters via frequency-shift power control (FSPC) without a RS485 communication link.

#### **i** PV inverters without backup mode

For PV inverters without backup mode, the country data set must be set to the locally typical value for grid-tie PV systems as per UL1741. The PV inverter is then configured for operation on the utility grid. In the event of a utility grid failure, the Sunny Island is unable to derate the PV inverters by means of Frequency-Shift Power Control (FSPC). If there is an excessive supply of energy, the PV inverters will switch off.

## 4 Communication Products for Configuring PV Inverters

### **i** SMA Grid Guard code required to change grid-relevant parameters

To change grid-relevant parameters in the PV inverter after 10 operating hours, you will need the SMA Grid Guard code.

- Select a communication product corresponding to the type of communication and the PV inverter used.
- Apply for an SMA Grid Guard code to change grid-relevant parameters (for an application for the SMA Grid Guard code, see the Certificate "Application for SMA Grid Guard Code" at [www.SMA-Solar.com](http://www.SMA-Solar.com)).

### **PV inverters with RS485**

You can configure PV inverters with RS485 using the following communication products:

- Sunny WebBox
- Sunny Boy Control
- Computer with Sunny Data/Sunny Data Control software

For PV inverters without RS485 Piggy-Back or RS485 data module, you will also need a service cable for data transmission (USB Service Interface, SMA order number: USBPBS).

### **PV inverters with Speedwire**

You can configure PV inverters with Speedwire via the user interface or by using the following communication products:

- SMA Data Manager
- Sunny Explorer
- SMA Cluster Controller

## 5 Parameter Values in Stand-Alone Mode via RS485

The **OFF Grid** setting for the **Default** parameter affects the following parameters of the PV inverter that communicates via RS485. The given values are examples and have no general validity.

Parameter	Unit	Value
Test current	mA	Off (MSD=0)
Vac.Min	V	-50% $V_{AC\ Nom}^*$
Vac.Max	V	+20% $V_{AC\ Nom}^*$
Fac-delta- Lower range in which the Sunny Boy is active, based on $f_0$	Hz	-4.5 (starting from base frequency $f_0$ )
Fac-max+ Upper range where the Sunny Boy is active, based on $f_0$	Hz	+4.5 (starting from the base frequency $f_0$ )
dFac-Max Max. rate of change	Hz	5
Fac-start delta Frequency increase in relation to $f_0$ , at which point the power adjustment via frequency begins	Hz	1 (starting from the base frequency $f_0$ )
Fac-Limit delta Frequency increase based on $f_0$ , where the power control via frequency ends. The power of the Sunny Boy at this point is 0 W.	Hz	2 (starting from the base frequency $f_0$ )

\*  $V_{AC\ Nom} = 208\ V/240\ V/277\ V$

### PV inverter with configuration via own user interface or via Speedwire

For PV inverters with configuration via their own user interface or via Speedwire, the configuration of the grid management services is of special importance (see technical information "SMA GRID GUARD - Grid Management Services via Inverter and System Controller").

## 6 Frequency-Shift Power Control (FSPC)

If PV inverters are connected on the AC side in off-grid operation or back-up operation, the Sunny Island must be able to limit their output power. This situation can occur, for example, when the battery of the Sunny Island is fully charged and the PV power available from the PV modules exceeds the power required by the connected loads.

To prevent the excess energy from overcharging the battery, the Sunny Island recognizes this situation and changes the frequency at the AC output. This frequency change is monitored by the PV inverter. As soon as the power frequency increases beyond the value specified by **Fac-Start delta**, the PV inverter limits its power accordingly.

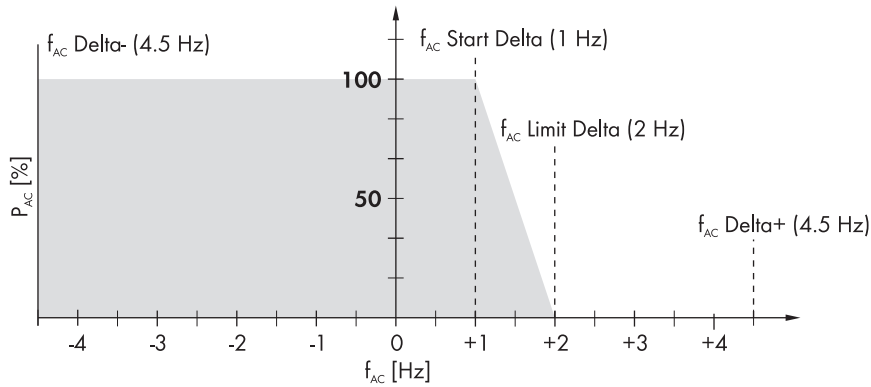


Figure 1: Operating principle of FSPC

The terms used have the following meanings:

- $f_{AC}$  refers to the base frequency of the stand-alone grid (here 60 Hz).
- $f_{AC}$  **Delta-** and  $f_{AC}$  **Delta+** are the maximum ranges relative to  $f_{AC}$  in which the PV inverter is active.
- $f_{AC}$  **Start Delta** is the frequency increase relative to  $f_{AC}$  at which frequency-based power control begins.
- $f_{AC}$  **Limit Delta** is the frequency increase relative to  $f_{AC}$  at which frequency-based power control ends. The power of the PV inverter at this point is 0 W.

If the limits  $f_{AC}$  **Delta-** or  $f_{AC}$  **Delta+** are exceeded, the PV inverters disconnect from the utility grid.

When an external energy source, (e.g. a diesel generator) is operating in the stand-alone grid, this external energy source determines the frequency and the PV inverters set to off-grid operation react to certain frequency changes brought about by the external energy source.

With diesel generators as external energy source, the frequency of the output voltage under load is 60 Hz. For this reason, in most cases the PV inverters will feed their entire power into the stand-alone grid, even when the diesel generator is in operation.

If the current battery voltage is greater than the battery voltage setpoint and the stand-alone grid is also to be synchronized with an external energy source, the Sunny Island temporarily increases the frequency and the PV inverters disconnect via frequency shutdown (overfrequency). Afterwards, the Sunny Island synchronizes with the external energy source.