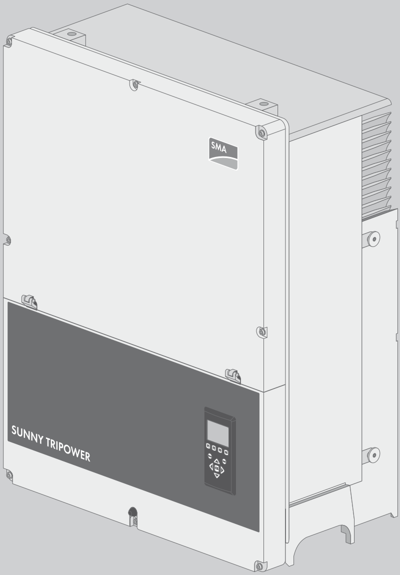
Planning Guidelines

SUNNY TRIPOWER 60



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ENGLISH

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Table of Contents

1 Introduction

The planning guidelines provide information required for planning and dimensioning an installation. They describe the requirements for the use of a Sunny Tripower 60 in PV systems.

Figure 1.1 Sunny Tripower 60

The following additional materials are available:

- Installation manual (supplied with the inverter) - contains information required to install and commission the inverter.
- Quick reference guide for installation of the SMA Inverter Manager and the I/O box - contains information required to install the SMA Inverter Manager.
- Service manual for replacing the fan – contains information required to replace a defective fan.
- Service manual for replacing the SPDs – contains information required to replace surge protection devices.

These documents are available in the download area at www.SMA-Solar.com or can be obtained from the inverter supplier. Additional application-specific information is available at the same location.

1.1 List of Abbreviations

Abbreviation	Description
ANSI	American National Standards Institute
AWG	American Wire Gauge
cat5e	Category 5 twisted pair cable (enhanced) for data transmission
DHCP	Dynamic Host Configuration Protocol – enables automatic assignment of the network address via the DHCP server
DNO	Distribution network operator
DSL	Digital Subscriber Line
EMC (directive)	Electromagnetic compatibility directive
ESD	Electrostatic discharge
FCC	Federal Communications Commission
FRT	Fault Ride Through
GSM	Global System for Mobile Communications (standard for digital cellular mobile network)
HDD	Hard Disk Drive
IEC	International Electrotechnical Commission – international standards organization
IT	Isolated Terra
LCS	Local Commissioning and Service
LED	Light-emitting diode
LVD (Directive)	Low voltage directive
MCB	Circuit breaker
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking determines the point of optimum PV power
NFPA	National Fire Protection Association
P	P is the symbol for active power and is measured in Watts (W).
PCB	Printed circuit board
PCC	Point of Common Coupling - Point of interconnection. The point on the public electricity grid to which other customers are, or could be, connected.
PE	Protective Grounding
PELV	Protected Extra-Low Voltage
PLA	Power Level Adjustment = Output power limitation
Pnom	Power [W], Nominal active power

Abbreviation	Description
POC	Connection point - The point at which the PV system is connected to the transmission line.
PSTC	Power [W], Standard Test Conditions
PV	Photovoltaic, photovoltaic cells
RCD	Residual-Current Device
RCMU	Residual Current Monitoring Unit
RISO	Insulation resistance
ROCOF	Rate of Change of Frequency
Q	Q is the symbol for reactive power and is measured in reactive volt-amperes (VAr).
S	S is the symbol for apparent power and is measured in volt-amperes (VA).
STC	Standard Test Conditions
SW	Software
THD	Total Harmonic Distortion
TN-S	AC grid with separated grounding and neutral conductors
TN-C	AC grid with combined grounding and neutral conductors
TN-C-S	Terra Neutral - Combined - Separate. AC Network
TT	AC grid with separation between operational ground of the generator and ground of the load system

Table 1.1: Abbreviations

2 Inverter Overview

2.1 Type Label

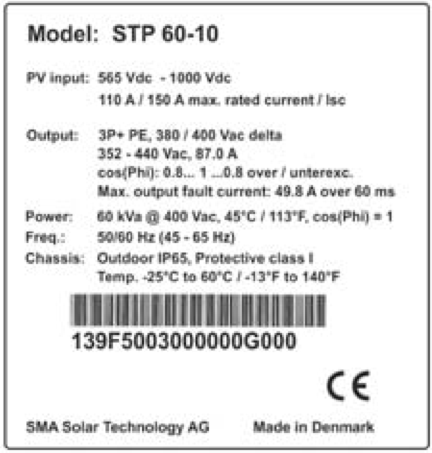


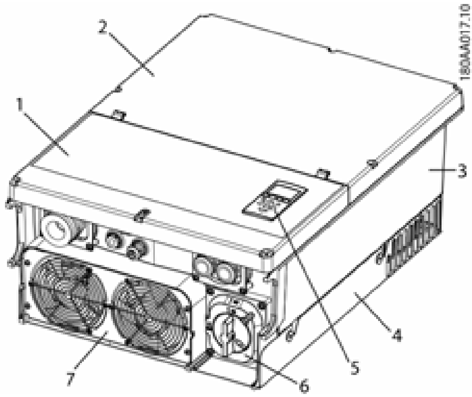
Figure 2.1 Sunny Tripower 60 type label

Figure 2.2 Sunny Tripower 60-US type label

The type label on the side of the inverter shows:

- Inverter type
- Important technical data
- Serial number, located under the bar code, for inverter identification

2.2 Mechanical Overview of the Inverter



1	Cover for installation area
2	Front cover
3	Die-cast aluminum heat sink
4	Wall mounting bracket
5	Display (read-only)
6	PV load-break switch
7	Fan

Figure 2.3: Mechanical overview of the inverter

2.3 Inverter Description

Inverter properties:

- IP65 enclosure/Type 3R
- PV load-break switch
- Grid management function
- Transformerless
- Three-phase
- 3-level topology with high performance capacity
- Integrated residual current monitoring unit
- Insulation test functionality
- Extended fault-ride through functions (to support reliable power generation during system incidents) - depending on the inverter parameterization
- Complies with the requirements for a wide range of national grids
- Adapted to local requirements and conditions via grid code setting

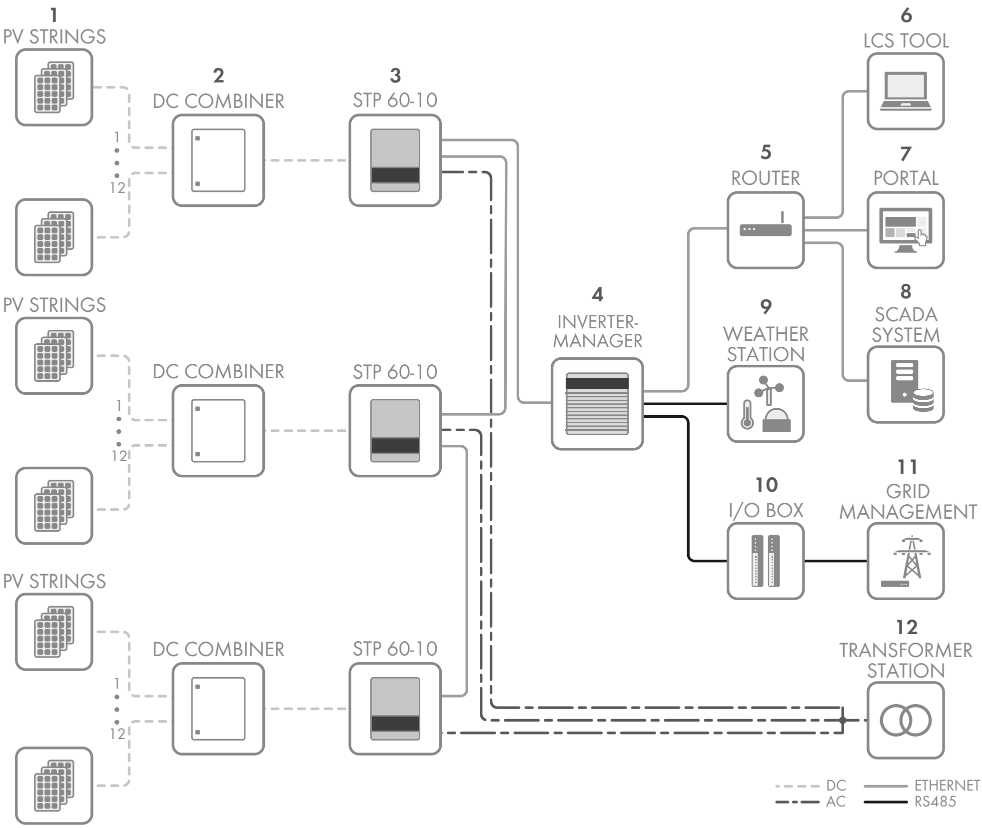
2.3.1 System Overview

The STP 60 system with a Sunny Tripower 60 uses the advantages of both string inverters and central inverters, making it highly applicable in many commercial and utility scale plants.

The STP 60 system consists of the Sunny Tripower 60, a DC String-Combiner and the SMA Inverter Manager.

The communication network of a STP 60 system is divided into two Ethernet networks: system network and inverter network. The system network is the communication interface to the STP 60 system and may be used by several SMA Inverter Managers as well as other IT devices, while the inverter network is solely used for the inverters. The system network must have a DHCP server (router) assigned to the inverter as the SMA Inverter Manager requires automatic IP assignment. It is recommended to use professional routers and network switches. The SMA Inverter Manager allows for:

- Control of up to 42 SMA inverters of type Sunny Tripower 60
- Single point of access for each 2.5 MVA system (maximum value) for simple system network deployment.
- Easy commissioning and maintenance of the system using the Local Commissioning and Service (LCS) tool
- Safe data upload to data warehouse services and control of all local requirements and settings from the DNO
- Open source Modbus TCP communication protocol using SunSpec Alliance profile via Ethernet both for monitoring and control, making it easy to integrate in SCADA systems, for example
- Grid management interface through the optional I/O box for PLA and reactive power commands
- Easy integration of metrological data using an RS485 SunSpec Alliance compliant weather station



1	Strings
2	PV array junction box
3	Sunny Tripower 60
4	SMA Inverter Manager
5	Router
6	LCS tool
7	Portal upload
8	SCADA system
9	Weather station
10	I/O box
11	Grid management
12	Transformer station

Figure 2.4: System overview

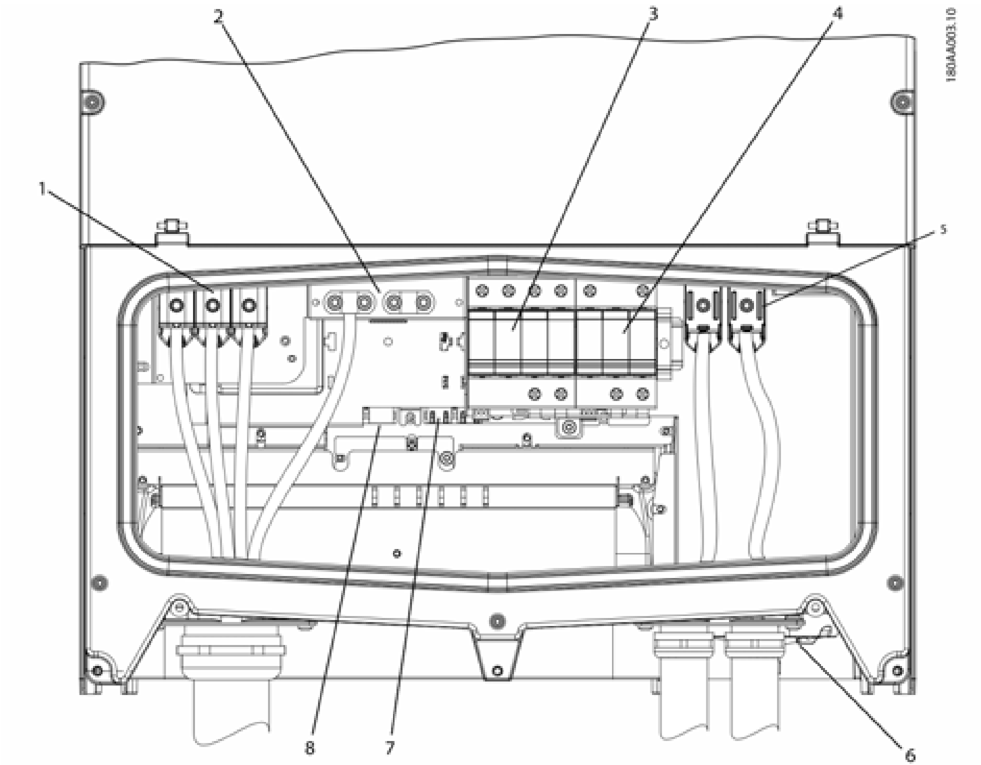


Figure 2.5: Overview of the installation area

PELV (safe to touch)	
2	Device grounding
7	Ethernet interface x 2
8	RS485 interface (not in use)
Live Parts	
1	AC terminals
5	PV terminals
Other	
3	AC overvoltage protection (SPDs)
4	DC overvoltage protection (SPDs)
6	PV load-break switch

2.3.2 Functional Safety

The inverter was developed for international use and has an electronic circuit for functional safety complying with a wide range of national requirements (see Section 2.5, page 16).

Single-Fault Immunity

The functional safety circuit has a fully redundant integrated single-fault detection. If a fault occurs, the inverter disconnects from the grid immediately. The method is active and covers all circuitry within the residual current monitoring, both for continuous levels and sudden changes. In order to guarantee safe operation, all functional safety circuits are checked during the inverter start-up phase. If a circuit fails more than once out of three times during the self-test, the inverter switches to "fail-safe" mode. If the measured grid voltages, power frequencies, or residual currents during normal operation differ too much between the two independent circuits, the inverter interrupts grid feed-in and repeats the self-test. The functional safety circuits are always activated and cannot be deactivated.

Insulation

During the self-test, the inverter has an isolation measuring system that detects whether the isolation in the PV system is above the required value. This is done before the inverter starts to feed into the grid. During grid connection, the inverter measures the continuous residual current in the system. If this value is exceeded more than four times within 24 hours, the inverter stops operating due to possible safety hazards in the PV system.

INFORMATION

Depending on the required local connection conditions, a minimum insulation resistance between ground and PV is specified. A typical value is 82 kΩ.

Self-test

The insulation resistance between the PV arrays and ground is also tested during the self-test. The inverter does not feed into the grid if the resistance is too low. After ten minutes, the inverter makes a new attempt to feed into grid.

Differential current

The residual current is continuously monitored. The inverter interrupts grid feed-in in the following cases:

- The cycle root-mean-square value of the residual current violates the disconnection settings for more than the duration of the "clearance time", or
- A sudden jump in the residual current is detected

Grid Monitoring

If the inverter feeds into the grid, the following grid parameters are monitored:

- Grid voltage magnitude (instantaneous value and 10 minute average)
- Grid voltage and power frequency
- Grid failure (islanding detection):
  - Three-phase grid failure detection
  - Rate of change of frequency (ROCOF)
  - Frequency shift.
- DC content of grid current
- Residual current by means of RCMU

The inverter interrupts grid feed-in if one of the parameters violates the grid code settings.

2.3.3 Operating Modes

The inverter has five operating modes, indicated by LEDs.

Status	LEDs	
Off grid	Green	
	Red	
Connecting	Green	
	Red	
On grid	Green	
	Red	
Internal inverter event	Green	
	Red	
Fail safe	Green	
	Red	

Table 2.1

Off grid (standby) (LEDs are off)

#0-51

When no power has been fed into the AC grid for more than 10 minutes, the inverter disconnects from the grid and shuts down. User and communication interfaces remain powered for communication purposes.

Connecting (green LED is flashing)

#52-53

The inverter starts up when the PV input voltage reaches the minimum DC feed-in voltage. The inverter performs a series of internal self-tests, including measurement of the resistance between the PV array and ground. Meanwhile, it also monitors the grid parameters. When the grid parameters are within the specifications for the required amount of time (depends on grid code), the inverter starts feeding into the AC grid.

On grid (green LED is glowing)

#60

The inverter is connected to the AC grid and feeds into the grid. The inverter disconnects from the grid in the following cases:

- It detects abnormal grid conditions (depending on the grid code), or an internal event occurs.
- PV power is insufficient (no power is fed into the grid for ten minutes).

The inverter switches to connection mode or operating mode "off-grid mode".

Internal inverter event (green LED is flashing)

#54

The inverter is waiting for an internal condition to be within the thresholds again (for example, when excessive temperature decreases) before it reconnects to the grid.

Fail safe (red LED is flashing)

#70

If the inverter detects an error in its circuits during the self-test (in connecting mode) or during operation, the inverter switches to fail safe mode and disconnects from the grid. The inverter will remain in "fail-safe" mode until PV power has been absent for ten minutes or the inverter has been shut down completely (AC+PV).

2.4 MPP Tracker and Power Reduction

2.4.1 MPP Tracker

The Maximum Power Point Tracker (MPPT) is an algorithm which is constantly trying to maximize the output power of the PV array. The algorithm updates the PV voltage fast enough to follow rapid changes in solar irradiation. The MPPT will find the maximum power point while the PV voltage is within the specified MPP voltage range. At voltages below the minimum MPP voltage of the inverter, the MPPT moves away from the maximum power point (see figure 2.6) in order to maintain sufficient DC voltage to generate the required AC grid voltage.

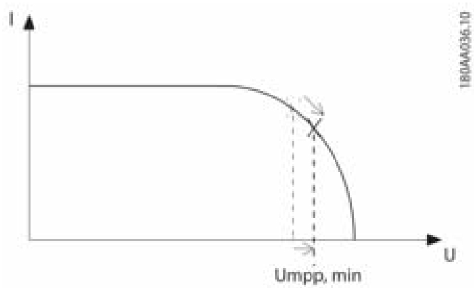


Figure 2.6 MPPT behavior at low MPP voltage

INFORMATION

Since the Sunny Tripower 60 has no step-up converter, the minimum MPP voltage varies as a function of the current AC grid voltage.

2.4.2 Power Reduction of the Inverter

In certain situations, the MPPT purposely moves away from the maximum power point. This behavior is called "power reduction" and is a means of protecting the inverter against overload or a reduction of output power in order to support the grid. Reactive power (supporting the grid) has priority when the derate function is reducing the AC output power, meaning that first active power is reduced to zero where after reactive power is reduced. The STP 60 system reduces its power under the following circumstances:

- Exceeding the maximum nominal AC power
- Internal overtemperature
- Grid overvoltage
- Excessive power frequency

- Output power limitation by settings or external command (PLA)

Each Sunny Tripower 60 inverter limits the AC output power according to the current power reference which corresponds to the lowest of the following values:

- Maximum nominal AC power (60 kVA)
- Fixed active/reactive power threshold set by the grid code file
- Active or reactive power reference from the SMA Inverter Manager
- Power limitation of the internal temperature-dependent power reduction. Power reduction due to temperature is a sign of excessive ambient temperature, a dirty heat sink, a blocked fan or similar. Information on maintenance can be found in the installation manual of the Sunny Tripower 60. The values shown in table 2.7 are measured at nominal conditions cos(φ) = 1

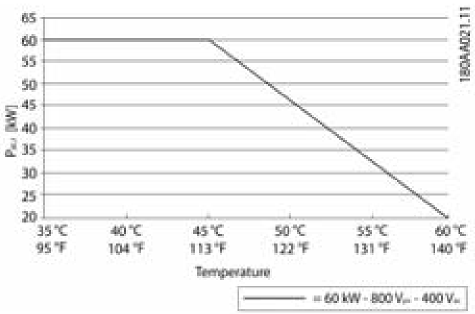


Figure 2.7 Power reduction as a function of the ambient temperature

INFORMATION

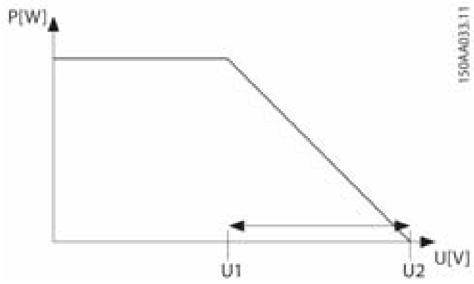
The inverter can use the entire permissible DC voltage range up to 1,000 V for power reduction. It is not restricted to the MPP voltage range.

2.4.3 Power Reference

The power reference for the individual inverters of type Sunny Tripower 60 will be generated by the SMA Inverter Manager based on the following functions. They are all stored in the SMA Inverter Manager and thus calculated on system level.

- **Grid Overvoltage**

  When the grid voltage exceeds the threshold U1 specified by the DNO, the inverter derates the output power. If the grid voltage increases and exceeds the defined threshold (ten-minute average value (U2)), the inverter interrupts grid feed-in in order to maintain grid quality and protect other devices connected to the grid.



U1	Fixed
U2	Disconnection limit

Figure 2.8 Grid voltage above threshold, defined by DNO

Power reduction - grid overfrequency

The output power is reduced as a variable of the power frequency. There are two methods for reducing the output power: ramp and hysteresis. The grid code setting determines which method is implemented in a specific installation.

Primary frequency control – ramp method

See figure 2.9.

The inverter reduces output power if the grid frequency exceeds f1. Reduction occurs at a preconfigured rate which is the ramp (R) shown in figure 2.9. When the frequency reaches f2, the inverter disconnects from grid. When the frequency decreases below f2, the inverter is reconnected to the grid and increases power at the same rate as for the reduction.

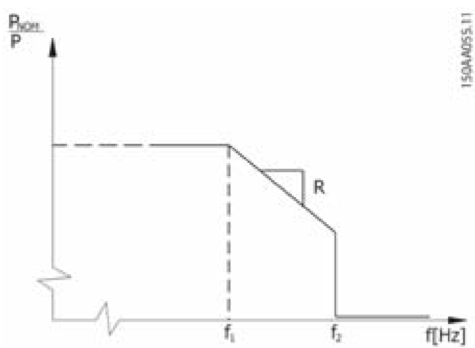


Figure 2.9 Primary frequency control – ramp method

Frequency Stability - (Active Power Reduction in case of Overfrequency) - Hysteresis

See figure 2.10.

To support power frequency stabilization, the inverter reduces its output power if the power frequency exceeds f1. Reduction occurs at a preconfigured rate which is ramp (R) shown in figure 2.10. The reduced output power limit is maintained until the grid frequency has decreased to f2. When the power frequency has decreased to f2, the inverter output power increases again following a time ramp T. If the power frequency continues to increase, the inverter disconnects at f3. When the frequency decreases below f2, the inverter is reconnected to the grid and increases power at the same rate as for the reduction.

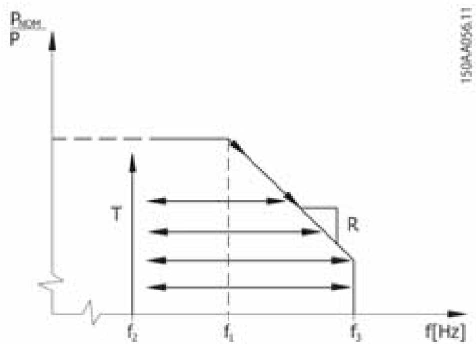


Figure 2.10 Primary frequency control – hysteresis method

2.5 Grid Code

The STP 60 grid code file contains settings that determine both the behavior of the single inverter and the entire system. The grid code file is divided into two main sections:

- Protection settings
- Grid support (grid management services)

The LCS tool used for commissioning the inverter is equipped with a range of standard grid codes to meet national requirements. Changing these standard grid code parameters requires a customer-specific grid code file supplied by SMA Solar Technology AG. Refer to Section 2.7, page 19 on how to apply for customer-specific grid code parameters.

INFORMATION

Obtain approval from the local distribution network operator (DNO) before connecting the inverter to the grid.

2.5.1 Grid Protection Settings

The grid protection settings are stored in each inverter. They ensure protection of the grid in case of certain grid events regardless of the connection to the SMA Inverter Manager. The inverter continuously monitors the following grid values and compares them to the disconnection values specified in the grid code. Example:

- Voltage disconnection
- Frequency disconnection
- Reconnection
- Grid failure

Voltage and frequency disconnection

The cycle root-mean-square values of the grid voltage are compared with two lower and two upper disconnection settings, for example overvoltage (level 1). If the root-mean-square values violate the disconnection settings for more than the duration of "clearance time", the inverter interrupts grid feed-in.

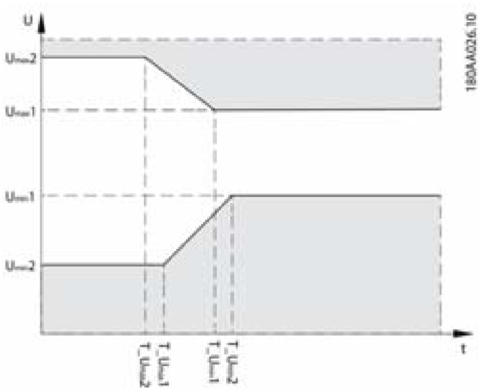


Figure 2.11 Overvoltage and undervoltage disconnection

Reconnection

During commissioning or when the inverter has disconnected from grid due to for example overvoltage or frequency, the reconnection values determine under which grid conditions the inverter can reconnect to the grid and start feed-in.

Grid Failure Disconnection (Stand-Alone Mode)

Grid failure is detected by three different algorithms:

- Three-phase voltage monitoring (the inverter controls the current of each individual line conductor). The cycle root-mean-square values of the grid voltages of the line conductors are compared with a lower or an upper disconnection setting. If the root-mean-square values violate the disconnection settings for more than the duration of the "clearance time", the inverters interrupts grid feed-in.
- Rate of change of frequency (ROCOF). The ROCOF values (positive or negative) are compared to the disconnection settings. The inverter disconnects from the grid when the thresholds are violated.
- Frequency shift. The inverter continuously tries to extend the power frequency a bit, but the stability of the grid prevents this from happening.

In a grid failure situation, the stability of the grid is no longer present, and this makes it possible to change the frequency. As the frequency deviates from the operating frequency of the cable, the inverter disconnects from the grid and interrupts grid feed-in. If the inverter stops grid-feed in due to power frequency or grid voltage (not due to a grid failure caused by phase imbalance), and if the frequency or voltage is restored within a short time (short interruption time), the inverter can reconnect when the grid parameters have been within their limits for the specified time (reconnect time). Otherwise, the inverter returns to the normal connection sequence.

2.6 Grid Support (Grid Management Services)

The grid management services are comprised in two main categories:

- "Fault Ride Through" function (FRT).
- Reactive and active power management

2.6.1 Fault Ride Through

The grid voltage usually has a smooth characteristic curve but occasionally the voltage drops or disappears for several milliseconds. This is often due to short circuits in overhead power lines or caused by operation of switching devices or similar in the high-voltage grid. In such cases, the inverter can continue to supply power to the grid using fault ride through (FRT) function. Continuous electricity supply to the grid is essential:

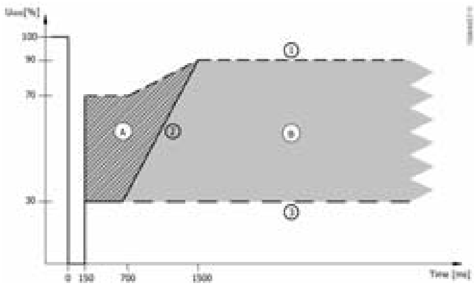
- to help prevent a complete voltage blackout and stabilize the grid voltage.
- to increase the energy delivered to the AC grid.

There are four different behaviors to select from:

- Zero current
- Reactive power only
- Active current only
- Full current – reactive power priority

How FRT Works

Figure 2.12 shows the requirements that must be followed by FRT. The example is for German medium-voltage grids.



Above line 1	For voltages above line 1, the inverter must not under any circumstances be disconnected from the grid during FRT.
Range A	The inverter must not disconnect from grid for voltages below line 1 and left of line 2. In some cases, the DNO allows short-term disconnection. The inverter must then be back on the grid after two seconds.
Range B	To the right of line 2, a short-term disconnection from grid is always permitted. The reconnection time and power gradient can be negotiated with the DNO.
Below line 3	Below line 3, grid connection is no longer required.

Figure 2.12 Example for Germany

In case of a short-term disconnection from the grid:

- The inverter must be back on the grid after 2 seconds
- The active power must be ramped back at a maximum rate of 10% of nominal power per second

Active Power Management

The inverter can support the local grid by either static or dynamic limitation of the system output power. The different control methods are:

- Fixed Pref – maximum active power limitation
- Power Level Adjustment (PLA) – remotely controlled maximum active power limitation (requires I/O box)

2.6.2 Reactive Power Management

The inverter can support the local grid by feeding in reactive power. The different control methods are:

Q(V)	Grid feed-in of reactive power as a function of the grid voltage.
Q(P)	Grid feed-in of reactive power as a function of the active output power.
Q(S)	Grid feed-in of reactive power as a function of the apparent output power.
PF(P)	Power factor as a function of active output power.
PFext	Power factor according to external signal either via Modbus or the external I/O box (RS485).
Qext	Grid feed-in of reactive power according to external signal either via Modbus or the external I/O box (RS485).

Table 2.2 Reactive power management, control methods

INFORMATION

Only one method can be used at the same time. A mode selector determines which method is to be activated.

With the setpoint curve Q(V), the inverter controls reactive power as a function of the grid voltage V. The values for the setpoint curve are determined by the local utility company and must be obtained from them (see figure 2.13).

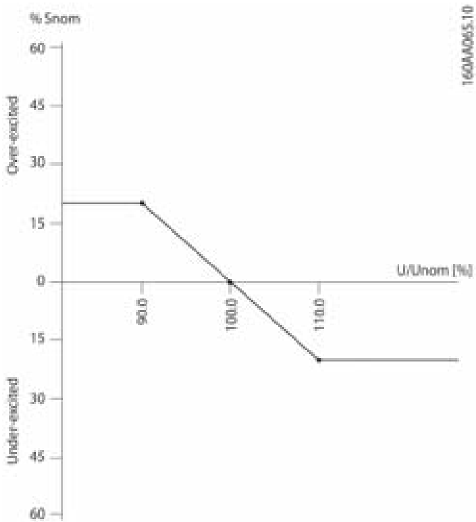


Figure 2.13 Q(V) setpoint curves – reactive power

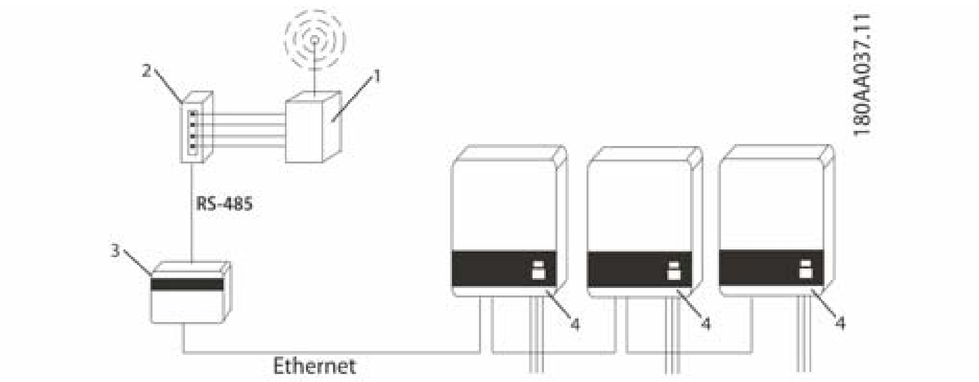
When the grid voltage is below the nominal value, the inverter is configured to feed-in over-excited reactive power in order to increase the grid voltage back to the nominal value. When the grid voltage is above the nominal value, the inverter feeds in underexcited reactive power to decrease grid voltage and thus supports the grid by maintaining a more stable voltage.

Qext. and PFext

Remote control of a system's active power and reactive power grid feed-in can be handled with I/O box via RS485 or via an external signal via Modbus.

I/O box

The I/O box monitors the relay state of the ripple control receiver (supplied by the DNO) and transmits the state to the SMA Inverter Manager via RS485. The SMA Inverter Manager translates the relay state into the corresponding PLA value (max. system output power) based on the grid code configuration.



1	Ripple control receiver
2	I/O box
3	SMA Inverter Manager
4	Sunny Tripower 60

Figure 2.14

External signal via Modbus

The Modbus SunSpec control profile can be used to control the amount of reactive power feed-in by the system.

2.6.3 Active Power Management

Apparent power management

The inverter can support the local grid by setting a maximum value for the apparent power.

- Fixed Sref – threshold for the maximum apparent power

Fallback

The inverters in the inverter network are controlled by a Qref and Pref from the SMA Inverter Manager. If the connection to the SMA Inverter Manager is interrupted, the inverter disconnects from grid within ten seconds. If the connection is re-established within two seconds, the inverter will not disconnect from grid. As soon as the connection is re-established, the inverter reconnects to grid.

2.7 Functional Safety Settings

The inverter is designed for international use and it can handle a wide range of requirements related to functional safety and grid behavior. Parameters for functional safety are predefined and do not require any alteration during installation. However, some grid code parameters may require alterations during installation to allow optimization of the local grid. Please contact SMA Solar Technology AG to obtain a customer-specific grid code.

3 System Planning – Mechanical

The aim of this section is to provide general information for planning the mechanical installation of the Sunny Tripower 60, including mounting and cable specifications.

3.1 Unpacking

Content:

- Inverter
- Wall mounting bracket
- Accessories bag containing:
  - 6 wall screw anchors, 8 x 50 mm
  - 6 mounting screws, 6 x 60 mm
  - 1 M25 cable gland with sealing grommet for Ethernet cables
  - 1 grounding bolt, 6 x 12 mm
  - For STP 60-10-US additionally included: 2 x cable channel with conduit bracket (2")
- Installation manual (multilingual)
- Quick reference guide for installation (poster)

3.2 Installation

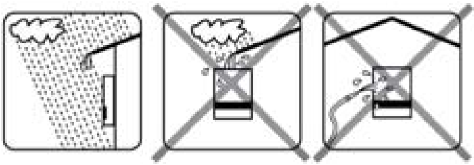


Figure 3.1 Avoid constant contact with water

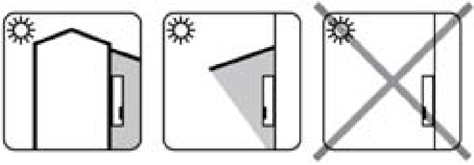


Figure 3.2 Avoid direct solar irradiation

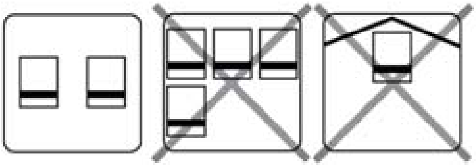


Figure 3.2 Ensure adequate air flow

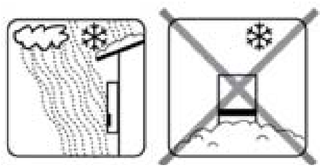


Figure 3.4 Ensure adequate air flow

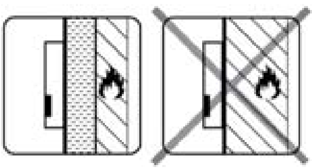


Figure 3.5 Mount on non-flammable surface

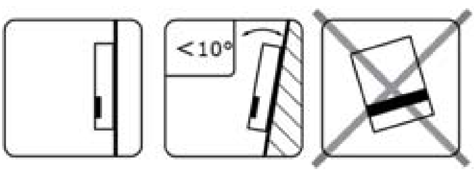


Figure 3.6 Mount upright on vertical surface. Tilt of up to 10 degrees is permitted.

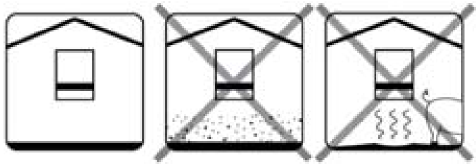


Figure 3.7 Prevent dust and ammonia gases

INFORMATION

When selecting the installation site, ensure that the product and warning labels remain visible on the visible. For details, refer to Section 6, page 33.

3.2.1 Installation Conditions

Parameter	Specification
Operating temperature range	-25°C to +60°C (possible power reduction above 45°C) -13°F to 140°F (possible power reduction above 113°F)
Storage temperature	-40°C to +60°C (-40°F to 140°F)
Relative humidity	95% (non-condensing)
Environmental class in accordance with IEC 60721-3-4	4K4H/4Z4/4B2/4S3/4M2/4C2
Cooling concept	Forced cooling
Air quality - general	ISA S71.04-1985 Class G3 (at 75% RH)
Air quality - coastal, heavy industrial and agricultural zones	Must be measured and classified in accordance with ISA S71.04-1985: G3 (at 75% RH)
Vibration	1G
Enclosure protection class	IP65
UL 50E enclosure type	Type 3R
Max. operating altitude	2,000 m (6,500 ft) above sea level (power reduction may occur at an altitude over 1,000 m).*
Installation	Avoid constant contact of water. Avoid direct solar irradiation. Ensure adequate air flow. Mount on non-flammable surface. Mount upright on vertical surface. Prevent dust and ammonia gases.

* Installations at altitudes > 2,000 m are possible on request. Contact SMA Solar Technology AG.

Table 3.1 Installation conditions

Parameter	Condition	Specification
Wall mounting bracket	Hole diameter	30 x 9 mm
	Orientation	Perpendicular ±5° all angles

Table 3.2 Specifications of the wall mounting bracket

3.3 Mounting the Inverter

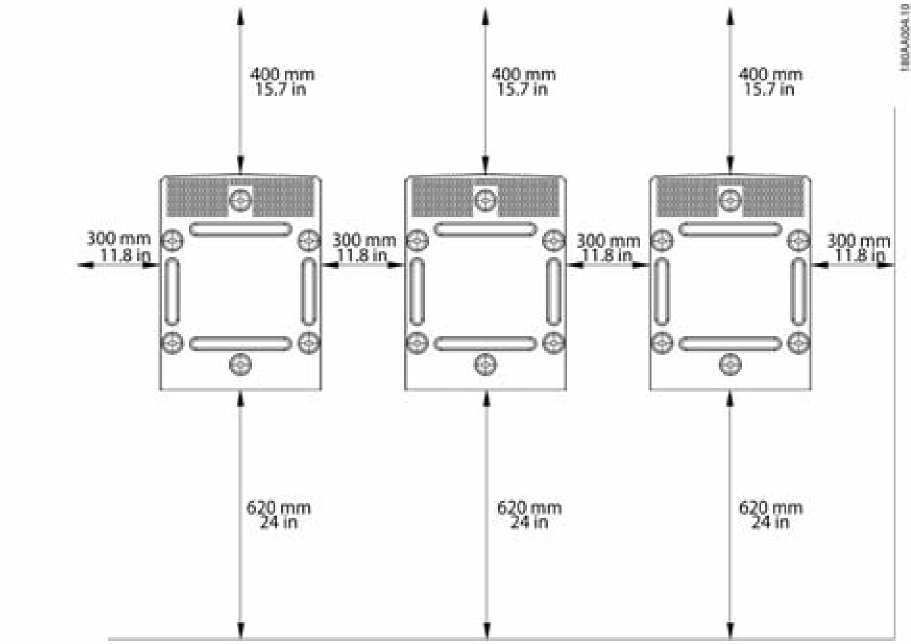


Figure 3.8 Safety clearances

INFORMATION

Ensure a minimum clearance of 620 mm/24 in. for adequate airflow.

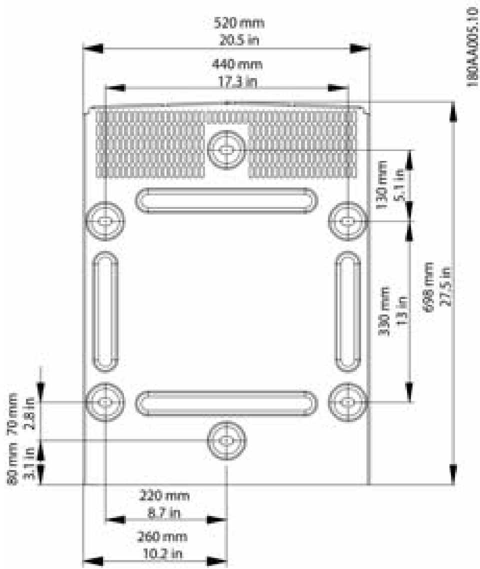


Figure 3.9: Wall mounting bracket

INFORMATION

Use of the wall mounting bracket delivered with the inverter is mandatory. If the inverter is mounted without the wall mounting bracket, the warranty becomes void. It is highly recommended to use all 6 mounting holes.

Important when mounting the wall mounting bracket:

- Mount the wall mounting bracket in the defined environment.
- Use screws and screw anchors that can safely carry the weight of the inverter.
- Ensure that the mounting plate is correctly aligned.
- Observe safety clearances when installing one more inverters to ensure adequate airflow. Clearances are specified in figure 3.9 and on the wall mounting bracket label.
- Mounting multiple inverters in a single row is recommended. Contact the supplier for guidelines in terms of mounting inverters in more than one row.
- Ensure adequate clearance at the front of the inverter for service access.

3.3.1 How to Position the Inverter

Use M12 or ½" lifting bolts and the corresponding nuts (not supplied in the accessories bag).

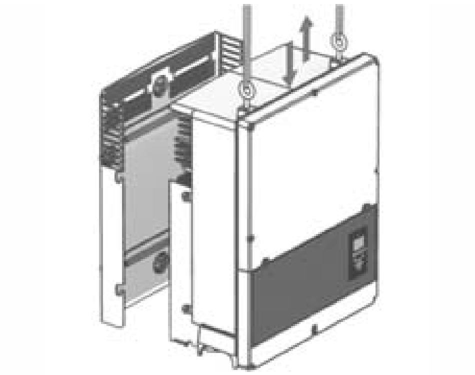


Figure 3.10 Positioning of the inverter

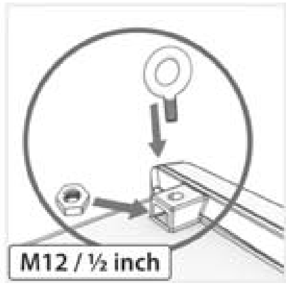


Figure 3.11 Lifting bolts

⚠ CAUTION

Refer to local health and safety regulations when handling the inverter.

3.3.2 Torque Specifications for Installation

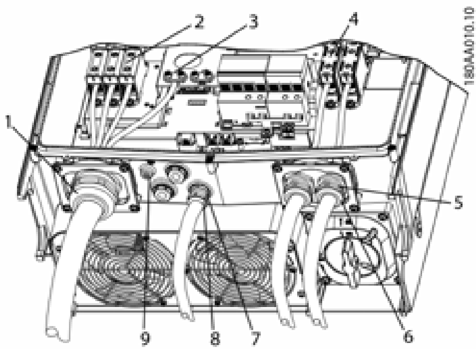


Figure 3.12 Overview of the inverter with torque specifications

	Parameter	Tools	Torque
1	M63 cable gland	Wrench 65/ 68 mm	6 Nm (53 in-lbf)
2	AC terminals	TX 30	14 Nm (124 in-lbf)
3	Grounding conductor	TX 30	3.9 Nm (35 in-lbf)
4	Terminals on DC	TX 30	14 Nm (124 in-lbf)
5	M32 cable gland	Wrench, 36 mm	6 Nm (53 in-lbf)
6	Swivel nut for M32 cable gland	Wrench, 36 mm	1.8 Nm (16 in-lbf)
7	M25 cable gland	Wrench, 27 mm	10 Nm (89 in-lbf)

	Parameter	Tools	Torque
8	Swivel nut for M25 cable gland	Wrench, 27 mm	1.8 Nm (16 in-lbf)
9	M6 equipment bonding	TX 20	3.9 Nm (35 in-lbf)
	Front screw (not shown)	TX 30	1.5 Nm (13 in-lbf)

Table 3.3 Torque specifications

CAUTION

If the blind plugs are removed (see (7) in figure 3.12), use the following types: 3, 3S, 4, 4X, 6, 6P.

3.4 Cable Specifications

Terminal	Range	Max. permissible conductor temperatures	Conductor material	Cable sheath diameter
AC+PE	16 to 95 mm² 6 to 4/0 AWG	90°C	Al/Cu	37 to 44 mm
PV	16 to 95 mm² 6 to 4/0 AWG	90°C	Al/Cu	14 to 21 mm

Table 3.4 Sufficient conductor cross-sections

4 System Planning – Electrical

4.1 Introduction

The aim of this section is to provide general information for planning the integration of the inverter into a PV system:

- PV system design, including grounding
- AC grid connection requirements, including choice of AC cable protection
- Ambient conditions, ventilation

4.2 DC Side

4.2.1 Requirements for PV Connection

The specifications for PV connection are shown in table 4.1.

Parameter	STP 60-10
MPP trackers/inputs per MPPT	1/1 (when using an external PV array junction box)
Maximum input voltage, open-circuit voltage (V_{dcmax})	1,000 V
Input voltage range	565 V to 1,000 V at 400 Vac 680 V to 1,000 V at 480 Vac
Nominal DC voltage	630 V at 400 Vac 710 V at 480 Vac
MPPT voltage range - nominal power*	570 V to 800 V at 400 Vac 685 V to 800 V at 480 Vac
Max. DC MPPT current	110 A
Max. DC short-circuit current	150 A

Table 4.1 PV operating conditions

* In case of grid connection via an assigned MV transformer, the MPP range can be changed via an AC voltage adaption, if required. Further information can be obtained from SMA Solar Technology AG.

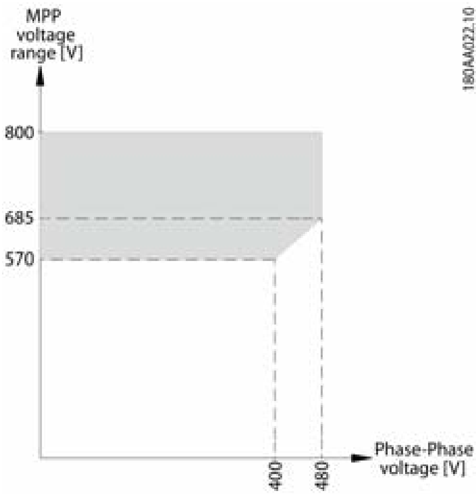


Figure 4.1 Operating range per MPP tracker

To avoid damage to the inverter, observe the thresholds in table 4.1 when dimensioning the PV array for the inverter.

CAUTION

Always observe local requirements, regulations and directives for the installation.

4.2.1.1 Maximum Open-Circuit Voltage

The open-circuit voltage of the string must not exceed the maximum open-circuit voltage limit of the inverter. Check the open-circuit voltage at the lowest PV module operating temperature expected for the location. If the module operating temperature is not known, refer to the locally common values. This calculation implies a maximum of 23 to 26 modules per string, for c-Si standard modules with 60 cells. It depends on the local climate, module model, and installation conditions (for example ground based or flush mounted). Also check that the maximum system voltage of the PV modules is not exceeded.

Special requirements apply to thin-film PV modules. See Section 4.2.3, page 27.

4.2.1.2 MPP Voltage

The string MPP voltage must be within the operating range of the inverter MPPT. The operating range is defined by:

- Minimum voltage operation MPP:
  - 570 V at 400 Vac*
  - 685 V at 480 Vac*
  - Other grid voltages: Estimate by " √ 2 x grid voltage [Vac]"
- Maximum voltage of the MPP (800 V) for the temperature range of the PV modules

* In case of grid connection via an assigned MV transformer, the MPP range can be changed via an AC voltage adaption, if required. Further information can be obtained from SMA Solar Technology AG.

This requirement implies a minimum of 23 to 25 modules per string, for c-Si standard modules with 60 cells. It depends on the location, module model, installation conditions and grid voltage. If the DC input voltage is below the minimum MPP voltage for a certain period of time, the inverter will not shut down but shift the operating point to the minimum voltage operating point MPP, resulting in some yield losses.

The MPP of the inverter can be below the minimum voltage operation MPP due to circumstances like:

- High cell temperature
- Partial shading conditions
- Insufficient number of modules per string
- High grid voltage

In general, the yield losses are minor for 400 Vac grids. Yield losses can be minimized for 480 Vac grids by:

- Increasing the number of modules per string
- Reducing the grid voltage seen by the inverters

  Grid voltage can be reduced by:
  - Modifying the tap changer position in the transformer station
  - Changing the inverter location
  - Modifying the AC cable sections

If the previous actions are insufficient for a particular project to minimize the yield losses due to MPP range at a low level, a transformer or an autotransformer with 480 V to 400 V can be installed in order to reduce the grid voltage.

INFORMATION

SMA Solar Technology AG can support you in the analysis of yield losses due to the MPP range for your particular project and in the selection of the best technical approach.

4.2.1.3 Short-Circuit Current

The short-circuit current (Isc) must not exceed the absolute maximum value that the inverter is able to withstand without any damage. Check the specifications of the short-circuit current at the highest PV module operating temperature and the highest irradiation level to be expected. Under standard test conditions, 125% of the module Isc is used per string for the calculation, following the recommendations of the NEC and other regulations. This implies that for standard c-Si modules no more than 14 strings per inverter should be used.

4.2.1.4 MPP Current

The Sunny Tripower 60 is able to provide full AC power even at its lower MPP range threshold. If the MPP current exceeds 110 A (due to high irradiation conditions or large number of strings per inverter), the inverter does not shut down but shifts the operation point, resulting in some yield losses. In addition, the inverter limits the power consumption by shifting the MPP when surplus PV power is available. For further information on PV oversizing and related consequences, see Section 4.2.2, page 27.

4.2.1.5 Resistance between PV Modules and Ground

Monitoring of the resistance between PV modules and ground is integrated in all grid code files. The inverter and/or the PV modules can be damaged in case of grid-feed in with a too low resistance. However, PV modules designed in accordance with the IEC 61215 are only tested to a specific resistance of at least 40 MΩ*m2. Therefore, for a 84 kWp system with a PV module efficiency of 14%, the total area of the modules is 600 m^2. This amounts to a minimum resistance of 40 MΩ*m^2/600 m^2 = 66.67 kΩ. The PV system configuration must be within the thresholds specified by the valid grid code. See also Section 2.3.2, page 12and Section 2.5, page 16.

4.2.1.6 Grounding

The terminals of the PV arrays must not be grounded. However, it can be compulsory to ground all conductive materials, for example, the mounting system, to comply with the general codes for electrical installations. In addition, the grounding conductor of the inverter must always be grounded.

⚠ CAUTION

It can be harmful to humans if not properly grounded.

4.2.1.7 Parallel Connection of PV Arrays

The Sunny Tripower 60 has one input and one MPPT. An external PV array junction box is always required. Due to the number of strings connected in parallel, fusing of the strings in the PV array junction box is necessary. It is recommended to place the PV array junction box near the strings. If only one cable for each terminal is led from the PV array to the inverter, the costs for cables and installation will be reduced.

4.2.1.8 Dimensioning and Laying of PV Cables

DC cabling is composed of two different cable segments:

- The string cables from the modules to the PV array junction box (usually 4 mm^2 or 6 mm^2)
- The combined cable from the PV array junction box to the inverter (at least 50 mm^2 (copper) or 70 mm^2 (aluminum) is recommended)

The cable section must be selected for each segment according to the current capacity of the cable and maximum DC cable losses according to local legislation.

The ampacity depends on the cable material (copper or aluminum) and the type of insulation (for example PVC or XLPE). Factors as for example high ambient temperature or grouping of cables lead to a reduction of the ampacity of the cables. Follow the local legislation for correction factors calculation.

The maximum permissible DC cable losses also depend on the local legislation. Note that the threshold must include both the losses in the strings and the combined cable. Cable losses depend on the cable material (copper or aluminum), cross-section area and the cable length.

Take the following into account:

- The total length of a string is defined as twice the physical distance between the string and the PV array junction box plus the length of the PV cables included in the modules.
- The total length of the combined cable is defined as twice the physical distance between the PV array junction box and the inverter

INFORMATION

For the combined cable, the maximum cable section connectable to the inverter (95 mm^2 / AWG 4/0) must be taken into account in the system design. If the calculated cable section exceeds this limit, you must use another cable type and the size of the PV system section, or the positon of the PV array junction boxes/inverters must be changed.

Avoid loops in the DC cabling since these serve as antenna for radio interferences coming from the inverter. Cables with positive and negative polarity must be led side by side with as little space between them as possible. This also lowers the induced voltage in case of lightning and reduces the risk of damage.

4.2.2 Determining Sizing Factor for PV Systems

When determining the PV system size factor, a specific analysis is preferred, especially for large-scale PV installations. Local rules of thumb for choosing the sizing factor can be determined, depending on local conditions, for example:

- Local climate
- Local legislation
- System price level

To select the optimal configuration/sizing factor, an investment analysis must be made. Large sizing factors usually reduce specific investment costs (€/kWp) but could also result in lower specific yields (kWh/kWp) due to power reduction losses in the inverter (excessive DC power or overheating) and thus lower income. Small sizing factors result in greater investment costs. However, specific yield is potentially greater due to little or no power reduction loss.

Installations in regions with frequent irradiation levels over 1,000 W/m^2 should be dimensioned with lower levels of sizing factor than installations in regions with infrequent irradiation levels over 1,000 W/m^2. In particular, this applies if high ambient temperatures are not expected during the irradiance peaks.

A lower sizing factor must also be considered for tracking systems, because they allow for higher irradiation levels over a longer period of time. In addition, derating due to overheating of the inverter must be considered for tracking systems in hot climates. This can also reduce the recommended sizing factor further.

The Sunny Tripower 60 supports different sizing factors, depending on the number of modules per string and number of strings per inverter. Any configuration that observes the varying conditions for different applications: the thresholds in Table 4.1 for short-circuit current and open-circuit voltage will be considered as valid and so covered by warranty.

4.2.3 Thin-Film PV Modules

The Sunny Tripower 60 is a transformerless inverter without step-up converter and so the PV voltage is distributed symmetrically to ground. Grounding of the positive or negative terminal is not allowed.

- The use of transformerless inverters such as Sunny Tripower 60 is approved by many thin-film PV module manufacturers if no grounding of the negative terminal is required.
- The Sunny Tripower 60 is not compatible with thin-film PV modules if grounding of the negative terminal is required.

INFORMATION

It is important to get approval from the module manufacturer before installing thin-film PV modules with inverters of type STP 60-10.

⚠ CAUTION

Module voltage during initial degradation can be higher than the nominal value in the data sheet. This must be considered when designing the PV system, since excessive DC voltage can damage the inverter. Module current can also be above the inverter current threshold during the initial degradation. In this case, the inverter decreases the output power accordingly, resulting in lower yield. Therefore, when designing, take both inverter and module specifications into consideration before and after initial degradation.

4.2.4 Internal Overvoltage Protection

The Sunny Tripower 60 includes high performance DIN-rail SPDs in both AC (type II+III, in accordance with IEC 61643-11) and DC (type II) sides. The SPDs are easy to replace if damaged.

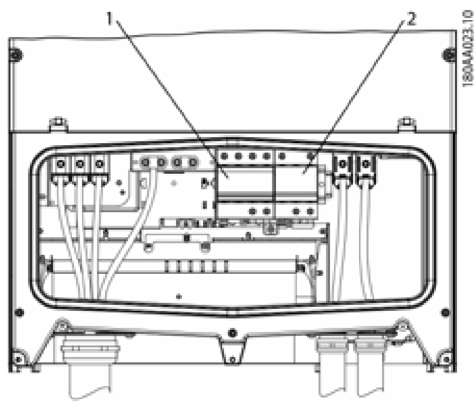


Figure 4.2 Overview of the installation area

1	SPD (AC) with 3 fuses Fuse to far right (green) does not require any replacement.
2	SPD (DC) with 3 fuses

Due to the replaced combination of gas-filled spark gap and MOV technology, SPDs in the Sunny Tripower 60 have the following advantages:

- No ground leakage current or operating voltage: no insulation error or disconnection of the inverter, no aging
- No follow current: no disconnection of the upstream overcurrent protection during surge events

If the PV system is installed on a building with an existing lightning protection system, the PV system must also be properly included in the lightning protection system.

⚠ CAUTION

When mounting the inverter on a grounded metallic surface, ensure that the inverter's ground potential and mounting plate are directly connected. Failure to do so can potentially result in material damage to the inverter, via arcing between the wall mounting bracket and the inverter enclosure.

4.2.5 Thermal Management

All power electronics generate excess heat, which must be controlled and removed to avoid damage and to achieve high reliability and long life. The temperature around crucial components like the integrated power modules is continuously measured to protect the electronics from overheating. If the temperature exceeds the thresholds, the inverter reduces its output power to maintain the temperature at a safe level.

The thermal management concept of the inverter is based on forced cooling with speed-controlled fans. The fans are electronically controlled and are only activated when needed. The rear of the inverter is designed as a heat sink that removes the heat generated by the power semiconductors in the integrated power modules. Additionally, the magnetic components are ventilated by force. When installed at higher altitudes, reduced cooling capacity must be taken into account. The fan control attempts to compensate for this reduced cooling. At altitudes higher than 1,000 m above mean sea level (MSL), consider a reduction of the inverter power when planning the system layout to avoid yield losses.

Altitude	2,000 m
Max. load of inverter	95%

Table 4.2 Height compensation

INFORMATION

PELV protection is only effective up to 2,000 m above mean sea level (MSL).

Account for other altitude-related factors, such as increased irradiation.

Inverter reliability and electrical endurance can be improved by mounting the inverter in a place with low ambient temperatures.

INFORMATION

For indoor locations, consider a maximum airflow of 640 m^3/h and a maximum heat dissipation of 1,500 W per inverter.

4.2.6 PV Simulation

Contact the supplier before connecting the inverter to an electricity supply for testing purposes, for example, simulation of PV. The inverter has functionalities that can harm the electricity supply or the inverter.

4.2.7 PV Field Capacitance

PV fields have a small parasitic capacitance, which is directly proportional to the area and inversely proportional to the thickness of the modules. Depending on the weather conditions, a total capacity of 50 to150 nF/kW can be determined for a sytem with crystalline modules. For standard thin-film PV modules (CdTe, CIS and a-Si), similar values are expected. Under extreme conditions, stainless steel sheet-based thin-film PV modules can produce values near to 1 mF/kW.

The Sunny Tripower 60 is designed to operate at a PV field capacitance of up to 8.8 μF. If this threshold is exceeded, the capacitive leakage currents can provoke an undesired disconnection of the RCMU class B of the Sunny Tripower 60, and, as a result, the inverter disconnects from the grid.

⚠ WARNING

Systems with no grounding of the structure can be dangerous. If a grounded person touches the modules, a capacitive leakage current can flow through his body. It is especially important to ground the support structure of the modules when a transformerless inverter with AC ripple on the DC side is installed in combination with high-capacity PV modules. This draws the capacitive leakage current to ground and prevents any bodily harm.

Observe the National Electric Code, ANSI/NFPA 70.

Input and output circuits are isolated from the enclosure. System grounding is the responsibility of the installer.

4.3 Connection to the Low-Voltage Grid

4.3.1 AC Connection Requirements

CAUTION

Local regulations must be observed.

For the connection to the AC grid, the Sunny Tripower 60 has a three-phase and grounding conductor terminal (without neutral conductor). The connection requirements are listed in table 4.3.

Parameter	Operating range
Grid interface	3P + PE (delta or star)
Grid voltage, line conductor-line conductor	400 V or 480 V (+/-10%)
Power frequency	50 Hz or 60 Hz (+/-10%)

Table 4.3 AC operating conditions

When choosing a grid code, the thresholds listed above are limited to comply with the specific grid codes.

Grounding Systems

The STP 60-10 inverters can operate on TN-S, TN-C, TN-C-S, and TT grid configurations. IT systems are not supported.

Where an external residual-current device is required in addition to the built-in residual-current monitoring unit, a residual-current device of type B must be used. Take a current sensitivity of 600 mA per inverter into account to avoid faulty tripping. Table 4.4 shows the maximum values of the grounding resistance in TT grid configurations, depending on the sensitivity of the residual-current device to ensure lower values than 50 V of contact voltage and thus a proper protection.

Current sensitivity		Maximum value of ground resistance
Basic sensitivity	20 A	2.5 Ω
	10 A	5 Ω
	5 A	10 Ω
	3 A	17 Ω
Medium sensitivity	1 A	50 Ω
	500 mA	100 Ω
	300 mA	167 Ω
	100 mA	500 Ω
High sensitivity	≤ 30 mA	>500 Ω

Table 4.4 Maximum ground resistance in TT TT grid configurations, depending on the current sensitivity of the residual-current device

INFORMATION

When using TN-C grid configuration to avoid ground currents in the communication cable, ensure identical grounding potential of all inverters.

4.3.2 AC Connection Protection

No consumer load must be connected between the grid circuit breaker/fuses and the inverters. An overload of the cable might not be recognized. Always use separate cables for consumer loads, protected against overcurrent and short circuit with proper fuses/circuit breakers.

Use circuit breakers/fuses with switching function for a short-circuit protection and safe disconnection of the inverters. Threaded fuse elements like 'Diazed' (D-type) are not considered adequate as a switch. Fuse holders can be damaged if removed under load. NEOZED fuses (D03-Typ, 100 A) can be used in fuse disconnectors suitable for switching purposes. LV/HRC fuses require a grip handle as additional tool.

Suitable fuses/circuit breakers for each individual inverter output cable must be installed in accordance with the specifications in table 6.4, in which it has been taken into account that power reduction of the fuses/circuit breakers can be necessary due to self-heating when installed in groups, or if exposed to heat. The maximum fuse size is 125 A.

For TN grid configurations with no residual-current device installed, check that the rating and curve of the fuses/circuit breakers selected are adequate for a proper residual-current protection (disconnection must be fast enough), considering the type of cable and cable length.

Consider the maximum short-circuit current in the location of the fuses/circuit breakers. Short-circuit currents can be as high as 60 kA, if the short-circuit current occurs inside a 2.5 MVA transformer station. This is the reason why only LV/ HRC fuses or MCCBs, with higher interruption capacity, should be used in the LV subdistribution integrated in the transformer station. D0 fuses and MCBs, with lower interruption capacity, should only be used for AC distributors distributed in the system.

AC distributors are not explicitly required for AC distribution in ground-based systems with inverters of type STP 60-10: the output cable of each inverter can be directly protected with LV/HRC fuses in an LV subdistribution integrated in the transformer station. If AC layout includes AC combiners and an LV subdistribution, selective coordination of protection should be considered, in order to avoid disconnection of protection in the LV subdistribution in case of short circuit in an inverter cable. This selective coordination can be particularly complex when MCBs are used in the AC distribution and MCCBs in the LV subdistribution.

Use the PV load-break switch to turn off the inverter before removing/replacing the fuses.

For information about cable requirements, see Section 3.4, page 24.

4.3.3 Grid Impedance

Grid impedance and installed power must match* in order to avoid an unintentional disconnection from the grid or a reduction of the output power. Ensure that cable dimensions are correct to avoid losses. Additionally, the open-circuit voltage at the connection point must be taken into account.

* The total system impedance Ztotal is calculated as percentage value as follows:
Ztotal [%]= ZPCC [%] + ZtrafoMVHV [%] + ZtrafoLVMV [%]

- ZPCC: Short-circuit impedance at the PCC, calculated based on the short-circuit power available at the PCC. (This value is usually provided by the grid operator.)
- ZtrafoMVHV: Short-circuit impedance of the MV/HV transformer according to the datasheet of the manufacturer (if not available, this is equal to 0%)
- ZtrafoLVMV: Short-circuit impedance of the LV/MV transformer according to the datasheet of the manufacturer (if not available, this is equal to 6%)

For Sunny Tripower 60, Ztotal = 30% is the maximum threshold of the entire system impedance.

4.3.4 AC Cable Considerations

The cable cross-section must be selected according to the ampacity of the cable and the maximum permissible AC cable losses according to local legislation. In TN grid configurations, if no residual-current devices are installed, the cable cross-section in combination with the short-circuit protection installed, must also ensure a sufficient residual current protection.

Current capacity of the cable depends on the cable material (copper or aluminum) and the insulation type (for example PVC or XLPE). Factors as for example high ambient temperature or grouping of cables lead to a reduction of the ampacity of the cables. Follow the local legislation for correction factors calculation.

The maximum permitted AC cable losses also depend on the local legislation. Cable losses depend on the cable material (copper or aluminum), the cable cross-section and the cable length.

In TN grid configurations, due to the low impedance for the fault loop, residual currents are high. This means that the short-circuit protection can also be used for residual-current protection, if a disconnection time lower than 0.4 seconds can be ensured, according to IEC 60364-4-41, table 41.1. This can be checked using the time/current curves of the fuses/circuit breakers installed for the minimum short-circuit current ($I_{sc,min}$) expected in the cables they protect.

Initially consider a minimum AC cabling section of 35 mm² (copper) and 50 mm² (aluminum).

INFORMATION

The maximum cable cross-section connectable to the inverter (95 mm²/AWG 4/0) must be taken into account in the system design. If the calculated cable cross-section exceeds this threshold, either use AC combiners or use another cable type and change the size of the substation or the location of the inverters.

5 Communication and System Planning, SMA Inverter Manager

5.1 Ethernet Communication

5.1.1 System Overview

The system consists of four components:

- PC with LCS software
- Router/DHCP for system network
- SMA Inverter Manager
- Sunny Tripower 60

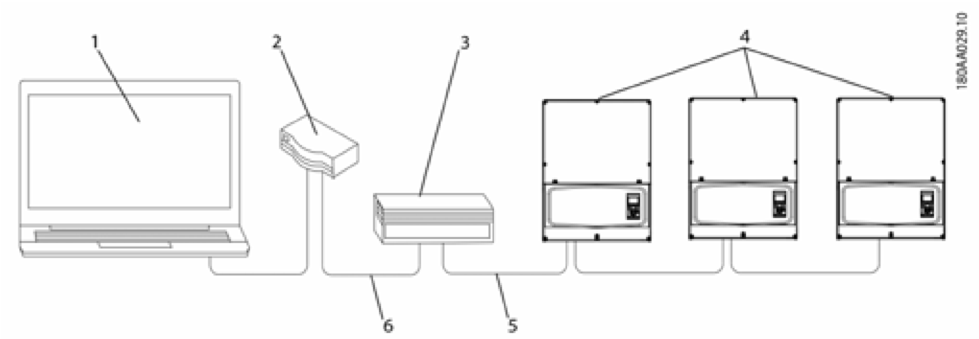


Figure 5.1 Commissioning inverters via the LCS tool

1	LCS tool
2	Router/DHCP
3	SMA Inverter Manager
4	Sunny Tripower 60
5	LAN 2
6	LAN 1

This section describes how the system works and the function of the individual components.

The system is divided into two Ethernet networks: system network and inverter network (see figure 5.1). The system network is the communication interface to the system and can operate together with other IT equipment while the inverter network must only be used for inverters of the STP 60 series.

The system network must be equipped with a router/DHCP server since the SMA Inverter Manager requires automatic IP assignment. It is recommended to use professional routers and network switches.

INFORMATION

When designing the system network, it is important to consider network security in order to ensure that only authorized personnel can access the system network. This is especially important when the system network is connected to the Internet.

⚠ WARNING

SMA Solar Technology AG accepts no liability for damage or losses due to unauthorized access to the system.

The inverters are equipped with a 2-port Ethernet switch allowing for daisy chaining. The SMA Inverter Manager hosts the DHCP server where up to 42 inverter can be connected per SMA Inverter Manager. In order to commission the system, all inverters must be connected to the SMA Inverter Manager. If the inverters loose connection, they will disconnect from the grid. Systems requiring more than 42 inverters can use multiple SMA Inverter Managers in the system network.

5.1.2 SMA Inverter Manager

The SMA Inverter Manager separates the system network and the inverter network and handles the following tasks at system level:

- Allows access via SunSpec Modbus TCP profiles (acts as gateway to the inverters)
- Decentralized control of active and reactive power (for example through reactive setpoint curves or output power limitation)
- Portal upload to FTP server
- Access to system configuration and maintenance through LCS
- Connection interfaces for external devices such as I/O box (grid management) and weather stations

5.2 User Interfaces

The Local Commissioning and Service tool (LCS) is used to commission the SMA Inverter Manager and inverters, enabling them to start injecting power into the grid. With the LCS Tool it is possible to:

- Perform software update of the system
- Read out inverter values (voltage, current etc.)
- Display inverter event logs
- Load customer-specific grid code files (information on how to obtain customer-specific grid files, see Section 2.5, page 16)
- Configure FTP portal upload
- Access commissioning reports
- Modbus gateway address list
- Add/replace inverters

The STP 60-10 inverters and the SMA Inverter Manager must be commissioned via the local commissioning and service tool (LCS tool). Commissioning is required before the STP 60 inverters are connected to the AC grid and start to feed-in energy.

The LCS tool is available in the download area at www.SMA-Solar.com.

The hardware requirements for the LCS tool are:

- PC with Windows™7 or later
- 1 GB HDD
- 2 GB RAM

The LCS tool must be installed on a local PC drive. The PC must be connected to the system network of the SMA Inverter Manager.

INFORMATION

The SMA Inverter Manager must have an IP address assigned by the DHCP server on port LAN 1.

It is important that the PC running the LCS tool is connected to the same IP subnet as the SMA Inverter Manager.

Port LAN 2 is intended for STP 60-10 inverters exclusively.

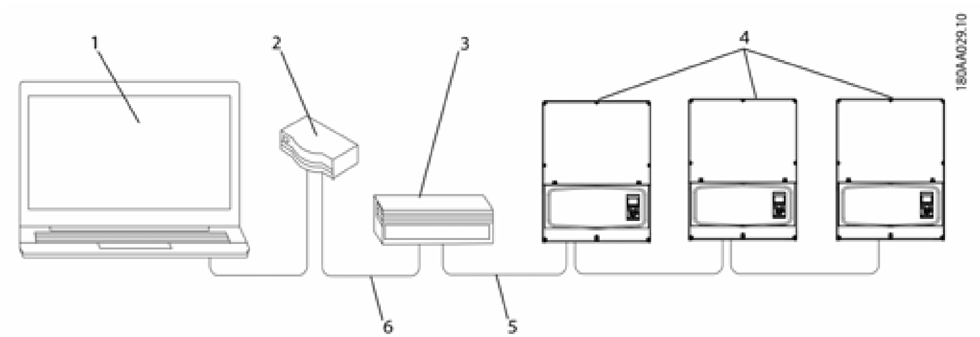


Figure 5.2 Commissioning inverters via the LCS tool

1	LCS tool
2	Router/DHCP
3	SMA Inverter Manager
4	Sunny Tripower 60
5	LAN 2 (inverter network)
6	LAN 1 (system network)

5.3 I/O Box

The I/O box is used for transmitting the relay state from a ripple control receiver, provided by the DNO, to the SMA Inverter Manager via RS485. An I/O box is required for each SMA Inverter Manager. The I/O box support six digital inputs.

5.4 Weather Station

Any SunSpec-compliant RS485 weather station can be connected to the SMA Inverter Manager.

6 Technical Data

6.1 Technical Data

Parameter	STP 60-10
AC	
Nominal apparent power[1)]	60 kVA
Nominal active power[2)]	60 kW
Reactive power range[1)]	0 to 60 kVAr
Nominal AC voltage (voltage range)	3P + PE (WYE)/400 V to 480 V (+/-10%)
Supported grounding systems	TT, TN
Nominal AC current	3 x 87 A
Max. AC current	3 x 72 A at 480 V
AC total harmonic distortion (THD at nominal output power)	<1%
Power factor – standard	> 0.99 at nominal power
Power factor – controlled	0.8 overexcited to 0.8 underexcited
Stand-by power consumption (for communication)	3 W
Nominal power frequency (range)	50/60 Hz (+/-10%)
DC	
Input voltage range	565 V to 1,000 V at 400 Vac 680 V to 1,000 V at 480 Vac
Nominal DC voltage	630 V at 400 Vac 710 V at 480 Vac
MPPT voltage range - nominal power	570 V to 800 V at 400 Vac 685 V to 800 V at 480 Vac
Max. DC voltage	1,000 V
Minimum power on the grid	100 W
Max. DC MPPT current[4)]	110 A
Max. DC short-circuit current[4)]	150 A
MPP tracker/Input per MPPT	1/1 (when using an external PV array junction box)
Efficiency	
Max. efficiency EU/CEC	98.8%
EU efficiency at 570 VDC	98.5%
CEC weighted efficiency at 400/480 Vac	98.0%/98.5%
MPPT efficiency, static	99.9%
Enclosure	
Dimensions (W / H / D)	740 × 570 × 300 mm (29 × 22.5 × 12")
Weight	75 kg (165 lbs)[3)]

Parameter	STP 60-10
Acoustic noise level	55 dB(A) (preliminary value)

Table 6.1 Specifications

[1] at nominal grid voltage

[2] at nominal grid voltage, Cos(phi) = 1.

[3] depending on the options installed

[4] under any conditions

Parameter		STP 60 series
Electrical		
	Electrical safety	• IEC 62109-1/IEC 62109-2 (Class I, grounded – Communication part Class II, PELV) • UL 1741 with not isolated, grid-tie PV inverters • IEEE 1547
	PELV on the communication and control card	Class II
Functional		
	Functional safety	• Voltage and frequency monitoring • Monitoring of DC current share in AC current • Insulation resistance monitoring • FI monitoring • UL1998
	Islanding detection - grid failure	• Active frequency shift • Disconnection • Three-phase monitoring • ROCOF/SFS
	RCD compatibility[1]	Typ B, 600 mA

Table 6.2 Safety specifications

[1] depending on local regulations

6.2 Thresholds for the Reduction of the Design Factors

To ensure that the inverters can generate nominal power, measurement inaccuracies are taken into account when enforcing the power reduction limits stated in Section 2.4.2, page 14.

(Threshold = nominal value + tolerance).

6.3 Standards

International standards	STP 60 series
Efficiency	EU efficiency, standard: EN 50530
	CEC weighted efficiency, standard: CEC guideline Test guideline: Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems (Draft): March 1, 2005
EC Low-voltage directive	2006/95/EC
EC directive for electromagnetic compatibility (EMC)	2004/108/EC
Safety	IEC 62109-1/IEC 62109-2
	UL 1741
	UL 508i
Functional safety	IEC 62109-2
	UL 1741/IEEE 1547
EMC, interference immunity	EN 61000-6-1
	EN 61000-6-2
EMC, emission	EN 61000-6-3
	EN 61000-6-4
	CISPR 11 Class B
	FCC Part 15
Harmonic currents	EN 61000-3-12
CE	Yes
Transmission line characteristics	IEC 61727
	EN 50160
	IEEE 1547 UI

Table 6.3 Compliance with international standards

Approvals and certificates are available in the download area at www.SMA-Solar.com.

6.4 Specifications for Grid Protection

Parameter	Specification
Maximum inverter current, IACmax	87 A
Recommended type of time-lag fuse gL/gG (IEC 60269-1)	100 to125 A
Recommended type of the time-lag fuse Class T (UL/USA)	125 A
Recommended circuit breaker type B or C	125 A
Maximum fuse size	125 A

Table 6.4 Specifications for grid protection

INFORMATION

Observe local regulations.

6.5 Technical Data of the Communication Interface

Interface	Parameter	Parameter details	Specification
Ethernet	Cable	Cable sheath diameter (⌀)	2 x 5 to 7 mm
		Cable type	STP cable (Shielded Twisted Pair, CAT 5e or SFTP CAT 5e)1)
		Cable characteristic impedance	100 Ω to 120 Ω
	RJ45 connector: 2 pcs. RJ45 for Ethernet	Wire size	24 to 26 AWG (depending on design of the RJ45 plug)
		Cable shield termination	Via RJ45 plug
	Galvanic interface insulation		Yes, 500 Vrms
	Direct protection against contact	Double/reinforced insulation	Yes
	Short-circuit protection		Yes
	Communication	Network topology	Star and daisy chain
	Cable	Max. cable length between inverters	100 m (328 ft)
	Max. number of inverters	Per SMA Inverter Manager	42

Table 6.5 Technical data of the communication interfaces

[1] For outdoor use, ensure that an appropriate cable is used. If the cable is very stiff, an intermediate terminal should be used in order to change from a stiff to a more flexible cable before connecting it to the inverter. For some cables, it might be sufficient to remove the hard outer mantle of the part of the cable inside the inverter enclosure. This is to protect the RJ-45 Ethernet ports mounted on the printed circuit boards from excessive strain which could lead to damage or connection issues.

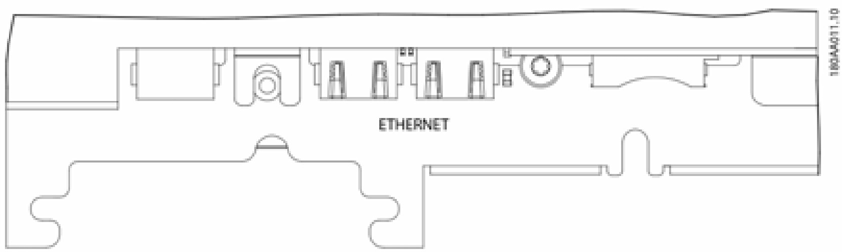


Figure 6.1 Auxiliary interfaces (cutout of the inverter installation part)

6.6 Ethernet Connections

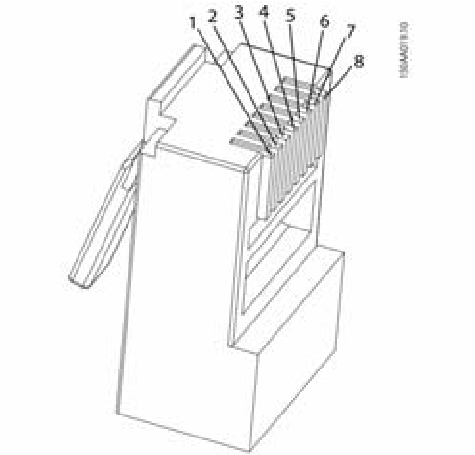


Table 6.6. Pin assignment of the RJ45 plug for Ethernet

Ethernet pin assignment	Color standard	
	Cat. 5 T-568A	Cat. 5 T-568B
1. RX+	Green/white	Orange/white
2. RX	Green	Orange
3. TX+	Orange/white	Green/white
4.	Blue	Blue
5.	Blue/white	Blue/white
6. TX-	Orange	Green
7.	Brown/white	Brown/white
8.	Brown	Brown

6.6.1 Network Topology

The inverter has two Ethernet RJ45 pin connectors enabling the connection of several inverters in a line topology (as an alternative to the typical star topology).

INFORMATION

Ring topology (C in figure 6.3) is only permitted if realized with an Ethernet switch supporting spanning tree.

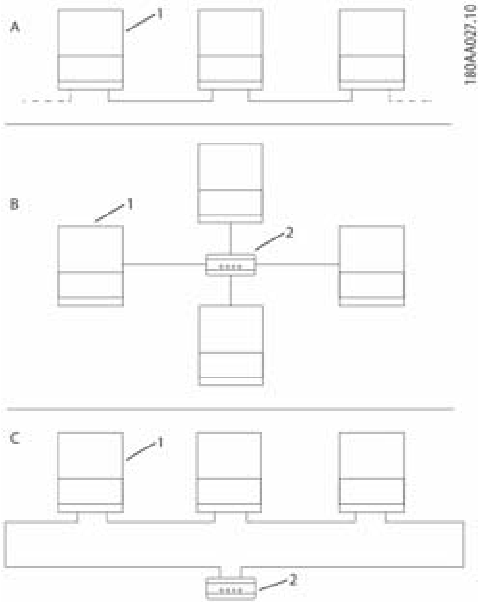


Figure 6.3 Network topology

A	Linear daisy chain
B	Star topology
C	Ring topology (only if spanning tree is used)
1	Sunny Tripower 60
2	Ethernet switch

Table 6.7 Network topology

Status of the LEDs next to the Ethernet interface is explained in table 6.8. There are two LEDs per interface.

Status	Yellow LED	Green LED
Off	10 Mbit/s data transfer rate	No link
On	100 MBit data transfer rate	Link
Flashing	-	Activity

Table 6.8 LED status

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