Technical Information

Integrated Plant Control and Q on Demand 24/7 SUNNY TRIPOWER / SUNNY HIGHPOWER

1 Function Availability

Reactive power is necessary for the stability of the utility grid. With the functions "Integrated Plant Control" and "Q on Demand 24/7", SMA Sunny Tripower inverters can feed reactive power into the grid during operation and overnight. This document provides basic information on reactive power and how to configure the inverter in order to provide reactive power in compliance with standards and demand.

The following table provides an overview of the device types and firmware versions for which the various functions are available. Please note that the complete firmware version of the inverter can only be displayed via a communication product.

SMA inverter (Device type)	Reactive power provision $0_{overexcited}$ to $0_{underexcited}$	Q on Demand 24/7	Integrated Plant Control
STP 50-40/ STP 50-US-40/ STP 50-JP-40	from firmware version 1.03.04	from firmware version 1.03.04	from firmware version 1.03.04
STP 33-US-41/ STP 50-US-41/ STP 62-US-41	from firmware version 1.09.03.R	from firmware version 1.09.03.R	from firmware version 1.09.03.R
STP 60-10/ STP 60-US-10	from firmware version 1.60	from firmware version 1.60	not available
STP 60-JP-10	from firmware version 1.80	from firmware version 1.80	not available
SHP 75-10	from firmware version 1.91	from firmware version 1.91	not available
SHP 75-JP-10	from firmware version 2.0	from firmware version 2.0	not available
STP 15000TL-10/ STP 17000TL-10	from firmware version 2.60.02	from firmware version 2.60.02	from firmware version 2.62.04
STP 15000TLEE-10/ STP 20000TLEE-10	from firmware version 2.61.06	from firmware version 2.61.06	from firmware version 2.63.03
STP 20000TL-30/ STP 25000TL-30	from firmware version 2.80.04	from firmware version 2.82.03	from firmware version 2.81.03
STP 12000TL-US-10/ STP 15000TL-US-10/ STP 20000TL-US-10/ STP 24000TL-US-10/ STP 30000TL-US-10	from firmware version 2.80.00	from firmware version 2.80.00	from firmware version 2.80.00

2 Definition of Active Power, Reactive Power and Apparent Power

Electrical power is the product of current and voltage. While current and voltage have stable values with direct current, the strength and the direction of both current flow and voltage change regularly in alternating current. In the utility grid, current and voltage have a sinusoidal progression, meaning that their product, electrical power, is also sinusoidal. In DC systems, the sign of the power indicates the direction in which the electrical energy, in the form of active power, is transported. In general, this also applies in an AC circuit. However, the power may not always be constantly positive or constantly negative, but rather its sign can fluctuate periodically, causing the power to oscillate back and forth. This oscillating power does not do any work and is therefore referred to as reactive power. The time delay between the current and voltage curve - the so-called phase shift - is a value which is easy to measure and characteristic of the relationship between active power and reactive power at the point under consideration in the electric circuit.

2.1 Active Power P

With no phase shift between the progression of current i(t) and voltage v(t) over time, both always have the same sign and simultaneously reach their maximum and minimum values. The power oscillates between zero and the positive maximum value. Averaged over time, this results in a positive power value P (unit: W; watt) and only active power P is generated. This behavior only occurs when ohmic loads are the only loads in the electric circuit. In a real utility grid, however, the line inductances and capacitances alone result in the active power always being accompanied by a small amount of reactive power.

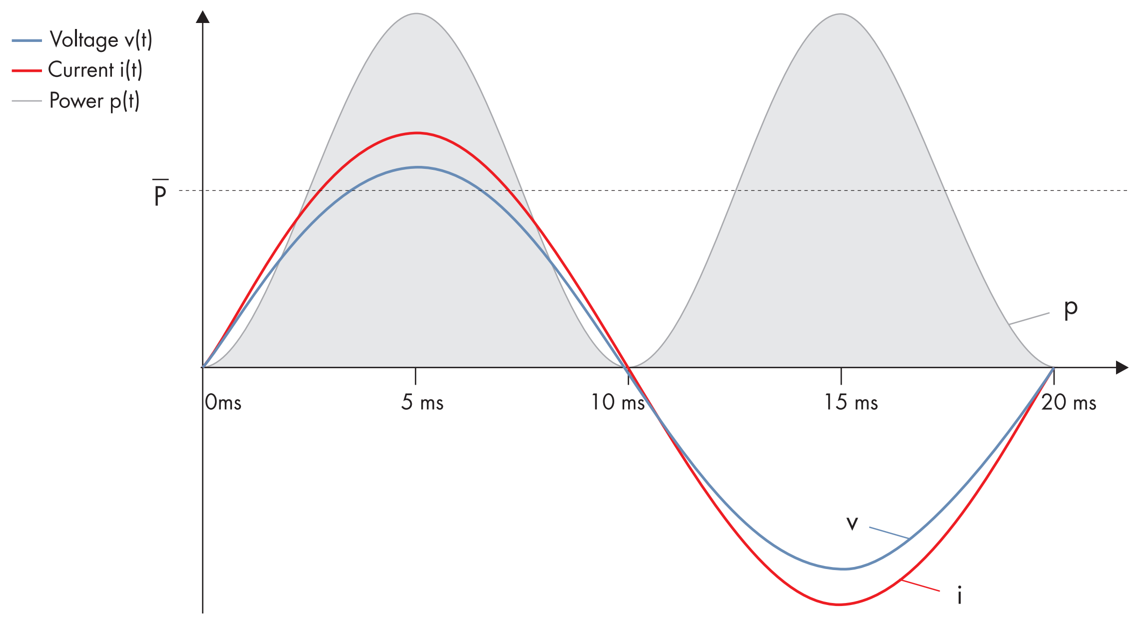


Figure 1: Pure active power: current and voltage are in phase

2.2 Reactive Power Q

With a phase shift phi of 90°, the maximum current occurs precisely when the voltage crosses zero, resulting in the power oscillating between positive and negative values. The average over time is therefore zero. This is known as pure reactive power Q (unit: Var, from the French volt-ampère-réactif), which moves "back and forth" in the lines.

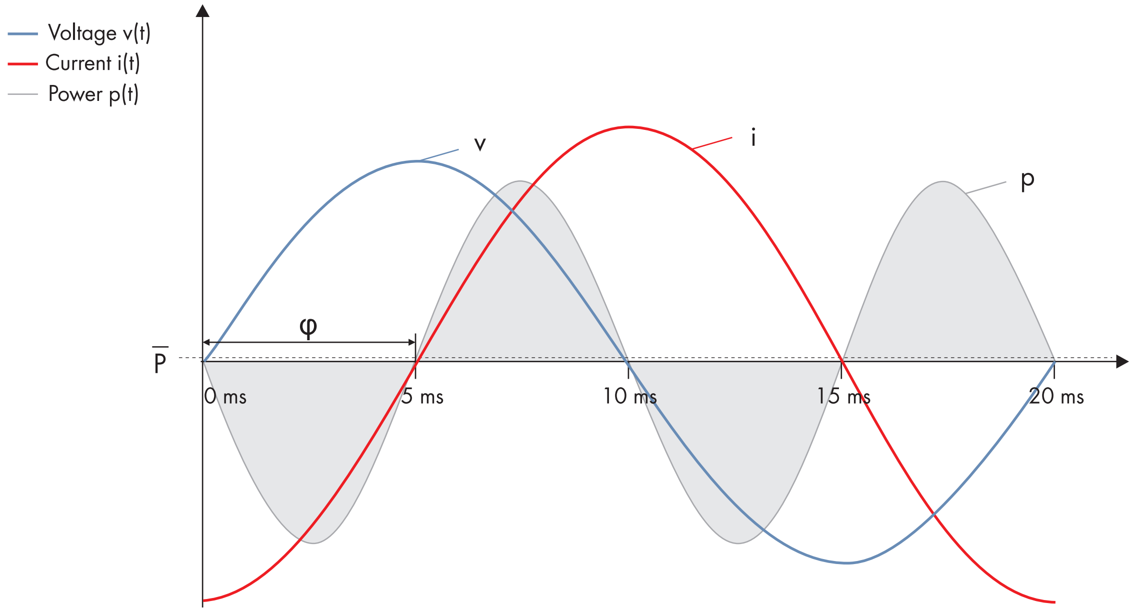


Figure 2: Pure reactive power: current and voltage are out of phase by 90°

2.3 Apparent Power S

In real AC circuits, there is a mix of active power and reactive power. This behavior occurs if there are lagging or leading loads in the utility grid. The shift between current and voltage is denoted by the displacement power factor cos φ.

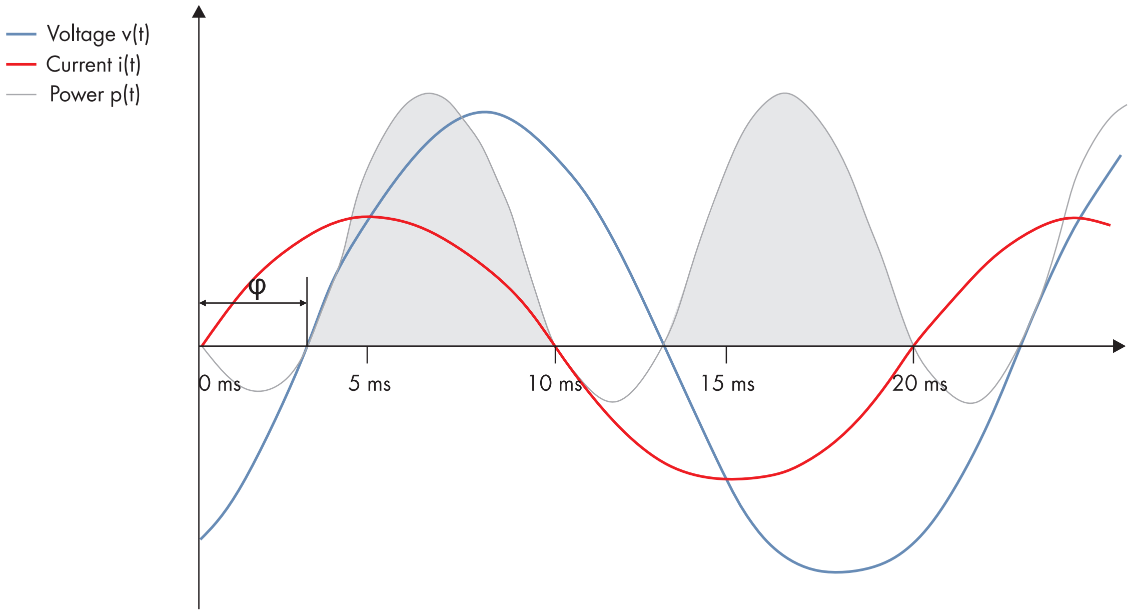


Figure 3: In real AC grids, current and voltage are slightly out of phase and reactive power occurs together with active power

Calculating Apparent Power

The sum of active power and reactive power is the so-called apparent power S (unit: VA; volt-ampère). It should be noted that the values are not simply added arithmetically, rather the geometric sum must be calculated: active and reactive power form the adjacent and opposite sides of a right-angled triangle respectively, the hypotenuse corresponds to the apparent power. The cosine of the angle between the active power and the apparent power is the displacement power factor.

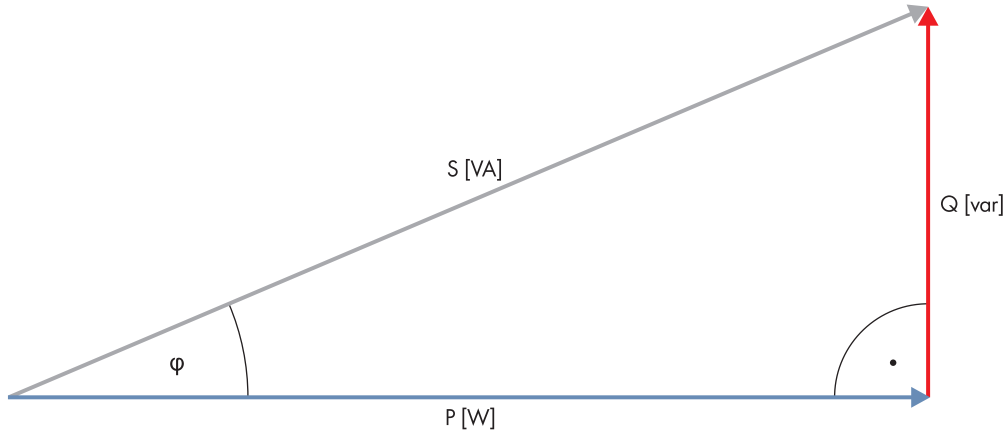


Figure 4: Geometric addition of active and reactive power

2.4 Reactive Power Compensation and Control with Sunny Tripower

Compensating for Reactive Power Demand with Q on Demand 24/7

Leading or lagging loads (e.g. cables, transformers) require reactive power. Transporting reactive power from the power plant to the load places a burden on the utility grid. It is therefore expedient to install a compensation system that provides reactive power at sites where there are many leading or lagging loads. In order to ensure the stability of the utility grid, grid operators demand that energy producers participate in reactive power compensation. A PV system can complement or replace such a compensation system.

Due to their design, large PV farms have a certain demand for reactive power that can be compensated for with Sunny Tripower inverters. At the same time, Sunny Tripower inverters can make reactive power available for the utility grid. Compensation can take place both during and outside of feed-in operation via the "Q on Demand 24/7" function. Via this function, the Sunny Tripower inverter provides reactive power for the PV farm equipment without placing an appreciable burden on the utility grid.

Controlling the Q(V) Characteristic Curve with Integrated Plant Control

The Sunny Tripower inverter can provide reactive power to the utility grid with the "Integrated Plant Control" function. The grid operator specifies via which process the inverter is to provide reactive power to the utility grid. In many cases, the grid operator will request control in accordance with a Q(V) characteristic curve.

SMA inverters with "Integrated Plant Control" are capable of reproducing this Q(V) characteristic curve without performing any measurement at the grid-connection point. The inverter can automatically compensate for equipment installed between the inverter and the grid-connection point.

The function "Integrated Plant Control" is not capable of compensating for irregular or fluctuating reactive power demands due to, for example, connected machinery, if the machinery is connected between the inverters and the grid-connection point. If the machinery is connected directly at the grid-connection point, it is possible to dynamically determine the additional reactive power demand of the machines using additional measurement equipment and then to provide this value as an offset to the Q(V) control.

3 Design of PV Farms

3.1 Typical PV Farm with Central PV Farm Control

Decentralized PV farms must be able to control the flow of reactive power. It is not sufficient for each inverter to comply with the characteristic specified by the grid operator, because all of the equipment (lines, transformers, switchgear, etc.) has an influence on the characteristic curve of the PV power plant as a whole.

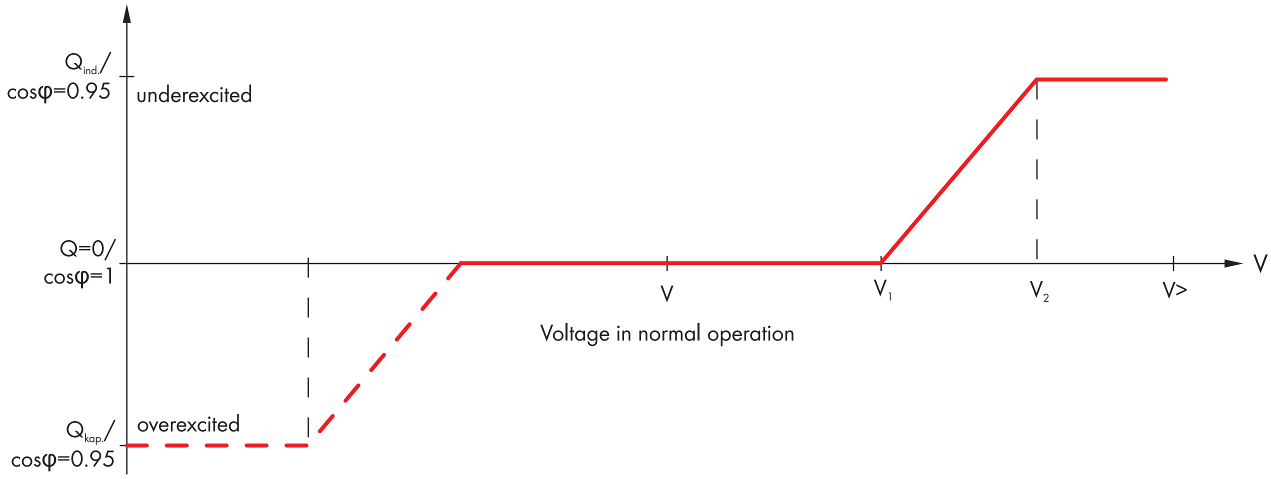


Figure 5: Example of a Q(V) characteristic curve specified by the grid operator

For this reason, the central PV farm control records the most important grid values at the grid-connection point and compares these with the characteristic curve specified by the grid operator. When deviations occur, a corrected uniform setpoint for reactive power is transmitted to the inverters which then ensures that the specified characteristic is achieved.

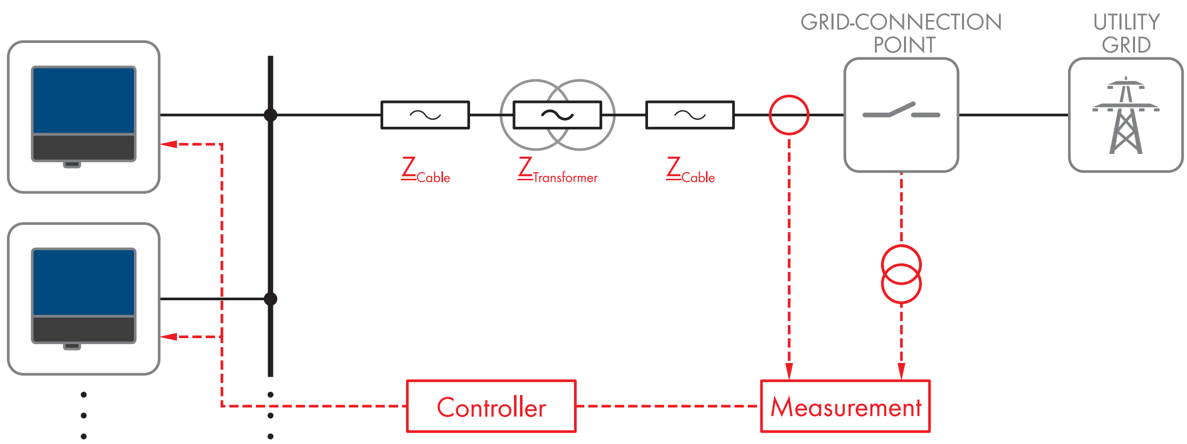


Figure 6: PV farm with central PV farm control

3.2 PV Farm with Integrated Plant Control

The "Integrated Plant Control" function enables each inverter within a group of several inverters to determine its own individual contribution, in order that the necessary reactive power can be provided at the grid-connection point. Each inverter in the group compensates for the impedance influences of the cables and of the transformer.

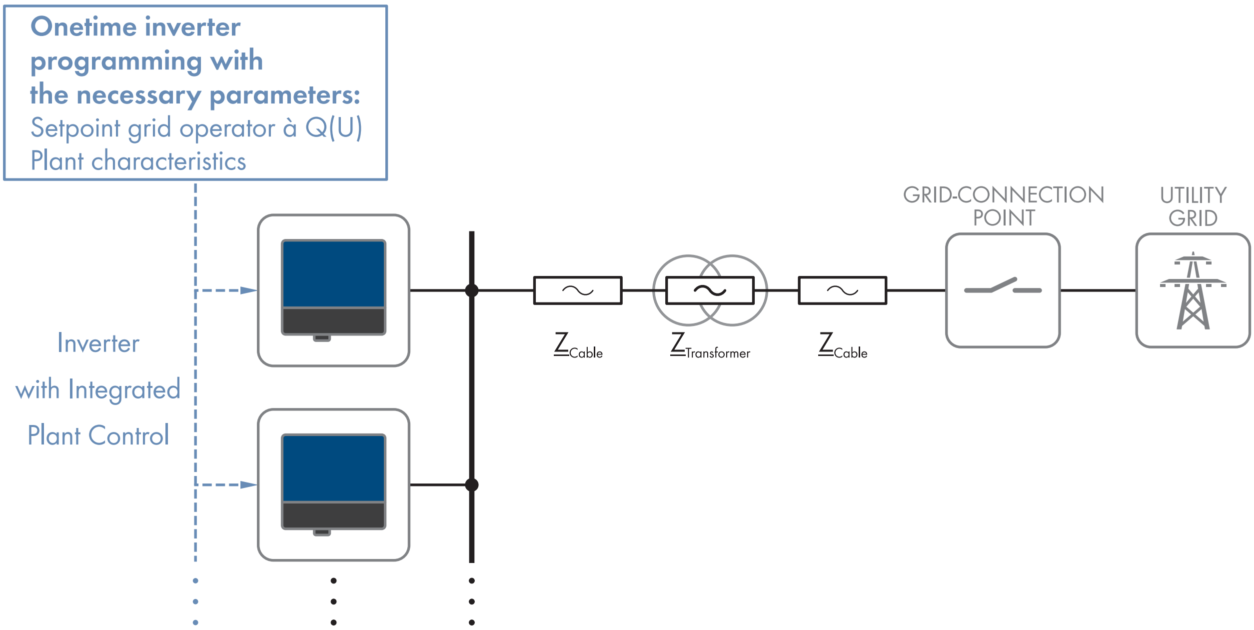


Figure 7: PV Farm with Integrated Plant Control

Advantages of Integrated Plant Control

- Economical: no additional costs for central farm control gear, measured value recording at the grid-connection point, fast data transmission or the installation and commissioning of these.
- Grid friendly: adherence to the characteristics desired by the grid operator even in the presence of very rapid changes in grid voltage.
- Clear and simple: simplifies system design and maintenance. Inverter parameterization is calculated via the Sunny Design design software.
- Secure: redundancy through individual integration and one-off parameterization of each inverter.
- Flexible: the grid characteristics of even small PV systems having two or more inverters can be optimized inexpensively. Existing PV systems can be updated via a software update.

Functionality of Integrated Plant Control

Despite the utmost care in the creation of the Integrated Plant Control function, SMA Solar Technology AG does not accept any statutory warranty for the functionality of "Integrated Plant Control".

4 Integrated Plant Control Configuration

In order to operate PV systems with Integrated Plant Control, the following settings are necessary:

1. The individual design of the PV system with all of its essential equipment must be entered in order that each inverter can calculate its own individual influence on the grid-connection point.
2. The desired characteristic at the grid-connection point (generally specified by the grid operator) must be set.

4.1 Determining the Key Values of the System

In order to determine the parameter settings at the inverter, the equipment between the inverter terminals and the grid-connection point must be characterized. Determine the following key values:

Lines used

- Line material
- Cross section
- Line length

MV transformer

- Nominal apparent power (S_N)
- Impedance voltage (u_k)
- Short-circuit impedance loss at nominal power (P_k)

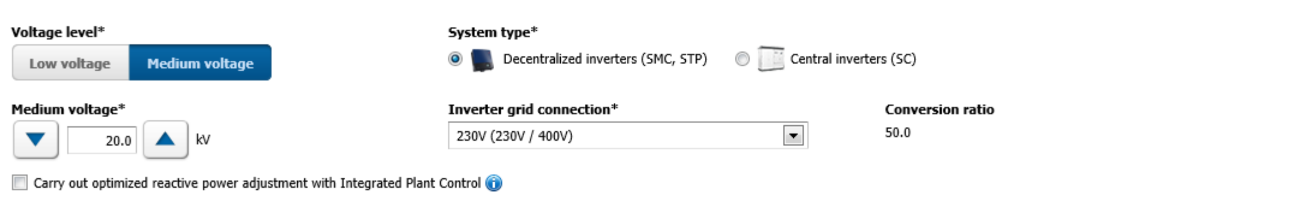
i MV transformer values

The required MV transformer values are usually to be found on the type label or in the datasheet. If these are not available, contact the manufacturer.

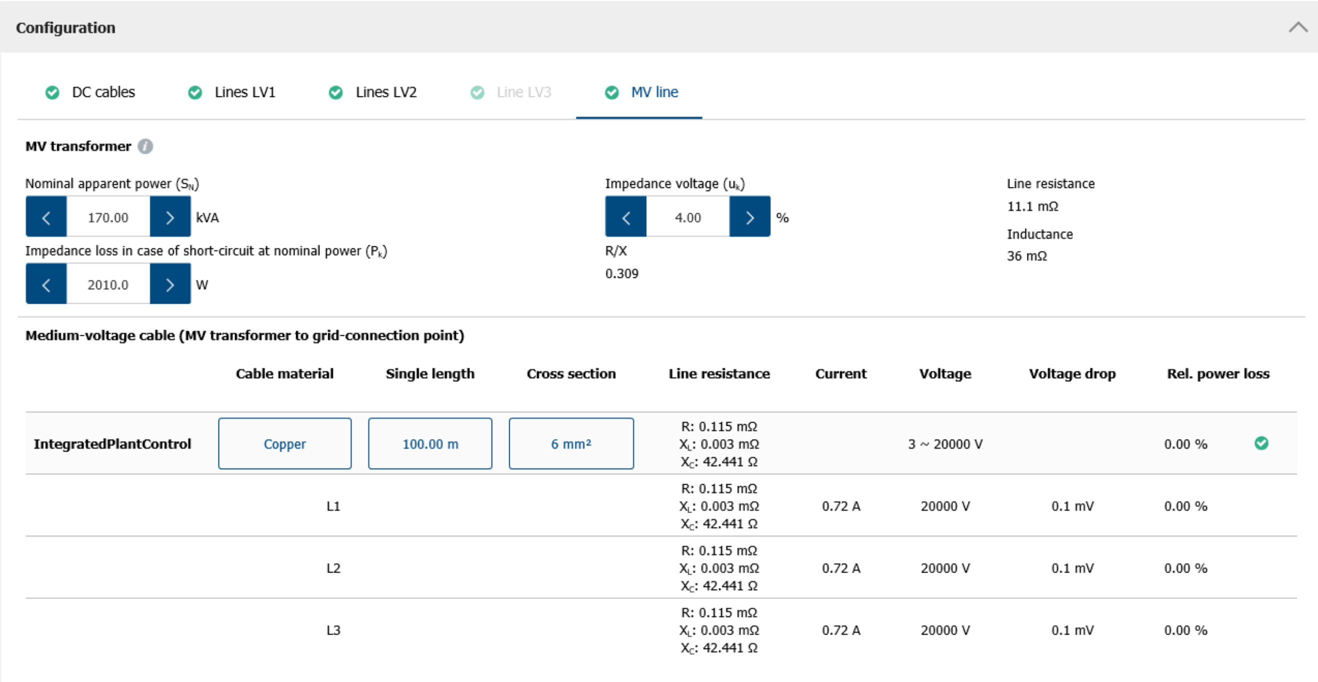
4.2 Entering the Key Values in Sunny Design

A detailed manual for Sunny Design is to be found at www.SMA-Solar.com. Proceed as follows to enter the key values in Sunny Design:

1. Open Sunny Design and log in as a user.
2. Create a new project.
3. Enter the project data.
4. Under **Project data**, select the option **Carry out optimized reactive power adjustment with Integrated Plant Control**.

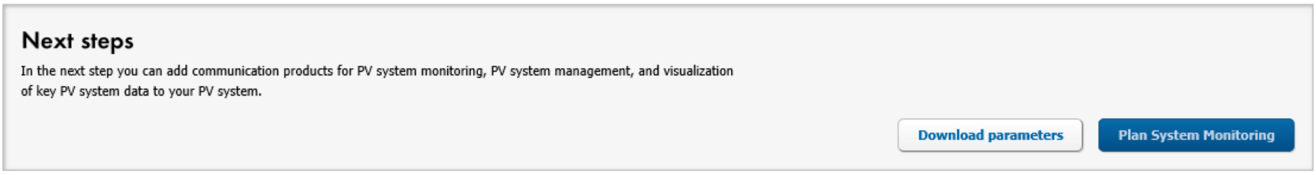


5. Select the button [**Configure the PV system**].
6. Select the PV arrays and inverters used from the menu.
7. Select the button [**Wire Sizing**].
8. If there is a project sub-distribution (LV3) available, select the option **Project subdistribution available (LV3)** from the **Overview** window.
9. In the **Overview** window, select the option **Medium-voltage line and MV transformer available (MV)**.



☑ The tabs for entering the information on the lines and the MV transformer are activated in the Configuration area.

10. Enter the key values for the cables used in the tabs **Lines LV1**, **Lines LV2** and **Lines LV3**.
11. In the tab **MV transformer**, enter the key values for the MV transformer.
12. In the window **Next steps**, select the button [**Download parameters**].



☑ The tabs for entering the information on the lines and the MV transformer are activated in the Configuration area.

	A	B	C	D	E	F	G	H	I	J
1	Project	Neues Projekt 1								
2										
3	Inverter parameters for optimized reactive power adjustment with Integrated Plant Control									
4										
5				PV system	Impedance compensation					
6	Subproject	Inverter	Serial numbe	Rated appare	Ohmic resist	Inductive resi	Capacitive resistance for impedance compensation [Ω]			
7	Teilprojekt 1									
8		1 x STP 17000TL-10		34.00	0.0208	0.0465	42.4			
9		1 x STP 17000TL-10		34.00	0.0184	0.0463	42.4			
10										
11	Impedance compensation switched on									
12										
13										

Parameter Description

Parameter name for BLUETOOTH or Speedwire/Webconnect	Parameter name with RS485	Description
Rated apparent power of all inverters	Plnt.VARtg	Rated apparent power of all inverters [kVA]
Ohmic resistance for impedance compensation	ImpCpn.OhmRis	Ohmic resistance for impedance compensation [Ω]

Parameter name for BLUETOOTH or Speedwire/Webconnect	Parameter name with RS485	Description
Inductive resistance for impedance compensation	ImpCpn.IndRis	Lagging resistance for impedance compensation [Ω]
Capacitive resistance for impedance compensation	ImpCpn.CapacRis	Leading resistance for impedance compensation [Ω]
Impedance compensation switched on	ImpCpn.IsOn	Impedance compensation switched on

4.3 Changing Inverter Operating Parameters

Always change operating parameters as described in this section. Some function-sensitive parameters can only be viewed and changed by qualified persons (for further information on changing parameters, refer to the manual of the communication product). The operating parameters of the inverter are set to certain values by default. To optimize inverter operation, you can change the operating parameters using a communication product.

Requirements:

- ☐ Depending on the type of communication, a computer with BLUETOOTH or Ethernet interface must be available.
- ☐ A communication product corresponding to the type of communication used must be available.
- ☐ The inverter must be registered in the communication product.
- ☐ The changes to the grid-relevant parameters must be approved by the responsible grid operator.
- ☐ For changing the grid-relevant parameters, the SMA Grid Guard code must be available (see "Application for SMA Grid Guard Code" at www.SMA-Solar.com).

NOTICE

Restricted function of Integrated Plant Control as a result of incorrect settings

If the required parameters for Integrated Plant Control are incorrectly calculated or if the parameters are entered incorrectly in the inverter, the Integrated Plant Control function is restricted. SMA Solar Technology AG does not accept liability for incorrect entries made by customers.

- For error-free functioning of Integrated Plant Control, the system must be modeled correctly using Sunny Design.

Procedure:

1. Call up the user interface of the communication product or software and log in as **Installer** or **User**.
2. Enter the SMA Grid Guard code.
3. Select and set the required parameter.
4. Save settings.

Storage of Documentation

The system settings should be properly documented and stored so that they can be easily retrieved.

Example:

Device type and serial number	PV system	Impedance compensation		
	Rated apparent power of all inverters [kVA]	Ohmic resistance for impedance compensation [Ω]	Lagging resistance for impedance compensation [Ω]	Leading resistance for impedance compensation [Ω]
STP 17000TL-10 0123456780	580	0.0062	0.012	35.6463
STP 17000TL-10 0123456781	580	0.0062	0.012	35.6463
STP 17000TL-10 0123456782	580	0.0062	0.012	35.6463
STP 10000TL-10 0123456783	580	0.0048	0.0119	35.6463

5 Q on Demand 24/7

With the "Q on Demand 24/7" function, the inverter remains connected to the utility grid overnight and is supplied with power via the utility grid in order that it can provide reactive power. When connected overnight, the inverter only draws an insignificant amount of active power from the utility grid to supply its internal assemblies.

The inverter can provide up to 100% of its power as reactive power. The provision of reactive power during feed-in operation leads to a reduction of the feed-in power. This means that at 100% reactive power, the feed-in power is 0%.

If the inverter is disconnected from the utility grid outside of feed-in operation, the "Q on Demand 24/7" function is not active. The "Q on Demand 24/7" function can only be restarted once there is sufficient PV power at the DC inputs of the inverter, meaning that the inverter can briefly switch back to feed-in operation at least once.

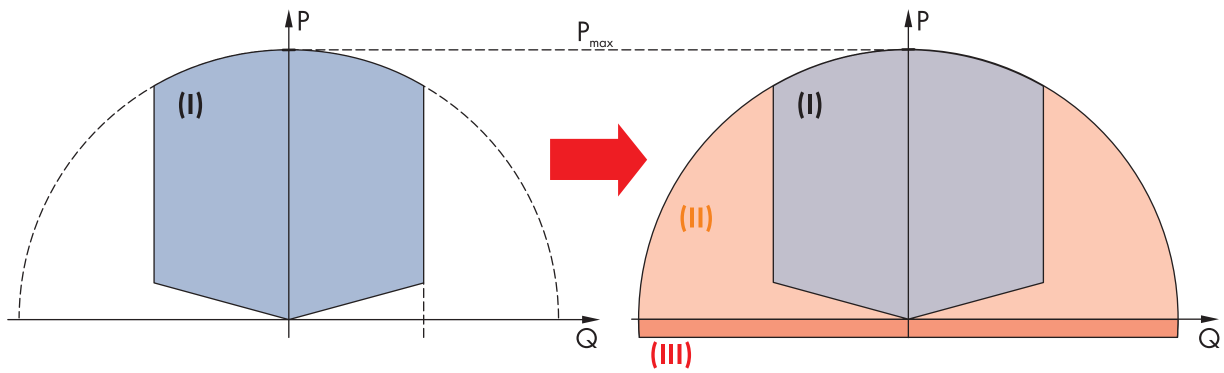


Figure 8: Extension of the operating range and the thresholds of a Sunny Tripower through the "Q on Demand 24/7" function

Position	Designation
(I)	Normal operating range of the inverter
(II)	Extended operating range with cos phi = 0 (overexcited) to cos phi = 0 (underexcited)
(III)	Reactive power provision outside of feed-in operation

Activating "Q on Demand 24/7" via Sunny Explorer

You can activate the "Q on Demand 24/7" function via Sunny Explorer as described in the following. With Sunny Tripower 60 devices, this function can only be activated via the LCS tool, not Sunny Explorer. To activate "Q on Demand 24/7" in a Sunny Tripower 60 device, proceed as described in the next section.

The general setting of the grid management service (e.g. cos(phi) setpoint or Q(V) characteristic curve) can not be fully set independently of the "Q on Demand 24/7" function via the relevant parameters - "Q on Demand 24/7" only permits Q specifications. It is to be noted here that certain settings can have an influence on other grid-support settings and functions.

This means that if the "Q on Demand 24/7" function" is active, no other grid-supporting functions (e.g. cos Phi) are possible between day- and night operation of the inverter. Should an independent reactive power provision be desired between day- and night operation, the reactive power provision must be communicated to the inverter via a superordinate control unit.

Currently, the provision of reactive power can only be read off via the phase currents and phase voltages in the instantaneous values (**Instantaneous values > AC-side > phase currents / phase voltages**) or requested via Modbus.

Requirement:

☐ The SMA Grid Guard code must be available (see "Application for SMA Grid Guard Code" at www.SMA-Solar.com).

Procedure:

1. Start Sunny Explorer.

2. Log in as **Installer**.
3. Select **Options > SMA Grid Guard ...**.
4. Enter the SMA Grid Guard code.
5. Select the relevant device in the System tree.
6. Select the tab **Settings** in the device menu.
7. Select [**Edit**].
8. Select the parameter group **System and device control system > Inverter > Configuration of the static voltage stability**.
9. Set the parameter **Operating mode of the static voltage stability** to the desired operating mode. When doing so, note that for "Q on Demand 24/7", none of the operating modes with cos Phi may be selected.
10. Select the parameter **Operating mode of the static voltage stability for Q on demand** and set this to the desired operating mode also.
11. Depending on the selection of the static voltage stability operating mode, set the parameters associated with the selected operating mode (e.g. the reactive power / voltage characteristic curve Q(V) with or without data points or the reactive power setpoint Q).
12. Select [**Save**].

Activating "Q on Demand 24/7" via LCS Tool

Procedure:

1. Contact Service and request the form "Settings request form for STP 60-10 / STP 60-10-US".
2. In the form under **Auxiliary Support Settings > Basic Settings > Night Mode**, enter a 1 in the column **Value**.
3. In the form under **Auxiliary Support Settings > Basic Settings > ModeSelect**, enter the desired operating mode in the column **Value**. When doing so, please note that for the "Q on Demand 24/7" function, only one of the operating modes 1: Q(V), 2: Q(P), 3: Q(S), 4: Q(T) or 5: Qext may be entered. The operating modes 6, 7, 8 and 9 are not compatible with the "Q on Demand 24/7" function.
4. Save the completed form and forward this to Service. In doing so, you are applying to obtain a configuration file with the desired parameter settings for the inverter.
5. Upon receipt of the configuration file, start the LCS tool.
6. Select the desired SMA Inverter Manager from the list.
7. Log in as **Installer**.
8. Select **Service > Grid Guard**.
9. In the field **Individual access code**, enter the SMA Grid Guard code.
10. Open **Setup > General** and select [**recommissioning**].
    ☑ A selection list with Inverter Managers opens.
11. Select the desired SMA Inverter Manager from the list.
    ☑ The LCS tool login page opens.
12. Log in as **Installer**.
    ☑ The Commissioning Wizard opens.
13. Follow the Commissioning Wizard up to the page **Grid code selection: Start by selecting a country**.
14. Import the configuration file supplied by Service. To do so, select [ ].
15. Select the configuration file supplied by Service and select [**Open**].
    ☑ The configuration file loads. Once the configuration file has been loaded successfully, the page **Please verify selections and commission when ready** opens.

16. Select [**Commission**].
17. If required, you can have the Commissioning Report displayed by selecting [**Yes**].